Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images

Luci Eldridge

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Abstract

How do contemporary imaging devices and the forms in which images are displayed affect our perception of Mars? How are scientists and engineers visually exploring, experiencing and navigating this uninhabitable terrain? Can we better understand this virtual landscape through immersive imaging techniques, or are these simply illusions? At what point does the glitch invade these immersive spaces, throwing us back into the realm of the image? And finally, can the glitch be seen as a method towards another kind of visibility, enabling us to 'see' and encounter Mars in productive ways?

Through the analysis of contemporary representations of the Martian terrain, *Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images* offers a new contribution to studies of the digital and virtual image. Specifically addressing immersive image forms used in Mars exploration the research is structured around four main case studies: life-size illusions such as panoramas; 3D imaging; false colour imaging; and the concept of a 'Mars Yard'. The thesis offers a new understanding of human interaction with a landscape only visible through a screen, and how contemporary scientific imaging devices aim to collapse the frame and increase a sense of immersion in the image. Arguing that these representations produce inherently virtual experiences, their transportive power is questioned, highlighting the image as reconstructed – through the presence of a glitch, illusion is broken, revealing the image-as-image.

This thesis takes an interdisciplinary approach in which scientific images are analysed through the prism of photography's relationship to reality, theories of vision and perception, representations of landscape, and digital and virtual image theory. At the heart of this thesis is the act of looking; critical and speculative writing is used to convey immersive encounters with images at NASA and the Jet Propulsion Laboratory (USA); University College London's Regional Planetary Imaging Facility; Airbus Defence and Space (UK); the photographic archive at the V&A; and the Panorama Mesdag (Netherlands). The research re-examines scientific forms of images against examples from the history of visual culture (be it art or popular culture) to draw parallels between different ways of seeing, representing and discovering the unknown.

The eyes of the Mars rovers provide viewpoints through which we regard an alien terrain: windows upon unknown worlds. Rover images bridge a gap between what is known and unknown, between what is visible and invisible. The rover is our surrogate, an extension of our vision that portrays an intuitively comprehensible landscape. Yet this landscape remains totally out of reach, millions of miles away. This distance is an impenetrable boundary – both physically and metaphorically – that new technologies are trying to break. *Mars, Invisible Vision and the Virtual Landscape* offers a two-way impact, constituting a new approach to the relationship between real and imagined images in order to demonstrate that the real Mars, however it is represented and perceived, remains distant and detached.

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Author's declaration

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Signature: L. Eldridge.

Date: 16 March 2017.

Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images

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Introduction
Collapsing the Frame and Stepping into the Image of Mars

Compellingly familiar yet hostile and remote, Mars captures our imagination. The eyes of the Mars rovers provide viewpoints through which we regard an alien terrain, windows upon unknown worlds, these images bridge a gap between what is known and unknown, between what is visible and invisible. The rover is our surrogate, an extension of our vision that portrays an intuitively comprehensible landscape. Yet this landscape remains totally out of reach, millions of miles away. This distance is an impenetrable boundary – both physically and metaphorically – that new technologies are trying to break.

Collapsing the frame and stepping into the image of Mars, this thesis investigates the fabrication of, and modes of experiencing contemporary rover images. As technologically manufactured representations, such images raise uniquely challenging issues because they capture and translate new discoveries that enter public consciousness as 'real' images of 'alien' landscapes. These images depict a virtual landscape, seen through the Mars rover's cybernetic eye; scientists explore the terrain virtually through images and engineers use image data and 3D modelling tools to help them make driving decisions. Focusing specifically on imaging techniques that are aimed at immersing the viewer and transporting them to Mars, this project investigates our quest for knowledge through imaging devices in relation to historical contexts of art and photography, and contemporary contexts of digital representation and virtual reality. Presenting a synthesis of approaches as a means to consider scientific methods of visualisation, this thesis challenges our ways of knowing, discovering and experiencing through an image, demonstrating that the real Mars, however it is represented and perceived, remains distant and detached.

The research does this in a number of ways and is structured around four main case studies; each chapter addresses a particular device that scientists and engineers are using to collapse the frame and step into the image of Mars. These include; life-size illusions such as panoramas; 3D images; false colour and white-balance imaging; and the Mars Yard. Each of these examples is re-framed within art history, with particular reference to photographic theory on the digital image as a construction, in order to question the transportive power of these kinds of immersive images. This thesis demonstrates that the construction of illusion reveals itself in a manner of ways specific to the image form under scrutiny, and glitch theory provides a lens through which to do this.[1]

Some of the key questions this research posits are: How do contemporary imaging devices affect our perception of Mars? How are scientists and engineers visually exploring, experiencing and navigating this uninhabitable landscape? What are the problems raised by

[1] The notion of 'glitch' will be defined in Chapter 2 with reference to Slavoj Žižek and Rosa Menkman.

representations of a reality we are unable to physically experience and see for ourselves? Can we better understand this virtual landscape through immersive imaging techniques, or are these simply illusions? What form does the glitch take, and at what point does it invade these immersive spaces, throwing us back into the realm of the image? And finally, can the glitch be seen as a method towards another kind of visibility, enabling us to 'see' and encounter Mars in productive ways?

In order to explore these questions further, it will first be important to define certain terminology and also explain why, in a study concerned with scientific imaging and invisible vision, Mars features as the main subject.

Invisible Vision and the Cybernetic Eye

Robert Hurt, a visual imager working for NASA and the Jet Propulsion Laboratory states that 'astronomers have built ways of taking off our invisible shades' creating 'cybernetic eyes' that extend 'our vision far beyond the narrow slice of visible light accessible to our biological eyes'.[2] It is in a similar manner that philosopher and cultural theorist Vilem Flusser describes the technical image as 'something invisible that has blindly become visible'.[3] Here Flusser was referring to digital representations, made from ones and zeroes, that construct an image out of nothing. With the aid of technology, Science has extended our biological vision into the invisible beyond, whether from the number of photons hitting the light detecting Charge-Coupled Device (CCD) or from capturing invisible wavelengths of light, these imaging technologies are making the invisible, visible.[4]

[2] Robert Hurt, "The Art of Space Imagery" (paper presented as part of the Karman Lecture Series, NASA/JPL-Caltech, California, 20 January 2012), accessed 10 October 2013, http://www.ustream.tv/recorded/19876092.

[3] Vilem Flusser, *Into the Universe of Technical Images*, trans. Nancy A. Roth (Minneapolis: University of Minnesota Press, 1985), 16. *Into the Universe of Technical Images* examines the potential and threat posed by digital communication technologies, arguing that as it develops, systems become more and more abstract.

[4] Instead of using a photographic plate that changes when exposed to light, the electrical photographic detector called a Charge-Coupled Device (CCD) captures precisely the number of photons that hit it. These detectors sit like water buckets and count the number of photons that 'fall into them'. Because the CCD relies on counting the amount of light entering it, the pixel can 'either be displayed as a number, or as a value of a shade of grey in a spectrum from black (zero photos) to white (many)'. Janet Vertesi, "'Seeing Like a Rover': Images in Interaction on the Mars Exploration Rover Mission" (PhD diss., Cornell University, 2009), 20, accessed 15 March 2014, http://hdl.handle.net/1813/13524. Imaging techniques that capture invisible wavelengths of light include x-rays, gamma rays, ultra-violet and infrared. NASA's *Hubble Space Telescope* is an example of an infrared-optical-ultraviolet telescope. Using different filters, *Hubble* is able to selectively screen out and bring into view various features that would otherwise remain invisible. For more information see: http://hubblesite.org.

Unable to see beyond our immediate surroundings, we as humans are blind; we must trust in the machine, and in turn, in the person who operates it. We are presented with a great number of these 'visions' on a daily basis, in the news and on social media, and accept them as truth in part because they originate from reputable sources, but also because they often conform to our preconceptions of how reality should be presented in the photograph. But is this representation of a reality we are unable to physically experience and 'see for ourselves' not problematic? Is our vision not mediated by the technological device? Such technologies give scientists 'perceptual access to the world they are sampling, while simultaneously shaping what they are able to see there'.[5] The medium extends and mediates our experience and to quote Marshall McLuhan's famous phrase, 'the medium is the message'.[6]

Professor of Science and Technology studies Michael Lynch has written on how scientists transform data in order to make it visible and analysable. In a 1985 essay titled "Discipline and the Material Form of Images: An Analysis of Scientific Visibility", Lynch exemplifies that the practice of working with images 'make[s] up an 'externalised retina' for scientific perception, a 'retina' that depends upon disciplined conduct within the laboratory setting' as 'objects and relationships which were initially invisible become visible and palpable as a result of highly technical skills and complex instruments'.[7] For Lynch, pictures are considered as part of the 'labour process', and although he only refers to examples from biology, his definition of 'invisible vision' can be extended to astronomical and planetary imaging and is key to this thesis.[8] Lynch's analogy helps define the term 'invisible vision' as not solely about the visioning machine; rather the term can also encompass pre- and post-production techniques, examples of *how* images are being used to see, understand, and gain new insights. With regards to Mars exploration, scientists are essentially making the invisible landscape visible and analysable through virtually immersive techniques.

Lynch furthers his discussion by arguing that 'what laboratory scientists perceive and work upon is thus artificial in the extent to which its appearance depends upon such technologies'.[9] Such 'rendering practices' – which might include 'graphs, photographs, charts

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[5] Charles Goodwin quoted in Stefan Helmreich, "Intimate Sensing," in *Simulation and its Discontents,* ed. Sherry Turkle (Cambridge, MA: The MIT Press, 2009), 142. In this case study, Helmreich writes about encountering the sea bed through 'thickets of technology'. Helmreich, 129.

[6] Marshall McLuhan, *Understanding Media: The Extensions of Man* (New York: McGraw-Hill, 1964), 7.

[7] Michael Lynch, "Discipline and the Material Form of Images: An Analysis of Scientific Visibility," *Social Studies of Science* 15, no. 1 (February 1985): 37, accessed 22 January 2014. http://dx.doi.org/10.1177/030631285015001002.

[8] Ibid., 39.

[9] Ibid., 37-8.

and diagrams', constituting 'the material form of scientific phenomenon' – are essential to the data's analysability.[10] Defining 'material' as 'sensible, analysable, measurable, examinable, manipulatable and "intelligent"' such practices make the object represented comprehensible.[11] Furthermore, these technologies do 'not merely *extend* the sensitivities of sensory perception', but 'domesticate' and 'routinise' 'space and time in accordance with the instrument's use' providing a perception that is an 'active reconstruction' of the object under scrutiny.[12] Lynch explains that scientific data is not wholly artificial, as this would imply such data is constructed out of 'thin air' and so his discussion of the scientific image as reconstruction is also crucial for this thesis.[13] As the images of Mars are based in an invisible reality but manipulated in order to draw particular conclusions, the *reconstruction* of images implies human intent. The data Lynch considers, is 'neither wholly constructed, nor simply a 'mirror of nature', arising [instead] from an encounter between a rational mind' and technological device.[14] Similarly, the partially constructed images of Mars – made out of various frames using a multitude of cameras – are *reconstructed* as immersive images that aim to create a sense of embodied perception.

A Window on Mars

To quote Charles Baudelaire, 'what one can see in the light of day is always less interesting than what happens behind a plane of glass'.[15] Lost in the kaleidoscopic colours captured by the *Hubble Space Telescope*, lured in by the deathly blackness of Comet 67P as represented by *Rosetta*, and straining to make out Pluto through the first images taken by *New Horizons*, we are awed by the vastness and intangibility captured within the confines of a picture.[16] As a society we have a fascination with things beyond our realm of perceptual understanding; presenting us with scenes that we empirically know nothing about, the image of a faraway

[10] Lynch borrows the term 'rendering practices' from Harold Garfinkel, using it to describe the 'transformation of lived activity into documentary phenomenon'. Ibid., 38, 62, 43.

[11] Ibid. 43.

[12] Ibid., 59.

[13] Ibid., 60.

[14] Ibid.

[15] Charles Baudelaire (1864) quoted in Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge, MA: The MIT Press, 2006), 5.

[16] In 2014 the European Space Agency's *Rosetta* spacecraft woke up from hibernation. After 10 years in space orbiting the earth and inner planets to gain gravity assist, it awoke on its final trajectory toward Comet 67P. It reached the comet at the end of 2014 and took a number of grainy pictures, which increased in detail as it reached its final orbit around the comet. On 30 September 2016 *Rosetta* concluded its mission with a planned impact into the comet. More information on Rosetta can be found at: www.esa.int/Our_Activities/Space_Science/Rosetta. Launched in 2006, NASA's *New Horizons* spacecraft made a close approach to Pluto in mid 2015. For more information, visit: http://pluto.jhuapl.edu/index.php.

planet on the NASA website is a mysterious one, and as Baudelaire may claim today, a far more fascinating one than our immediate setting.[17] We are reliant on scientists to provide us with these pictures and information so that we may explore these other worlds from the safety and security of our computers. Satisfying the public need for images they reflect humanity's ancient impulse to explore, to discover places with their own eyes, and if not our own, then those of our machines.[18]

So why Mars, when these other visions might seem more visually stunning and perceptually incomprehensible? It is precisely because Mars is in reach of our visual comprehension but out of reach of our bodily perception that it endures as a fascinating subject for a study concerned with the visible and the invisible. Recent images from NASA's rovers offer us technological windows onto ostensibly familiar yet remote and hostile terrains, their intrigue lying not in the sublime and the spectacular, but in the impressions made upon our imagination. Made possible through the recent proliferation of Mars images in the media, we may fleetingly transport ourselves to its dusty terrain. Secondary to their scientific significance, NASA's rovers have online personalities; tweeting and posting images to Facebook, they are the explorers in this digital age transmitting technological 'postcards' of remote lands. The personification of the rovers in this way allows for us to see them as our precursors to this alien world. With recent advances in space exploration technology, scientists are now able to navigate the Martian terrain virtually using satellites and rovers, and hope to place humans on Mars in the 2030s.[19] When asked about the obsession with Mars, Sam Seaborn, a character in the US series *The West Wing* replies:

> 'cause it's next, 'cause we came out of the cave and we looked over the hill and saw fire, then we crossed the ocean and we pioneered the West and we took to the sky. The history of man is on the timeline of exploration and this is what's next.[20]

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[17] Images are a necessary aspect of science and engineering missions, especially costly ones like NASA's Mars Science Laboratory (*Curiosity*). As well as providing the necessary data to uncover discoveries and make decisions on how and where to direct the rover, the images from *Curiosity* also provide a secondary function. *Curiosity* was initially funded for 90 days, which was its prime mission and when this time was up, NASA had to bid for more funding. Funded by the US government, NASA missions are paid for by the taxpayer; the images therefore function as a validation of big budgets, demonstrating money well spent.

[18] In the 1500s Christopher Columbus and Ferdinand Magellan took artists on board their ships to document the new world and in the late 1700s, Captain Cook did the same. Accounts of art and science in exploration can be found in Michael Jacob's *The Painted Voyage: Art, Travel and Exploration 1564 – 1875,* as well as in the "Art and Science of Exploration, 1768-80" room at the Royal Museums Greenwich.

[19] The *Mars One* organisation for instance is planning one-way trips to Mars to set up colonies on the surface by 2032. Elon Musk's privately funded *SpaceX* programme hopes that in 40-100 years humans will be living on Mars in self-sustaining colonies of one million people. NASA are developing the capabilities to send humans on a return trip to Mars in the 2030s.

[20] *West Wing*, season 2, episode 9, "Galileo," directed by Alex Graves, aired 29 November 2000, on NBC, accessed 7 March 2015, https://www.youtube.com/watch?v=oHGK96-WixU.

As ecological concerns for Earth grow, so does a desire to transcend our planet and colonise another.[21] It is precisely because it holds such a place in our imagination, in future endeavours to colonise another planet, its constant subject for science fiction novels and films, and its recent proliferation in the media that Mars is the central focus for this study. These images increasingly represent hopes for the future.[22]

The Mars Rover's Cybernetic Eye

Mars is half the diameter of Earth and is the last of the four terrestrial inner planets orbiting our sun.[23] Its thin atmosphere is made up of 80% carbon dioxide, a small amount of nitrogen and some oxygen, making it uninhabitable for life as it exists on Earth. Nicknamed the Red Planet because it glows red in the night sky, Mars is actually more of a dusty orange/brown, due to the high level of iron content in the top layer of Martian soil rusting.[24] More orbiting spacecraft, landers and rovers have been sent to Mars than any other planet, meaning that it is the most imaged otherworldly landscape. Science fiction also offers us explanations as to why Mars has fascinated us for so long; visible on a clear night, the planet has captured the imagination of writers exploring its imaginary terrains and speculating on possible Martian life forms and human colonisation. From H.G Wells' novel *War of the Worlds* (1898) to films such as *Total Recall* (1990) (which takes influence from Phillip K. Dick's *We Can Remember It For You Wholesale*), *Last Days on Mars* (2013), and most recently, *The Martian* (2015), visions of Mars have grown more and more advanced.[25] In 2000 Robert Zubrin, president of the

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[21] Robert Zubrin's *The Case for Mars* makes a case for Mars colonisation. He details ways of building structures from available materials, and how the planet might be terraformed to provide an environment we could live in. The book also details why Mars could be a potential source for metals and fuel. Robert Zubrin, *The Case for Mars: The Plan to Settle the Red Planet and Why We Must* (New York: Free Press, 2011).

[22] On a less romantic, more scientific note, Rob Manning details the interest in Mars:

> We go to Mars seeking answers to some of the great questions of our time:
> - Was Mars ever habitable for single-cell organisms?
> - Can we find evidence that past life once existed or perhaps even still exists on Mars?
> - Can we find clues on Mars that will help us understand how life on Earth began?

Rob Manning and William Simon, *Mars Rover Curiosity: An Inside Account from Curiosity's Chief Engineer* (Washington: Smithsonian Books, 2014), 6.

[23] The terrestrial planets are the four inner planets orbiting the sun, these are: Mercury; Venus; Earth; and Mars. Derived from the Latin words for earth *terra* and *tellus,* these planets have a solid, earth-like composition: that is, they are made from rock.

[24] In ancient Roman mythology, Mars was the god of war. He was also the god of spring and fertility. Usually portrayed as a warrior, these pre-conceptions of Mars as being fearful and violent contrast the actuality of the planet's serenity.

[25] After the first NASA missions *Mariner* and *Viking* which sent back pictures of a desolate and hostile terrain, the vision of Mars as inhabited by alien life was swiftly altered to explore visions of colonisation and terraforming the planet to make it habitable.

Mars Society, articulated how technology has progressed with increasing speed since 1900 and the implications of this on visions of the future:

> We now have cities with skyscrapers 100 stories tall and 200-ton ships flying through the air at 500 miles an hour across the oceans – we live in a science fiction world by the standards of the year 1900. Looking at this progress, who can imagine, that if we dare, that if we crack the shell, that if we break out of the cradle, who can deny that 1000 years from now that there cannot be a new branch of human civilisation on Mars? And looking back over the past 1000 years, at the world lit only by fire, the cold world of early medieval times and how much things have changed since then, and how much magical almost our world would have to seem to someone at that time, who can deny that if we take this step, that if we break out of this cradle, that 1000 years from now that there won't be 1000's of branches of human civilisation on 1000's of planets orbiting starts in this neck of the galaxy?[26]

Similarly, William J. Clancey has reported on a statement made by a member of the Mars Exploration Rover (*Spirit* and *Opportunity*) team, Bettye Woodruff, who compared Mars exploration to voyages that discovered the New World:

> Five hundred years ago, you would take a boat and discover another place […] You would record that, come back and tell your story to a limited number of people. The word was spread at the speed of the horse, or human voice. Today six billion people on January 4, 2004, discovered a new site on another planet. This is human exploration. Not human because humans were there, but because we [are] ALL there, together, through a robot![27]

Satellite views of Mars capture a sense of the planet as a whole, whilst also depicting it as distant and remote. Rovers on the other hand are for many the next best thing to being there ourselves. Through rover images scientists are able to discover this terrain virtually; at eye level the rovers' visions are analogous to how we might see Mars, resulting in many scientists, geologists and engineers likening their experience of working with rover data to actually 'being on Mars'. As Dr. Michael Carr wrote in 2007, 'we can transport ourselves through our surrogate rovers to a surface both strange and familiar and readily imagine some future explorers following their paths'.[28] The rovers emulate a human geologist on Mars.[29] 'Acting through' them, we experience an 'extended embodiment of the human eyes and hands'.[30]

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[26] Robert Zubrin quoted in William J. Clancey, *Working on Mars: Voyages of Scientific Discovery with the Mars Exploration Rovers* (Cambridge, MA: The MIT Press, 2012), 254.
The trajectory of space exploration was initially very slow but after World War 2 the world witnessed a surge of technological developments. As it is beyond the scope of this study to detail every technological development in Mars exploration, a timeline of these may be found in Appendix A.

[27] Bettye Woodruff quoted in William J. Clancey, "Becoming a Rover," in Turkle, 125.

[28] Michael Carr, *The Surface of Mars* (New York: Cambridge University Press, 2007), ix.

[29] Mark W. Powell et al., "Scientific Visualisation for the Mars Exploration Rovers," *IEEE International Conference on Robotics and Automation* (April 2005)*:* 4302, accessed 30 February 2015, http://www-robotics.jpl.nasa.gov/publications/Mark_Powell/Scientific_Visualisation_MER.pdf.

[30] Clancey, *Working on Mars,* 7.

The Jet Propulsion Laboratory in Pasadena, California is part of the California Institute of Technology (Caltech for short) and is contracted by the National Aeronautics and Space Administration (NASA).[31] As Mars rover driver John R. Wright explains, 'JPL is the centre for the robotic exploration of the solar system', carrying out the vast majority of robotic missions for NASA.[32] In the last twenty years, NASA has sent two missions of great note to Mars. As this study examines *contemporary* scientific imaging, the main focus of this thesis is the visions of NASA's most recent mission: the Mars Science Laboratory, otherwise known as *Curiosity.*[33] With reference to studies carried out by Janet Vertesi and William J. Clancey, this thesis also looks at images taken by the twin Mars Exploration Rovers, often referred to as MER. An analysis of *Curiosity's* imaging devices will be carried out in Chapter 1 in order to demonstrate how its 'visions' are reconstructed, however, as my position is an art historical one concerned principally with the image, scientific discoveries will be of secondary importance to the actual image forms under study.

The Mars Exploration Rovers *Spirit* and *Opportunity* (fig. i, pg. 30) landed at two different locations in January 2004. This mission is now infamous; with a 'follow the water' strategy, the rovers' aims were to monitor the compositional materials on the surface to study the 'aqueous, climatic, and geologic history of sites [...] where evidence of possible prebiotic processes might have been preserved'.[34] The two rovers were given a lifespan of 90 Martian

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[31] JPL was founded by a group of graduate students and rocket enthusiasts in the early 1930s when rockets were a fairly new science. Aerodynamicist Theodore von Karman (whose work had led to the development of early aircraft) saw potential in the designs of Jack Parsons and Ed Forman, and instructed student Frank Melina to work with the pair. These three became the core of JPL, and together they invented rocket fuel and subsequently, in October 1936, carried out the first successful test of a rocket engine. Initially funded by the military, when it was founded in 1958, JPL was moved over to NASA because it felt it wasn't proper for military development to be carried out at an educational institution. 90% of the work carried out at JPL is contracted by NASA, but the people who work there are actually employed by Caltech to run JPL, which is why, in many respects, it functions and looks much like a university. NASA has 10 sites across the United States including: Kennedy Space Centre (Florida); Vandenberg Airforce Space (California); Johnson Space Centre (Texas); Ames Research Centre (California); and the Edwards Airforce Space/ Armstrong Space Flight Centre (California). Jet Propulsion Laboratory, Public tour attended by author, Pasadena, CA, 2 November 2015.

[32] John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2016. Wright works on the Mars Exploration Rover mission, the Mars Science Laboratory, SMAP (Soil Moisture Active Passive) and Mars 2020.

[33] NASA's images are all open source and the ones I will be considering may be found online at the Jet Propulsion Laboratory's Photojournal. This database is constantly being updated with new information and it allows its visitors to input various search criterion including the planet, mission, spacecraft and the instrument used.

[34] Matthew Golombek, "Spirit and Opportunity – Martian Geologists," *Planetary Report* 27, no. 3 (May-June 2007): 12-16. More information on MER may be found on NASA/Jet Propulsion Laboratory's mission page, and in several books written by scientific investigators. Authors exploring the science and engineering in detail include Jim Bell, Dave Lane, Ronald Mak, Elizabeth Rusch, Jesse Russell and Ronald Cohn.

days (or sols), however both lasted much longer; after six and a half years *Spirit's* wheels became stuck and it became a permanent monitoring station. Communication was lost in March 2010 and JPL ended attempts to re-establish contact on 25 May 2011. At the time of writing this *Opportunity* is still operational.

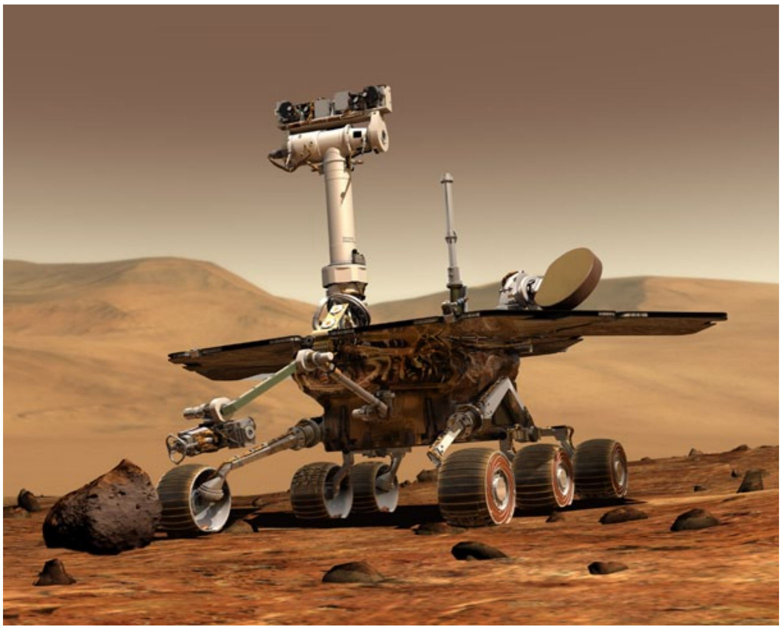

Figure i. Simulated view of the Mars Exploration Rover. *Spirit* and *Opportunity* are identical. Credit: NASA.

Figure ii. *High-Resolution Self-portrait by Curiosity Rover Arm Camera.* Image captured on 31 October 2012 (sol 84). Credit: NASA/JPL-Caltech/Malin Space Science Systems.

On 6 August 2012, the Mars Science Laboratory *Curiosity* landed in the middle of Gale Crater, its mission: to search for life on Mars by identifying habitable environments.[35] These rovers mimic aspects of human form, which has been played up by their online presence; stereo-vision at human eye-height, arms carrying instruments and wheels that enable movement over long distances, the rovers facilitate what Clancey has termed 'virtual presence'.[36] With stereo capability referred to anthropomorphically as left and right, the Navigation and Mast Cameras on *Curiosity* are located at approximately 1.97m from the ground (MER cameras are 1.5m from the ground).[37] Martin Kemp argues that these sorts of imaging machines and the way data is presented is always linked to the eye because

> it is the human visual system that initiates any kind of photographic activity, […] the end product is rigged to work within the parameters of our sight, and […] images are irredeemably subject to our ways and habits of seeing in all their variability.[38]

The cameras are the eyes of the rover, and in turn an extension of our vision. By looking upon an image that places the human at the centre of the mediated experience, the Navigation and Mast Camera images make way for the possibility of a virtual experience. Presenting 'human-like' perspectives of this formidable terrain, these rovers are, to quote Steve Squyres, 'our robotic precursors to a world'.[39] The likening of the rovers to surrogate explorers is a form of psychological immersion in both the missions and terrain. This ability to be able to see the terrain at human scale allows for us to project ourselves imaginatively into the landscape; in a study concerned with how we experience virtual images and virtual landscapes, this is the principle reason for looking at rover imaging.

<u>The Virtual Landscape: Stepping into the Space of an Image</u>

At the beginning of *The Human Condition,* written in 1958, Hannah Arendt details the 1957 launch of *Sputnik*. The first spaceship to be sent outside of this planet, men could look up from Earth and 'behold a thing of their own making', the 'first step toward escape from men's imprisonment to the Earth'.[40] For all but a small handful of Earth's population this dream of escape has not become a physical reality, yet it persists imaginatively in both science fiction

[35] This goal was in fact met early on in the mission at *Curiosity's* landing site. As the landing stage thrusters blew up dust from the surface, rounded pebbles were uncovered, indicating that water once flowed across this region.

[36] Clancey, *Working on Mars,* 59-60.

[37] Average eye height is 1.44m – 1.65m approx. for females and 1.56m – 1.77m approx. for males.

[38] Martin Kemp, *Seen Unseen: Art, Science and Intuition from Leonardo to the Hubble Telescope* (Oxford: Oxford University Press, 2006), 268-69.

[39] Steve Squyres, *Roving Mars: Spirit, Opportunity, and the Exploration of the Red Planet* (New York: Hyperion, 2006), 377.

[40] Hannah Arendt, *The Human Condition* (London: University of Chicago Press, 1958), 1.

and science fact. The foundation of this thesis lies in the notion of facilitating a *virtual escape* – be it virtual exploration for scientific purposes or imaginative escape in entertainment – in the viewer's mind, namely through the space of the image which relies on the visual immersion of the participant. In *The Art of the Motor,* Paul Virilio claims 'it is the eyeball that now englobes man's entire body'; with visual tricks and machines of vision we can experience Mars.[41] But as Anne Friedberg states in *The Virtual Window: From Alberti to Microsoft;*

> The entertainment function of these optical devices relie[s] not only on the verisimilitude of the images seen and the recording capacities of mediated vision, but also on the illusion of verisimilitude, the very virtuality of the experience produced.[42]

Humankind has conquered the Moon, and since this time our gaze has been fixed outwards upon the next celestial body within our technological grasp, Mars. This thesis is concerned with how scientists and visual imagers are using different methods to experience and explore the otherworldly landscape virtually.[43] In *Bodies in Code*, written in 2006, Mark Hansen observes that despite experiencing the world in three-dimensions, throughout history we have only been able to represent the world on a flat plane, noting that 'only in the past half century has scientific and artistic attention focused on the total simulation of perceptual reality'.[44] The techniques and devices discussed in this thesis aim at collapsing the frame of

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[41] Paul Virilio, *The Art of the Motor* (Minneapolis: University of Minnesota Press, 1995), 48.

[42] Friedberg, 63. In *The Virtual Window* Anne Friedberg considers the 'window' as a metaphor, an architectural opening, and a screen on the dematerialised reality held within our computers. She argues that although attempts have been made to break free of the frame (seen in Cubism, modern architecture and moving image) these have tried to do so within a single 'window'. Friedberg claims that in the digital age of multiple windows coexisting on the computer screen, traditional perspective is at its end. Plato dismissed mimetic tricks like those of Zeuxis as works of entertainment, 'cheap tricks that interested the lower classes'. Anne McCauly, "Realism and its Detractors," in *Paris in 3D: From Stereoscopy to Virtual Reality 1850-2000,* ed. Francoise Reynauld, Catherine Tambrun and Kim Timby (Paris: Paris Musees; Booth-Clibborn Editions, 2000), 24.

[43] Virtual reality techniques are also used in astronaut training procedures; the European Space Agency's astronaut Tim Peake explains the benefits of training for EVAs (or space walks) in a swimming pool:

> Being in water is a great way to train for zero gravity. Not just because of the neutral buoyancy but also as you mention it is the feeling of being immersed in water which gives that added feeling of isolation, reliance on your fellow crewmember and extra element of risk that all help to increase the mental perception of performing a spacewalk. Of course, water is not truly representative of zero gravity since the extra viscosity of water makes things hard to get moving and easy to stop, (exactly the reverse in space) but it's the closest we can simulate for long periods of time […] The space station mock up in the pool is also very detailed and quite accurate [...] which all adds to the 'illusion' of performing a real space walk. We are encouraged to embrace this illusion, since the best and most valuable way to train for space walking is not just to simulate that you are doing it but instead to really 'imagine' that you are space walking.

Tim Peake (European Space Agency astronaut), email message to author, 1 February 2014.

[44] Mark Hansen, *Bodies in Code: Interfaces with Digital Media* (New York: Routledge, 2006), 1. *Bodies in Code* explores how our bodies experience and adapt to digital environments.

the two-dimensional image so that it might be stepped into conceptually and imaginatively and at times physically.

Throughout this thesis, *virtual reality* is used in reference to spaces of visual immersion conjured up by the image. The term 'virtual reality' was coined by Jaron Lanier in 1987; 'virtual' means both 'not really existing' and 'almost the same' and so *virtual reality* is a contranym combining two words with opposing meanings.[45] It is in this sense that metaphors are virtual, as although they refer to the material world, they 'reside in the immateriality of language', remaining only as substitutes for something literal.[46] The image then may also be considered as a virtual manifestation of an object or landscape and virtual reality technologies push this concept further to simulate real life experiences.

The term also has a history within computing of great relevance to this study. As outlined by Michael Heim in "The Metaphysics of Virtual Reality", the contemporary use of the word *virtual* comes from software engineering and 'connote[s] any type of computer phenomenon' that forms its basis in reality, and replicates physical realities within a digital space, virtual mail and libraries being examples.[47] Similarly in "A Virtual Indication", Samuel Weber claims that 'the virtual is framed and instrumentalised by the real' and when using the term in this way, it comes to mean, to quote Heim, a 'not-quite-actual space, something existing in contrast to the real hardware space but operative as if it were real space'.[48] To quote Anthony Bryant and Griselda Pollock in their introduction to *Digital and Other Virtualities: Renegotiating the Image*:

> There is similarity with the actual thing; but it is not the thing itself. It is not the real; yet it is not false. It displays, nonetheless, similar enough traits for our interactions with the virtual to function as if they were indeed real.[49]

Bryant and Pollock state that in a non-technological sense, virtuality must also be 'understood in relation to the faculty of imagination and phantasy: the psychic plane of an effective, if not perceptual reality'.[50]

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[45] Virtual Reality Society, "Who Coined the Term 'Virtual Reality?'" 2009, accessed 15 January 2014, http://www.vrs.org.uk/virtual-reality/who-coined-the-term.html. Previous to this, Lanier had set up VPL, a company which pioneered the research into virtual reality and 3D graphics. It was the first company to produce virtual reality gear such as glasses, data gloves and the full data suit. The definition of 'virtual' meaning 'not really existing' and 'almost the same' comes from: Anthony Bryant and Griselda Pollock, eds., *Digital and Other Virtualities: Renegotiating the Image* (London: I.B. Taurus, 2010), 11.

[46] Friedberg, 12.

[47] Michael Heim, "The Metaphysics of Virtual Reality," in *Virtual Reality: Theory, Practice and Promise,* ed. Sandra K. Helsel and Judith P. Roth (Westport, WA: Meckler, 1991), 29.

[48] Samuel Weber, "A Virtual Indication," in Bryant and Pollock, 66; Heim, 29-30.

[49] Bryant and Pollock, 14. *Digital and Other Virtualities* is an interdisciplinary collection of essays from leading artists, filmmakers, theorists, philosophers, literary critics and cultural analysts. It is as much about indexicality as virtuality in contemporary cultural theory.

[50] Ibid.

Similarly in *The Virtual Window,* Anne Friedberg claims that 'the space of the screen is a virtual space, an elsewhere that occupies a new dimension'; virtual spaces open up possibilities for imagination.[51] Immaculate and hard-edged forms are often associated with computer games and other machine-made images and as aesthetics only experienced through screens, they are arguably the aesthetics of virtual realities. It is for this reason that the film *Jurassic Park* was such a landmark achievement; the computer image was seamlessly integrated with the film through degrading the computer-generated image 'to match the imperfection of the film's graininess', thereby recreating the look of photographic realism within computer-generated imagery.[52] But despite this sense of realism, the dinosaurs do not exist beyond the virtual realm of the screen, therefore exemplifying Friedberg's use of the term 'virtual' to distinguish anything that represents and looks like, but does not consist of the same material as its origin.[53]

In "Informating with Virtual Reality", Michael Spring claims that remote-controlled interplanetary robots provide computer mediated realities; the data is based 'in reality' but results in the user experiencing 'a reality that is not really happening' for his or herself on the ground.[54] The meaning of the term *virtual reality* throughout this thesis then is twofold; it encompasses immersive spaces of illusion which *also* represent landscapes that, not being physically present, exist for the viewer as virtual.

Vision was considered by Plato and Aristotle, and later Descartes as the 'noblest of the senses'.[55] The image attempts to recapitulate vision in a solid transferrable form however, as historian and theorist Martin Jay notes, there are 'ambiguities surrounding the word "image", which can signify graphic, optical, perceptual, mental, or verbal phenomena'.[56] Scholar and critic Philip Furbank reinforces that the 'word "image" is used as a synonym for "metaphor" – that is to say, to signify a comparison' but he states that using image as metaphor is awkward, as 'image' implies a picture.[57] Metaphors are virtual manifestations of things, and images are also virtual manifestations of things. Both simulate a picture of something, either mentally, or as a representation, or imitation, reproducing what cannot be

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[51] Friedberg, 179.
[52] William J.T. Mitchell, *What do Pictures Want? The Lives and Loves of Images* (Chicago: University of Chicago Press, 2006), 201-01.
[53] Friedberg, 11.
[54] Michael B. Spring, "Informating with Virtual Reality," in Helsel and Roth, 8.
[55] Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* (Berkeley: University of California Press, 1994), 27.
[56] Ibid., 9.
[57] Philip Nicholas Furbank, *Reflections on the Word 'Image'* (London: Secker & Warburg, 1970), 1.

experienced physically at that moment in time. However, both conjure up the visual world and media theorist W.J.T. Mitchell considers images as a kind of language:

> Instead of providing a transparent window on the world, images are now regarded as the sort of sign that presents a deceptive appearance of naturalness and transparence concealing an opaque, distorting, arbitrary mechanism of representation, a process of ideological mystification.[58]

It is important to note that this thesis revolves not around the mental image but around the visual image: the scientific, the virtual, the technological and the art historical.

The space of the visual image has been used throughout art history to immerse a viewer in another world, and goes back primarily to the European classical traditions for which latest technologies of the day were employed to maximise illusion.[59] Historical analysis of the development of virtual spaces can be found in *Virtual Art: From Illusion to Immersion*, in which Oliver Grau discusses spaces whereby the 'eye is addressed with a totality of images'.[60] Through an analysis based on the illusory spaces of fresco rooms, panoramas, circular cinema and computer generated art in the CAVE, Grau characterises immersion as a 'diminishing critical distance to what is shown and [an] increasing emotional involvement in what is happening', implying that what must entail is a *conscious* suspension of disbelief.[61] Undoubtedly, the most effective method of immersion is to hermetically seal off the external world and 'expand perspective of real space into illusion space' as well as use lighting to enhance the effects of reality.[62] Unlike traditions of other illusionistic painting such as Renaissance trompe l'oeil which tended towards a 'window on the world' – often disrupted by museum surroundings and disparate lighting effects – the frame disappears in immersive art to give the sensation that the viewer stands at the very location of depiction.[63] *Virtual Art* is a comparative reflection upon the history of illusion and realism in relation to contemporary forms of virtual art, and in it Grau defines virtuality as a relationship between humans and images in which there is always a paradigm between physical and psychological perception.[64] For Grau the term *virtual reality* 'describes a space of possibility or impossibility formed by illusionary addresses to the senses', it is, to quote Webster's dictionary, 'in essence

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[58] William J. T. Mitchell, *Iconology: Image, Text, Ideology* (Chicago: The University of Chicago Press, 1986), 8.

[59] Oliver Grau, *Virtual Art: From Illusion to Immersion,* trans. Gloria Custance (Cambridge, MA: The MIT Press, 2003), 4-5.

[60] Ibid., 13.

[61] Ibid. Cave Automatic Virtual Environments are immersive spaces in which projectors are directed at three, four, five or six walls of a cube shaped room.

[62] Ibid.

[63] Ibid., 14. The deception in trompe l'oeil is always recognisable; 'in most cases, because the medium is at odds with what is depicted and this is realised by the observer in seconds, or even fractions of seconds'. Ibid., 16.

[64] Ibid., xi.

or effect, but not in fact'.[65] It is not a simulation of something that already exists but encompasses more of the impossible made possible via illusion and participation, a kind of 'as if'. For Grau:

> Virtual reality stands for the complete divorce of the human sensorium from nature and matter. In the history of illusionism in art and media, virtual reality constitutes the greatest challenge so far to the human senses and their relationship with the environment, which produces, sustains, and permeates them. The interactor inside the image space recognises that what is visible is an illusionistic environment where the perceptions of the organs of sense and the quantities of time and space have become variables.[66]

Scientists and engineers are using 3D images, panoramic visualisations, head mounted displays and false colour images to immerse themselves 'in Mars'. Mars is being reconstructed and explored virtually. In discussing the images of Mars in relation to historical forms of immersive space, this thesis takes a similar approach to Grau but one which goes further, pushing and questioning the immersive devices used in visualising unknown lands.

William J. Clancey describes scientists exploring Mars in relation to the notion of 'becoming the rover' and with this in mind I propose a means of critically analysing these devices, one that incorporates the thinking of French phenomenologist Maurice Merleau-Ponty. Grau claims that 'the computer has transformed the image' suggesting that it is now possible to '"enter" it'.[67] Instead of stepping into the image in Grau's sense, (i.e. into a room whose walls are covered in image space), I explore these images by *imaginatively* stepping into them. In *The Phenomenology of Perception,* Merleau-Ponty discusses the importance of experiencing the world from *within,* with the body as the locus of perception:

> I do not see [a space] according to its exterior envelope; I live in it from the inside; I am immersed in it. After all, the world is all around me, not in front of me.[68]

The image is a space in which the objects do not surround us and immersive technologies attempt to deceive us otherwise by enveloping us in the image. Using Merleau-Ponty's necessity to experience the world from within, what might it be like to experience the image from within, to imagine 'becoming the rover'? As we can only experience Mars through the image, what might it be like to step into the *image*, rather than onto the terrain? Speculative writing and thick description will be used to perform this concept in different ways, becoming a generative research method that documents personal and more subjective encounters with the image forms under scrutiny.

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[65] Ibid., 15; Webster Dictionary quoted in Helsel and Roth, 6.
[66] Grau, 213.
[67] Ibid., 3.
[68] Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 178.

As opposed to James Elkins and Elizabeth Kessler, who are concerned with limits of visibility and the borders of abstraction (as exemplified by those of the *Hubble Space Telescope*), this thesis is concerned with limits of representation in a different sense; with liminality, with boundaries.[69] Bringing the visions of Mars back down to Earth, these limits lie in the threshold between an immersive experience of Mars and how that immersive experience is reconstructed through various devices. *Hubble* images, claims Kessler, invite us to cross the boundary into the unknown, confronting us with a 'metaphorical and phenomenological frontier, a threshold we are encouraged to cross, not bodily but mentally through the extension of our sensory imagination'.[70] This 'crossing the boundary into the unknown' is a central focus of this thesis, expanding on Kessler's concepts of resemblance and the threshold. These ideas are developed in light of new technologies and in terms of how these contribute to a new approach to reading constructed images in relation to fiction, spectacle and the virtual. How might one cross this boundary and collapse the frame? It may not happen bodily, as Kessler points out, but virtually, in our minds and imagination, through prolonged engagement with the image.

The greater the illusion in an image, the greater chance the eye has for this disembodiment and Brian O'Doherty speaks of this phenomenon in *Inside the White Cube: The Ideology of the Gallery Space.* O'Doherty argues that the presence of the framing device plays a key role in our immersion:

> One "steps" firmly into such a picture or glides effortlessly, depending on its tonality and colour. The greater the illusion, the greater the invitation to the spectator's eye; the eye is abstracted from an anchored body and projected as a miniature proxy into the picture to inhabit and test the articulations of its space. For this process, the stability of the frame is as necessary as an oxygen tank is to a diver. Its limiting security completely defines the experience within.[71]

Yet as soon as the framing device becomes apparent, it becomes a parenthesis, and you realise you are looking at only a segment of the landscape, a depiction.[72] As the images of Mars are often constructed by mosaicking hundreds of snapshots into one, this thesis

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[69] The idea of James Elkins' *Six Stories from the End of Representation* is to 'think through images' in order to consider how each discipline works with limits of instrumentation and borders of representation. James Elkins, *Six Stories from the End of Representation* (Stanford: Stanford University Press, 2008), xvi. In *Picturing the Cosmos: Hubble Space Telescope Images and the Astronomical Sublime,* Kessler discusses the construction and aesthetics of *Hubble* images in relation to Kant's notion of the sublime and 18th century paintings of the American West.

[70] Elizabeth Kessler, *Picturing the Cosmos: Hubble Space Telescope Images and the Astronomical Sublime,* (Minneapolis: University of Minnesota Press, 2012), 227.

[71] Brian O'Doherty, *Inside the White Cube: The Ideology of the Gallery Space* (Berkeley: The Lapis Press, 1976), 18.

[72] 'Once you know that a patch of landscape represents a decision to exclude everything around it, you are faintly aware of the space outside the picture. The frame becomes a parenthesis.' Similarly, a photograph is defined by its frame: 'In a photograph, the location of the edge is a primary decision, since it composes – or decomposes – what surrounds it.' Ibid., 19.

demonstrates that the landscape as reconstructed carries with it evidence of its own making. Chapter 2 draws on Rosa Menkman's *The Glitch Moment(um)* and Slavoj Žižek's 'digital break' in illusion; unveiling the constructed image and presence of the device, the 'glitch' manifests itself in different ways specific to the illusion under scrutiny. This rupture in representation plays a vital role in my research; making the viewer consciously aware of the act of looking, it foregrounds my argument that we may only step into the *image* of Mars whilst the real Mars remains detached and remote.

This thesis explores notions of virtuality in the scientific imaging of Martian terrain and investigates methods of presenting Mars to the public for entertainment purposes, ways of experiencing Mars in order to gain scientific knowledge, and ways of exploring Mars virtually in three-dimensions. Professor of Computer Science Edward Tufte has described the importance of surpassing the two-dimensional image as 'escaping flatland':

> The world portrayed on our information displays is caught up in the two-dimensionality of the endless flatlands of paper and video screen. All communication between the readers of an image and the makers of an image now take place on a two-dimensional surface. *Escaping flatland is the essential task of envisioning information – for all the interesting worlds (physical, biological, imaginary, human) that we seek to understand are inevitably and happily multivariate in nature. Not flatlands.*[73]

Virtual realities attempt to escape the space of the screen, yet as the image is contained within it, the screen is forever present. The purpose of this research is to discover if it is possible to collapse the frame and step into illusion, or if illusion must remain perpetually in two-dimensions, in which the framing device and the presence of the image as reconstructed always push to the fore. Through the various approaches to immersing myself in the image of Mars I demonstrate that the glitch has many forms.

[73] Edward R. Tufte, *Envisioning Information* (Connecticut: Graphics Press, 1990), 12.

Methodology

The central research questions are addressed with an interdisciplinary approach in order to contextualise and re-examine contemporary scientific imaging of Mars within an arts and humanities framework. The theorising of the image has mostly taken place within art history and photographic theory, and so this is the main platform from which to approach these images and image forms. This involves analysing images through the prism of photography's relationship to reality, contemporary art theory and critical readings of the image, theories of perception and vision, representations of landscape, digital and post-digital screen theory and the imaginary. Because the images under examination are developed and mostly experienced within a scientific discourse, I need to be attuned to scientific ideas about knowing and discovering. By re-examining such images within an artistic discourse, relations are drawn between two different ways of seeing, representing and discovering the unknown, thus constituting a new approach to the relationship between real and imagined images.

Research is investigatory and interdisciplinary including visits to scientific imaging laboratories and conversations with scientists and engineers at NASA, the Jet Propulsion Laboratory and the European Space Agency. These discussions take place alongside more traditional forms of arts and humanities research such as library, gallery and archive visits. Reading draws upon historical and theoretical materials relating to photography, art and philosophy, scientific imaging and visions of the universe. The materiality of the different forms of text makes for a hybrid body of research, reflecting a contemporary blurring of boundaries between arts, humanities, science and entertainment industries. Embracing this synthesis, critical readings of images are intertwined with creative responses in which imaginative writing becomes another approach to research.

The images from NASA's rover *Curiosity* are the main focus of the investigation. All data sent back by *Curiosity* is uploaded online to NASA and JPL's MSL mission page and JPL's Photojournal and Planetary Data System. All the images are therefore open source. This project is specifically about the virtual landscape as represented by the digital image, with particular focus on how scientists and engineers are using different imaging devices to experience and explore Mars virtually. Analysis of these images then is threefold: I interview scientists and engineers working with rover imagery, apply critical theory to them, and I also engage on a personal level through imaginative writing. Thus writing is used both analytically and as a generative research methodology, speculating on what it might be like to step into the image of Mars rather than onto the terrain. Here I see writing very much as a form of practice, as a means to push ideas imaginatively to reconsider scientific method and practices of exploring Mars beyond the historical and critical frameworks listed above. Chapters 2 through to 5 commence with a more speculative and imaginative encounter based on the initial image and this writing has acted as a launch pad to each chapter. Speculative writing serves as a generative research method, highlighting ideas and drawing out specific observations that are fleshed out in the more critical and historical writing that follows. As a means to distinguish between the writing, these opening ruminations are italicised. In addition, thick description functions to relay primary research visits and subjective encounters with images, predominantly in Chapters 3, 4 and 6. These descriptive interludes are demarcated in a different font.

At the heart of this thesis is the act of looking; by integrating theory with visits to archives, space agencies and through prolonged and intensified looking, modes of immersing oneself in Mars are deeply scrutinised. The final chapter takes this act of looking further by physically stepping into and onto the image of Mars at the Mars Yard. Here looking alone does not suffice, instead mechanised looking is used as a research method, stepping into the image with a camera in order to image an image of Mars. Becoming a rover, reconstructing a reconstruction and straining towards an image of authenticity I deliberate: at what point does illusion collapse, and can the virtual spill out into the real by means of photography? The making of my own images in this final chapter attempts to determine if the superficial nature of such an illusion as the Mars Yard might be made to look more 'real' by the act of photography, and if photography in this case might function as a further method of immersion. Whereas Chapters 2 through to 5 begin with a speculative account of the image, Chapter 6 takes a reverse approach. At the end, photography serves as the speculative act, performing an immersive encounter.

Literature Review

As an interdisciplinary study this thesis can be situated within a number of different contexts. As a study concerned with 'invisible vision', the veracity of the scientific image, and its ability to transport the viewer virtually to another world, this project contributes to the wider context of photographic and digital imaging theory. As an offshoot of this it contributes more specifically to the body of literature concerned with virtual reality in the digital age. Chapter 1: "The Martian Landscape as Reconstructed" draws on leading theorists and philosophers such as Walter Benjamin, Roland Barthes, Christian Metz, Kendall Walton, Jean Baudrillard, Martha Rosler, Lev Manovich and E.H. Gombrich to establish the concerns surrounding image authenticity in a digital age. Many photography historians and theorists concerned with the state of the image today have looked at surveillance, popular culture, social media, and scientific representations. Inherent in these studies are critical theories surrounding the image, perception, vision, truth and belief and philosophical notions of what it means to present and re-present reality. This study then comes out of the discourse of photography and the theorising of the image, for which the digital and the virtual are cutting edge and timely issues in an age of increasing image saturation supported by the internet. How scientific images are conveyed and understood depends on the image's proliferation; the context in which it is experienced and under what conditions play a vital part in the formation of knowledge. For these reasons this study contributes to this growing theorisation of the virtual non-art image in a digital age. These theories are examined in more detail in Chapter 1 in relation to *Curiosity's* images.

In addition, the study contributes to an existing body of research that places images of outer space, dating from the 1950s onwards, within a wider framework of art history. Very few of these texts focus entirely on astronomical imaging and even fewer place Mars as a central focus; my thesis aims to bridge this gap.[74] Previous scholarly research that looks at astronomical images and art tends to explore scientific imaging in its wider form; often

[74] There has been a body of literature addressing the exploration of Mars from a mission standpoint. Studies include Jim Bell's *Postcards from Mars*, which emphasises the aesthetics of panoramic photographs taken by MER whilst also providing a first-hand account of the mission. Similarly, Roger Wiens' *Red Rover: Inside the Story of Robotic Space Exploration, from Genesis to the Mars Curiosity Rover,* and Rob Manning and William L. Simon detail the *Curiosity* mission from first person perspectives, from planning and preparation stages through to landing and 'working on Mars'. These kinds of texts prove useful in gaining insight into the workings of the mission, and I draw on these and scientific papers that relay the science and engineering aspects when it proves relevant to the discussion, however they do not consider the implications of the image within a wider frame of visual culture.

astronomical images feature as one facet alongside molecular biological imaging, brain scans, microscopic imaging, mathematics, quantum mechanics, X-rays, and particle physics.[75] Furthermore, these texts mostly address production techniques, and almost always use *Hubble Space Telescope* images as their prime example. The reason is clear: within an arts and humanities framework, *Hubble* images offer visually spectacular 'visions' into the unknown. Dictated by the form and content of these images, discussion revolves around their aesthetics, their sublime nature, and on a deeper level, their claims to truth.[76] *Hubble* is the ultimate 'cybernetic eye'; visioning the invisible.[77] Its images are considered by many as works of art and as such, a number of art historians have focused their attention on them; Martin Kemp, James Elkins, Elizabeth Kessler, Michael Lynch and Samuel Edgerton being the predominant figures.[78] The gap in this art historical body of research discussing astronomical imaging is twofold; firstly, these texts do not address Mars, and secondly they do not focus on how the otherworldly landscape is experienced and explored using virtual reality techniques. This thesis then offers an in depth critique into how Mars is being explored virtually. As the history of immersive technologies and techniques is indebted to developments in pictorial illusion (Oliver Grau provides an excellent account), it is necessary to place such devices within their art historical context, specifically with regard to how the 'unknown' was and is presented to public audiences. In the words of James Elkins, 'art history is centrally positioned in the emerging field of image studies because it possesses the most exact and developed language for the interpretation of pictures'.[79] It is in this regard that my study must stake its claim within an art historical and theoretical framework, as

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[75] Texts that explore the development of scientific images include: John D. Barrow's *Cosmic Imagery: Key Images in the History of Science;* Felice Frankel's *Envisioning Science: The Design and Craft of the Science Image;* Frankel's *On the Surface of Things: Images of the Extraordinary in Science;* Timothy H. Engström and Evan Selinger's *Rethinking Theories and Practices of Imaging;* and Lorraine Daston and Elizabeth Lunbeck's *Histories of Scientific Observation.*

[76] The *Hubble* telescope records data digitally, not pictorially, and the data has to be translated by visual imagers after which it is mediated many times over to draw out various sets of information. The appearance of the final images are the results of varying combinations of the telescope optics and its digital detectors, the computer programmes used to render the data and the visual imagers who manually process the data. The appearance of the images, therefore, results from a series of decisions that combine scientific and aesthetic concerns which quite often involve some discrepancy over how the images should 'look'. Kessler, 14-15.

[77] As the 'ultimate form of sight' the *Hubble Space Telescope* differs vastly from the 'instantaneous snapshot', looking back 11 billion years. Kemp, 242.

[78] The presentation of images of outer space as 'art' can be seen in gallery exhibitions in recent years. These include: an exhibition of *Hubble* images at the Blue Gallery in London in 1997; early drawings of the moon through to *Hubble* images presented in light-boxes in a gallery setting at *Visions of the Universe* at Royal Museums Greenwich in 2013; and analogue NASA photographs being shown alongside the photographic artwork of Jan Kempenaers at Breese Little Gallery in 2015.

[79] James Elkins, *The Domain of Images* (New York: Cornell University Press, 1999), 6.

without this, an analysis of the image (its form and its content) might prove futile and impossible.

In addition to these key contexts of art history and image theory there is also a third body of literature to which this thesis contributes; the relatively new academic field of science and technology studies.[80] One branch of this field explores representational practices used in scientific research as means of attaining new knowledge. This branch offers analysis of how scientists work with images, machines and team members. Although not directly linked to art history, it is here that studies of Mars exploration can be found. William J. Clancey is a key figure exploring this field, however his study is concerned with humans' relationships to machines and the sociological aspects of working as a team toward collective goals, for which images are considered only one aspect. In a similar vein, Janet Vertesi explores the use of images within a wider sociological framework to comment on how scientists are embodying the rover and doing science through images; I draw on and expand Vertesi's study in Chapters 4 and 5.

Chapter 1 provides an in depth contextual review regarding the historical and current state of the image. Setting up key ideas surrounding photography's relationship to reality and the problems arising when representing something without a referent, this chapter provides a lens through which to consider *Curiosity's* images of Mars. The purpose of this literature review then is to examine the ways in which astronomical imaging has been written about in an art historical context, singling out several key texts whose interdisciplinary approach might be aligned with my own. The second purpose of this review is to examine how Mars exploration has been analysed in science and technology studies, and why a refocusing on the form of the image as a means of embodied perception – in the context of arts and humanities – is necessary.

Art, Science and Visions of Outer Space

This thesis draws parallels between scientific and art historical modes of visual immersion. Several writers have sought to re-examine astronomical images within an interdisciplinary framework and here I shall outline a few of the leading examples in order to demonstrate how my study builds on and differs from what has gone before.

[80] Science and Technology Studies (STS) is a relatively new academic field which emerged between the end of World War 2 and the beginning of the Cold War. At this time scientists, historians and sociologists of science 'became interested in the relationship between scientific knowledge, technological systems, and society'. Harvard Kennedy School, "What is STS?" Program on Science, Technology & Society, accessed 15 March 2015, http://sts.hks.harvard.edu/about/whatissts.html.

Martin Kemp draws out themes recurring in the mechanical reproduction of images from science and art in *Seen Unseen: Art, Science and Intuition from Leonardo to the Hubble Telescope* (2006).[81] This is a broad study which refers to many forms of technological 'seeing' in order to explore invisible vision of two kinds: the micro and the macro.[82] Kemp pleads for the images of art and science to be seen alongside each other within their visual histories, suggesting that 'visual intuitions are one of the most potent tools we possess for feeling our way into the unknown'.[83] Pictures, he states, 'provide a highly effective way of communicating to non-specialist audiences'.[84] This thesis builds upon this importance; it is both specialist and non-specialist audiences that benefit from tools aimed at immersing the viewer virtually in Mars. James Elkins has also taken an interdisciplinary approach when writing about the relationship between art and science in *The Domain of Images* (1999) and *Six Stories from the End of Representation* (2008).[85] Offering various accounts on scientific 'non-art' images, Elkins' is concerned with objects that 'resist depiction', things invisible to the human eye that are represented through advanced technologies and the imagination.[86] Most

[81] The book is split into chapters concerning the Renaissance ("Journey into Space" – 'the rise of the naturalistic image'); Romanticism ("Lesser and Greater Worlds" – 'depictions of nature becoming increasingly concerned with dynamic interaction' and sublimity); classic modernism ("Discerning Designs" – 'hidden abstract forms and forces'); and our current age ("Out of Our Hands" – our ability to create varying types of images and ability to broadcast them). Kemp, 4.

[82] This includes analyses of medical photography, X-rays, sonar, radar, microscopic imaging, molecular modelling, mathematical drawings, and astronomical images. From the inception of Renaissance perspective and the theorems of Alberti, Brunelleschi and Leonardo through to telescopes, microscopes, camera obscuras, radar, photography and the *Hubble* telescope *Seen Unseen* is about the visual, how it is represented, and the issues of representing the invisible in relation to truth and belief.

[83] Kemp, 330.

[84] Ibid., 3.

[85] In *The Domain of Images* Elkins argues that fine art images make up a 'tiny minority' of the vast proportion of visual artefacts surrounding us and he calls for an examination of the 'domain of images' that remain 'disjoined from the principle histories of images in art'. Elkins, *The Domain of Images,* xi. Elkins is concerned with 'informational images' or 'non-art' images such as graphs, plans, patents, stamps, astronomical charts, technical drawings and symbols which are often seen as separate to the visual arts due to their 'lack of expressive power, the technical demands they make on viewers, and the absence of visual theories and critical apparatus'. Ibid., 6, 4, xi. These images, claims Elkins often 'seem like half-pictures, or hobbled versions of full pictures, bound by the necessity of performing some utilitarian function and therefore unable to mean more freely'. Ibid., 4. Holding such images in high esteem – as equal to paintings of the Renaissance – Elkins argues for these images as 'compelling, expressive, historically relevant, and theoretically engaging'. Ibid., ix. In *Six Stories from the End of Representation* examples are drawn from painting, photography, astronomy, microscopy, particle physics and quantum mechanics.

[86] James Elkins, *Six Stories from the End of Representation,* xv. Claiming that the links between art photography and astrophysics imagery remain purely formal, Elkins touches on the "pretty pictures" of *Hubble* only to disavow them. Marking these as 'hopped up versions of legitimate photographs, with the colours intensified or falsified', Elkins is critical of space agencies and astronomers' interests in images he feels are only good for calendar art and press releases. Ibid., 87. I had a similar experience on attending an "Astroimaging" conference at the Royal Astronomical Society: the conference focused predominantly on the construction of these 'pretty pictures' of distant galaxies,

recently, Elizabeth Kessler has placed the abstract nature of *Hubble* imagery within an art historical context; her 2012 book *Picturing the Cosmos: Hubble Space Telescope Images and the Astronomical Sublime* is concerned with the production and appearance of these images and the development of 'representational conventions and an aesthetic style'.[87] *Hubble* images, she argues, 'present the universe as one *might* see it'.[88] Building on the frameworks set out by Kemp, Elkins and Kessler, this thesis draws on defined examples from art history and a wealth of photographic theory to add to the discourse of what it means to see and know the invisible through representation, both in science and in art. However, in taking Mars as a central focus point, and by looking at immersive imaging devices, this project is more specific. Through the lens of art history and theorisation of the image this thesis re-examines how scientists are using images to explore Mars; thus it addresses the absence of art and science literature on Mars, and on more immersive imaging techniques used in scientific exploration.

This thesis does not function as a genealogy of Mars exploration.[89] Nor does it act as a 'history of the visual' to provide a parallel account of astronomical representation and Western perspective as seen in Kemp's *Seen Unseen*, Samuel Y. Edgerton's *The Mirror, The Window and the Telescope* or Michael Lynch and Edgerton's *Abstract Painting and Astronomical Image Processing.*[90] Instead I engage with a few contemporary examples of how Mars is

and I became frustrated by the lack of critical engagement with the processing tools being used to manipulate images for visual effect. Royal Astronomical Society, papers presented at "Astroimaging," London, 17-18 February 2014.

[87] Kessler, 4. Kessler's study in an interdisciplinary, multifaceted one drawing on the history of science, technology, philosophy and art history to discuss the *Hubble* images and also how late 20th century Americans saw their place in the universe.

[88] Ibid.

[89] More specific technological developments in space exploration can be found in: Robert Zimmerman's *The Universe in a Mirror;* Roger Launius and Howard McCurdy *Robots in Space;* Carl Sagan's *The Pale Blue Dot: A Vision of the Human Future in Space;* and Oran W. Nicks' *Far Travellers: The Exploring Machines.* A timeline of Mars exploration can be found in the Appendix to this thesis.

[90] The term 'histories of the visible' comes from Kemp, 7. In order to look at present-day images within their historical context, Kemp demonstrates that the 'current explosion of imagery' is not driven solely by computers, but is in part a 'visual revolution of the Renaissance'. Ibid., 2. In *The Mirror, the Window, and the Telescope,* Edgerton details the development of Renaissance perspective from Brunelleschi, the representation of religious beliefs and icons, through to Alberti's concept of the 'window' and how this affected Galileo's early visions of the moon. Samuel Y. Edgerton, *The Mirror, the Window, and the Telescope: How Linear Perspective Changed our Vision of the Universe* (New York: Cornell University Press, 2009). *Abstract Painting and Astronomical Image Processing* was written by Edgerton and Lynch in 1996 and published in a collection of essays titled *The Elusive Synthesis: Aesthetics and Science.* The essay charts the representation of the heavens from Galileo through to modern day astronomical techniques. It draws connections between these representations and those from art with regard to linear perspective and chiaroscuro. Lynch and Edgerton claim that works of art from the late 19th and early 20th centuries by Monet, Seurat, Klee and Kandinsky hold aesthetic ties to astronomical images in terms of a flattening of visual field, colour, texture and abstract form. Samuel Y. Edgerton and Michael Lynch, "Abstract Painting and Astronomical Image Processing,"

experienced, re-examining these in light of their origin within art, exploration and technological image making.

This thesis highlights the rover's cybernetic eye as simultaneously an extension of vision and barrier to truth. I argue that the rover's image of Mars is constructed in order to allow for a virtual experience of a virtual landscape that is millions of miles away, expanding on Kemp, Lynch, Kessler and Edgerton's concerns with mediation and the veracity of astronomical images.[91] Although my focus is Mars, the issues involved in depicting an object that is without its referent remain unchanged; debates surrounding image construction, false colouring and enhancement are prevalent throughout the discourse of digital image making, and are drawn out in Chapter 1 with reference to W.J.T. Mitchell, Lev Manovich, Ernst H. Gombrich, Martin Jay, Neil Allen and Joel Snyder.[92] Here I re-contextualise the images of Mars against the backdrop of photographic questions on mediation in order to demonstrate how the image of Mars is manipulated and constructed.

At face value, studies like Kessler's might seem of great relevance to a thesis concerned with the scientific image and its context within an art historical discourse. However, despite Kessler's interest in *Hubble* as a cybernetic eye, her study is predominantly based on aesthetic experience, formal analysis, and how these images represent the sublime.[93] As is clear from previous studies by Kemp, Elkins, Edgerton and Lynch, it is perhaps down to the abstract

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in *The Elusive Synthesis: Aesthetics and Science,* ed. Alfred Tauber, (Dordrecht: Springer, 1996), 103-124.

[91] Similar to Michael Lynch's definition of 'invisible vision' (as detailed earlier) Kemp is concerned with the representation of something that cannot be seen within the visible spectrum, and more predominantly, the artistic license required in producing scientific images. Kemp analyses the construction of scientific images within what he terms as 'The Persistent Box' to demonstrate how Renaissance perspectival ideals are prevalent within scientific representations. Here Kemp explores images of places that remain invisible, such as the bottom of the ocean (visualised using sonar) and the surface of Venus (visualised using radar) to consider if we are 'stuck with the old schemata, locked by visual inertia into old modes?' or if it is the power and efficiency of this system that prolongs its' use. Kemp, 55. Kemp states that the 'translation of its perceptions' into 'brilliant cosmic landscapes' requires 'a level of contrivance even greater than that of a traditional landscape painter'. Ibid., 242. Similarly, Kessler draws on W.J.T. Mitchell's "the visual turn" (our cultural fascination with images in a visually saturated world) to consider the cultural and social significance, whereby the 'crafting' of *Hubble* images often results in a certain ambivalence towards them:

> Because digital data are numeric, astronomers can intervene by modifying a single value, or pixel, or an entire data set. But they must also determine, given the impossibility of a perfect translation, the elusiveness of a perfect reflection of numeric data as visual representation, when to maintain indexical aspects and when to convey attributes symbolically.

Kessler, 127.

[92] These visual theorists consider the implications of perspective, scale, framing, and colour enhancement upon truth and belief in mechanised imaging. Kemp uses Elsie Wright and Frances Griffiths' fairies as an example of how photography was liable to falsehood, even in its most early stages.

[93] Kessler argues that *Hubble* images' formal qualities make them analogous with the paintings of Thomas Moran, Albert Bierstadt and the black and white photographs of William Henry Jackson, Ansel Adams and Timothy O'Sullivan.

nature of such images that one cannot go beyond an analysis of how the images are constructed, how they appear, and to what they might or might not pertain. Evan Snider for instance has claimed that this kind of scholarship concerned with aesthetics, awe and wonder often black-boxes these images.[94] This obsession with the sublime image of deep space, particularly in the media, is not one I wish to pursue; drawing this 'invisible vision' closer to home this thesis engages on a more critical and theoretical level with images of a place we need no astronomical or art historical background in order to engage with. Even if we cannot experience it first-hand, we can intuitively understand the Martian landscape because it holds strong similarities with places on Earth. Elkins discusses images that show objects on the very limits of visibility and my research differs from his, and from Kessler's in this regard. Although an analysis of *Hubble* images might prove fruitful for a discussion into truth and belief in relation to 'invisible vision', I fear it would lead into how these images are *produced* rather than how they are shown and *experienced* in order to *explore* a virtual landscape. Due to the aesthetic nature of Kessler's chosen images, they may readily be framed within an art historical context of abstract form, landscape painting and the sublime and by defining my study as one exploring the *virtual landscape* it goes beyond the perceived notion of a window as outlined by Edgerton. Drawing on historical spaces of illusion within art and through the discourse of image theory, this thesis places these immersive images within a wider visual context to render new questions regarding how we might experience and explore a terrain through indirect virtual presence.

'Seeing Like': Embodied Perception in Science and Technology Studies

There are a number of texts exploring issues of visualisation, cognition and how representation is being used to gather knowledge in scientific practice today. In the late 1970s and early 80s historians such as Martin Kemp, Samuel Edgerton, Svetlana Alpers and Martin Rudwick had started to establish that 'visual and graphic materials were crucial for enabling discovery and establishing properties' and not simply 'secondary to logical reasoning and

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[94] Snider's 2011 essay "The Eye of Hubble: Framing Astronomical Images" deals with the aesthetics and rhetoric of *Hubble* images as 'pretty pictures', framed within the context of coffee table books. Referencing Walter Benjamin and W.J.T. Mitchell, Snider outlines the problems arising from digital representations within the context of photography, claiming that *Hubble* images within the public sphere are 'desperately in need' of 'problematising'. Snider argues that outputs like these result in lay audiences misinterpreting the images as direct representations of visual realities. Drawing on Roland Barthes' *Image – Music – Text,* Snider claims that glossy anthologies of *Hubble* images serve to 'fix the denotations and connotations of a polysemous image' as they 'construct and perpetuate certain rhetorics, aesthetics and ideologies'. Evan Snider, "The Eye of Hubble: Framing Astronomical Images," *Frame: A Journal of Visual and Material Culture* 1, no. 1 (Spring 2011): 4-6, accessed 14 November 2013, http://framejournal.org/system/files/articles/evan-snider-frame-one.pdf.

mathematical reckoning in the sciences'.[95] In 1984 Bruno Latour organised a workshop titled "Visualisation and Cognition" which sought to propose that 'scientific imagination was a matter of "thinking with eyes and hands"'.[96] Latour preferred the term 'visualisation' over 'perception' and 'observation' because it 'connoted practices of *making visible'.* [97] Latour's emphasis on visualisation is especially important for this thesis as it presents images in a light that do not make claim to *visual* truth. Rather, these representational practices seek to present data in ways that draw out *scientific* truths. Writers exploring the use of images for embodied perception in science and technology studies (STS) include Latour, Kemp, Lynch, Lucy Suchman, Steve Woolgar, Anne Beaulieu, Lorraine Daston, William J. Clancey and Janet Vertesi and this is the third context within which my research is situated.

Ludwig Wittgenstein states that representation is 'very elastic', 'intimately connected' with 'what is seen'.[98] *Representation in Scientific Practice Revisited* (2014) is a recent study that draws together many of these leading figures in science and technology studies.[99] The book examines and elucidates 'the temporal and practical working and reworking of materials that (sometimes) culminate in the presentation and re-presentation of scientific facts, models, and ordered regularities'.[100] Although contributors to this field of study do not tend to analyse the scientific image through an art historical lens, their ideas surrounding the notion of 'making visible' are nevertheless of great importance to this thesis, and are expanded upon in Chapter 5. The purpose of *Representation in Scientific Practice Revisited* was to demonstrate that scientific images are reconstructed in ways that facilitate various forms of analysis.[101] Furthermore, it also takes into account today's landscape as one 'coloured by discussions of mediation,

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[95] Catelijne Coopmans, Michael Lynch, Janet Vertesi and Steve Woolgar, eds., *Representation in Scientific Practice Revisited* (Cambridge, MA: The MIT Press, 2014), vii.

[96] Ibid.

[97] Ibid.

[98] Ludwig Wittgenstein, *Philosophical Investigations,* trans. Gertrude E. M. Anscombe, 2nd ed. (Oxford: Basil Blackwell, 1958),169.

[99] The book is based on the 1990 version *Representation in Scientific Practice* and draws 'attention to the many ways in which words do more and other than refer, pictures do more and other than depict, and representations do more and other than correspond to objects and/or ideas'. Michael Lynch, "Representation in Formation," in Coopmans, Lynch, Vertesi and Woolgar, 325.

[100] Coopmans, Lynch, Vertesi and Woolgar, viii.

[101] Working with images in scientific practice is key to drawing out knowledge and understanding and the book demonstrates the many ways scientists are doing this. Examples analysed include: images of Mars *as* representations that reveal soil compositions; 'artful' representations of datasets; the functioning of a laboratory as in cognitive neuroscience for which representations act as '*materials for enactment'*; technological mediation in surgical practices; the material functions of paper and chalk in development of mathematical theory; the brain scan as an interface; the rendering of molecular models; nanotechnology images as "hybrid monsters" mixing representational conventions; hybridity in computational biology; and the problems Photoshop poses to scientific journal images. Ibid., 7.

ontology, enactment, materiality, and the discursive "performance" of images'.[102] As I have already outlined, this thesis contributes to the discussion around the mediation and reconstruction of images, and taking scientific images as the principal focus, it in turn contributes to this field of research on scientific representational practices. Each chapter provides a case study for the different ways scientists and engineers are using the form of the image to explore and experience Mars virtually; as stereoscopic imaging, panoramic visualisations, false colour and white-balanced images and Mars Yards are means of engaging with the 'materiality' of the image in order to 'enact' an experience of Mars, these particular notions predominating throughout *Representation in Scientific Practice Revisited* are key areas to build upon. However, unlike theorists working within science and technology studies, this thesis provides a more interdisciplinary approach.

Of particular note in this field is the work of Janet Vertesi, a sociologist of science and technology at Princeton University and William J. Clancey, a computer scientist specialising in cognitive sciences and artificial intelligence.[103] Both have written extensively on Mars exploration and the use of imaging to explore the planet's surface virtually. Broadly speaking, these authors are concerned with the sociological implications upon NASA's Mars Exploration Rover (MER) team members and how the scientists and engineers work collectively to 'become the rover' and make discoveries. Vertesi offers a critical examination of false colour images and her work on 'drawing as' (using image manipulation 'to pull or guide, to reveal or conceal,' and 'to work with and around material objects') will be of particular importance in Chapters 4 and 5.[104] Vertesi's research 'seeks to broaden our understanding of visualisation and embodiment' in the 'collective work of the laboratory': 'seeing like a rover' she claims is not just about learning how to interpret the images, but is also about the visualisation, talk, and gesture of the whole team on Earth in relation to the rover on Mars.[105] Clancey's book *Working on Mars: Voyages of Scientific Discovery with the Mars Exploration Rovers* does not engage with image data directly but focuses on how scientists, geologists and engineers are conducting 'field science' using the rover as a mobile

[102] Ibid., viii.

[103] Vertesi's PhD dissertation, from which many of the references in this thesis are taken, was published in 2015 by University of Chicago Press as *Seeing Like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars.*

[104] Janet Vertesi, "*Drawing as:* Distinctions and Disambiguation in Digital Images of Mars," in Coopmans, Lynch, Vertesi and Woolgar, 20.

[105] Janet Vertesi, "Seeing like a Rover: Visualisation, Embodiment, and Interaction on the Mars Exploration Rover Mission," *Social Studies of Science* 42, no. 3 (2012): 397, accessed 14 March 2014, http://dx.doi.org/10.1177/0306312712444645.

laboratory.[106] Thus his discussion is grounded in what it means to explore a landscape through an 'intermediary' device; his work is important for this study because it deals with the rover as a surrogate 'robotic geologist', referring indirectly to it as a cybernetic eye.[107]

Such studies are concerned with the image as *one* facet in scientific exploration; this opens up a space in which to conduct new research into how images are being used to acquire virtual experiences. The focus of my research is not the interactions between the team members and the rover, but is solely with the presentation of Mars in image form; specifically it is concerned with how immersive imaging techniques might enable scientists and lay audiences to step into the image of Mars.[108] By drawing rover imaging of Mars into an art historical framework concerned with the construction and re-presentation of images, this research expands ideas on the notion of working *with* images, as set out by Vertesi. Vertesi and Clancey both refer to scientists seeing themselves 'on Mars' through the body of the rover; 'We were all there, together, through a robot!'[109] By employing an art historical and theoretical standpoint concerned with the theorisation of the image in the digital age, I will contest this, arguing that it is only the image that may be stepped into, by which the rover acts both as an aiding mechanism and as a body that stands in the way of true immersion. I argue that manipulating and working with images affects not only our knowledge and

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[106] Clancey first discusses how scientists are exploring Mars virtually and how this is changing the practice of field science in a short essay titled "Becoming a Rover" in *Simulation and its Discontents,* edited by Sherry Turkle and published in 2009. The book *Working on Mars: Voyages of Scientific Discovery with the Mars Exploration Rovers* expands on ideas set out in the essay and focuses on the first 90 mission 'sols' (Martian days) of the MER rovers. Clancey defines the MER missions as collaborative enterprises and discusses the twin rovers against the historical backdrop of previous NASA missions such as *Viking*, *Surveyor*, *Sojourner* and *Pathfinder.* Clancey poses two main questions thrown up by this new form of rover exploration: 'how does working with a mobile, programmable laboratory change the nature of field science?' and 'how does being a member of the science team with a shared robotic intermediary change what it means to be a scientist?' Clancey, *Working on Mars*, x.

[107] Ibid., 7. There has been a body of literature concerned with robotic systems and virtual presence, with the notion of machines as surrogates and precursors to unknown worlds. Here, topics of 'presence' and 'agency' are important, allowing projection into the image of Mars. Key texts exploring computer visualisation systems for virtual reality include Nathaniel Durlach, Thomas Sheridan and Stephen Ellis' "Human Machine Interfaces for Teleoperators and Virtual Environments," Ken Golberg's *The Robot in the Garden: Telerobotics and Telepistemology in the Age of the Internet* and specifically for Mars, Clancey's *Working on Mars.* These are interesting examples of critical analysis on how knowledge is acquired at a distance, yet it is important to establish the difference between these notions of "virtual presence" or *telepresence*, and the concept of virtual reality I defined earlier. For Clancey, as for Goldberg, telepresence is 'the experience of being effective at a distance through a telerobot' as through 'mediated agency' scientists are able to 'become the rover' and 'do' field science. Ibid., 112. As I have explained, the meaning of the term virtual throughout this thesis is two-fold, encompassing spaces of illusion conjured up by the image, and landscapes that are not physically present. Thus, although scientists psychologically 'work remotely' the images allow for a virtual experience here on Earth. Ibid., 54.

[108] This project also focuses on the visions of NASA's *Curiosity* rover, as opposed to MER.

[109] Clancey, *Working on Mars,* 6.

understanding of the terrain, but the possibility for our embodied perception in it. Since W.J.T. Mitchell's 1992 *The Reconfigured Eye: Visual Truth in the Post-Photographic Era*, a wealth of theory has emerged that questions the truth of photographic and digital imaging techniques.[110] My thesis examines images of places we cannot see unaided; distance, the unknown and the impenetrable lie at the heart of these images which also act to control our perceptions. It is *through* the rover and not *as* the rover that we experience the image of Mars.

[110] Mitchell studied the context of digital images and how we use and understand them.

Chapter Outline

Chapter 1: "The Martian Landscape as Reconstructed" reviews key thinkers in an existing body of scholarship concerned with image authenticity in the digital age. Drawing on the writings of Walter Benjamin, Roland Barthes, W.J.T. Mitchell, Allan Sekula, Martha Rosler, Lev Manovich and E. H. Gombrich, this study utilises and extends historical and contemporary theories to engage critically with the images of Mars taken by the *Curiosity* rover. As technologically manufactured representations that capture unknown lands, the images of Mars demand a re-thinking of the indexical; as such, I question the veracity of post-photographic techniques as means of representing 'unseen' referents. In order to do so it is necessary to set up key questions surrounding photography's relationship to reality in the digital age. This study extends the wide recognition that images are liable to falsehood by specifically addressing the image as experienced within virtual reality devices. Virtual reality technologies attempt to immerse us in the image, to collapse real space into illusory space. Chapter 1 considers the image of Mars on its base level – when it is seen as a two-dimensional image – to question how the technology used to capture and process images affects our perception of a landscape we can see only through a device. This first chapter then outlines the problems associated with representing the invisible, asking; how can we trust an image of something when there is no referent? Is the landscape not reconstructed via these imaging devices?

In direct response to the first composite image taken by the *Curiosity* rover, Chapter 2: "*Curiosity's New Home*: Stepping through a Fractured Window" sets up key ideas on the glitch drawn from Jacques Lacan, Slavoj Žižek and Rosa Menkman. This concept of a glitch comes out of screen theory and from Chapter 1's notion of the digital image of Mars as reconstructed; through the presence of the glitch, the image as construction reveals itself, making us aware of the subjective nature of the act of looking. Here I propose that the composite image yields a fractured window, and it will be necessary to set up ideas on the frame, how it might be collapsed and how the presence of the glitch – with its varying manifestations – prevents Mars from being stepped into. A key question here is, does the glitch break the illusion, or does it reveal the real, the *image-as-image*?

Chapter 3: "Panoramic Visions: Mars as Image" takes as its case studies a full panoramic vision of Mars as seen in a 360° image space titled FutureFlight Central at NASA Ames Research Centre in California, and a 16 metre curved projection of Mars at Greenwich Maritime Museum's 2013 exhibition *Visions of the Universe.* In this chapter the Mars panoramas are considered in relation to the painted panoramas of the 18th and 19th centuries. The painted panorama represented both moments from history and unseen corners of the globe at a time before photography and this chapter draws similarities between the Mars rover and panorama painter; capturing and relaying pictorial information the rovers are our surrogate explorers, allowing us to travel to distant lands through the image. As such, this chapter considers the panorama as a virtual reconstruction of time and place, as an illusion which attempts to collapse and conceal the frame. Drawing on the writings of Maurice Merleau-Ponty with reference to media artist Maurice Benayoun's virtual reality installation *World Skin* and the painted *Panorama Mesdag* in The Hague, this chapter interrogates the Mars panorama's effectiveness in immersing the viewer in a frameless image. Can such an all-encompassing display 'entrap' (a phrase used by Oliver Grau) the viewer in Mars? Or does the glitch – manifesting itself in the frame and the viewer's body – uncover a certain failure to entrap, highlighting the intangibility of the unseen referent and the impenetrability of its reconstructed panoramic vision?

Chapter 4: "A Glimpse of Mars through Fragmented Illusion: The Materiality of the 3D Image" analyses the use of 3D imaging in Mars exploration and rover driving. 3D images reconstruct both vision and landscape in order to help scientists and engineers get closer to a feeling of 'being there' on Mars. This chapter outlines the history of stereoscopic imaging as a reconstruction of vision in order to explore how these images are perceived and received as three-dimensional reconstructions. The chapter specifically focuses on: the stereoscopic device which became hugely popular after the invention of photography in the mid 19th century; the anaglyph image of Mars which becomes '3D' through the donning of red/blue glasses; and the 3D visualisation of the Martian terrain in a mapping software used by NASA Mars rover drivers to plan traverses. Drawing on research at the Victoria and Albert Museum's photographic archive, the Regional Planetary Imaging Facility at UCL, and time spent with a rover driver at JPL, this chapter offers in depth subjective accounts as to what it is like to experience these images. As most 3D images of Mars are viewed on small scale computer screens, the sense of immersion in such images relies not on an all-encompassing illusion but on the viewer's active engagement; their ability to project themselves *imaginatively* into the space of the image. What kind of immersive space does this create for the viewer? Is it one of pure three-dimensionality? Or does it conjure forth a space that hovers between a penetrable illusion of landscape and the flatness of a screen? This chapter argues that despite endeavouring to reconstruct a sense of 'being there' on Mars, the space of the 3D image can only ever allow us to 'glimpse' Mars; the illusion is fractured by the glitch which manifests itself as colour, dust, void and veil, obscuring a partial reconstruction that is very much framed by the limits of technology. Gaining its own kind of materiality and presence that opens up new ways of seeing, the glitch in the 3D image is also something to be enamoured by.

Chapter 5: "Coloured Light upon the Surface: Glitch-as-Method" examines a three-part image of Mars that displays the 'raw' un-calibrated photographic data, the 'natural' calibrated version and finally a 'white-balanced' image which shows the landscape under Earth-like rather than Martian lighting. Taking the three-part image as a case study, this chapter considers the scientific practice of working with images to reveal chemical and geological compositions in relation to the perceptual studies on changing aspects of Ludwig Wittgenstein and Janet Vertesi. This chapter re-positions the three-part image of Mars within the context of Louis-Jacques-Mandé Daguerre's painted dioramas of the 19th century: these dioramas used the interplay of colour and light to manipulate the surface of the image to reveal scenes under different lighting conditions for dramatic effect. In Mars exploration colour balanced and false coloured images are used to reveal chemical compositions of rocks, or to make stratigraphic comparisons between geology on Mars and Earth. Presenting the different variations of the image side by side in this three-part image of Mars immediately makes us as viewers aware of the image's constructed and reconstructed nature; we can see first-hand the representational practice of working with images to reveal the invisible. Through the act of comparison between the three images subjectivity is made explicit as we become aware of our own, and others, acts of looking. In fracturing the relationship between what might be seen on Mars (what the camera records) and what is seen in the image (after colour balancing has taken place) a glitch occurs between vision and representation. But disrupting a 'true' perception of what the landscape looks like enables us to 'see' Mars differently. Can the glitch in this case be seen as a method towards another kind of visibility which is connected to knowledge and understanding in relation to what we know of Earth? In the desire to bring the vision of the Martian rover into our earthly grasp, is the glitch a productive method of becoming immersed in the virtual landscape-as-image?

Chapter 6: "Staging and Re-staging Mars: The Mars Yard" returns to the image of *Curiosity's New Home* in order to consider the physical reconstruction of Mars in the Mars Yard as an image without a referent. This chapter likens *Curiosity's New Home* to the museum dioramas at the American Museum of Natural History and as photographed by artist Hiroshi Sugimoto to propose the Mars Yard as a similar space of simulation which combines object and image. Whereas in the panorama, the 3D image and the false coloured image the representation exists behind some kind of screen, the *image* of Mars is physically reconstructed in the Mars Yard. This chapter highlights primary research at the Jet

Propulsion Laboratory's Mars Yard and the Roverscape at NASA Ames Research Centre but takes as its main case study the indoor Mars Yard being used to test the European Space Agency's 2020 *ExoMars* rover. It is this Mars Yard's use of panoramic image along with rocks and sand that enables us to see it as a space of illusion. Drawing on Jean Baudrillard's simulation theory and Christopher Stewart's writing on military test sites as spaces of 'rehearsal', the Mars Yard may be seen as a space of simulation; a staging and re-staging of a landscape that is without a referent. In this chapter I argue that the Mars Yard is an immersive testing space for the rover, but it is the rover – having Paul Virilio's 'machine vision' – that reveals the glitch: unlike the human visitor to the space who has the ability to imaginatively suspend their disbelief, the rover 'sees' the panoramic image as it is: a flat wall. Revisiting the photographic works of Sugimoto and looking at the artwork of Debby Lauder the latter part of this chapter explores the ability of the photographic lens to create a feeling of proximity. Drawing on the ideas laid out in both artists' practices, and further definitions of the 'glitch' as a 'slippery area' and productive process that enables us to question what a photograph is and can be (ideas proposed by Edward Dimsdale and Simon O'Sullivan), the chapter concludes with a series of photographs. These photographs were captured during my research visit to the Mars Yard and in this instance take the place of the speculative writing. Here photography becomes the speculative act, performing an immersive encounter, allowing me to 'step' into the image of Mars.

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Chapter 1
The Martian Landscape as Reconstructed

> The question at hand is the danger posed to *truth* by computer-manipulated photographic imagery. How do we approach this question in a period in which the veracity of even the *straight*, un-manipulated photograph has been under attack for a couple of decades?[1]
>
> Martha Rosler, 1991.

The advent of digital imaging has simplified the editing and reproduction of photographs, bringing about a faltering relationship between what is represented, and what is regarded as real by the viewer. In this post-photographic age, images are no longer physical entities and instead exist as numbers and codes, materialising as an arrangement of pixels behind screen.[2] In *Working on Mars,* William J. Clancey quotes Dr R. Aileen Yingst, a Senior Research Scientist at the Planetary Science Institute, on processing the Panoramic Camera's images taken by Mars Exploration Rovers:

> It's a very complex camera that gives you back information in ones and zeroes, instead of an image you can immediately understand. A PanCam image, once it's downloaded – once it's been sent back to us by the spacecraft – has to be looked over and calibrated. You have to know what you're looking at. And then various versions of those images have to be released in formats that computer software can read and understand. That's a lot of background information to digest before you get to a picture of a rock, which is what you're trying to get to.[3]

Understanding these images goes beyond surface appearances and happens at a deeper level that is both computational and human centred. The visual data is subject to varying degrees of alterations, in order to create an image that can be read by both scientists and machines.

Virtual reality technologies attempt to immerse us in the image, to break down the barrier between real and imaginary space. The images used in such immersive spaces are captured and exist primarily as two-dimensional renditions on screen or on a page. On a

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[1] Martha Rosler, "Image Simulations, Computer Manipulations: Some Considerations," *Digital Dialogues, Photography in the Age of Cyberspace* 2, no. 2 (1991): 52.

[2] The term post-photographic is marked by a shift from analogue to digital, from the chemical reaction of light upon a negative to the compression of the visual into pixels. A digital image differs profoundly from an analogue photograph in that it is post-chemical. W.J.T. Mitchell outlines the differences between analogue and digital imaging in *The Reconfigured Eye: Visual Truth in the Post-Photographic Era* where he defines post-photographic images as representations that may be reproduced and transmitted an infinite number of times without degradation. Post-photographic images need not necessarily be made up of representations of the real world; they may include composites, renderings, and digitally painted marks. William J. T. Mitchell, *The Reconfigured Eye: Visual Truth in the Post Photographic Era* (Cambridge, MA: The MIT Press, 1992). Early developments of digital imaging coincided with space exploration in the 1960s; 'new devices were invented for capturing, storing, transmitting, and displaying digital images' and by 1964, NASA could use image processing techniques to clean up images sent back by the *Ranger 7* spacecraft on the moon. Ibid., 10. All images of Mars are 'post-photographic'; unlike the moon landings – whereby *Apollo* astronauts could return their negatives to Earth for processing – *Curiosity* beams back electronic data via radio signals. Although the translation of form into image requires the presence of light, no chemical procedure takes place.

[3] Dr R. Aileen Yingst quoted in William J. Clancey, *Working on Mars: Voyages of Scientific Discovery with the Mars Exploration Rovers* (Cambridge, MA: The MIT Press, 2012), 94.

more basic level then, how does the technology used to capture images of Mars affect our perception of a landscape that can *only* be perceived through a device? This is the principal question of this chapter.

The truth, veracity and transparency of the photograph have been in question since photography's invention in 1839, but these discussions were initially limited to a few intellectuals.[4] In the 1970s and 80s, critical theory surrounding the photographic image reached its peak with theorists like Roland Barthes, Jean Baudrillard, Martha Rosler and Allan Sekula challenging every aspect of what we think we know about all types of images.[5] Today it is well known that manipulation of digital images can occur with the tap or swipe of a finger.[6] The image is a malleable entity and as such is inherently suspect. Images are the principal means by which we experience Mars on a day to day basis; the question of how technological devices affect our perception of a distant landscape then, is indebted to the critical framework that has long surrounded the photographic and digital image.

Postcards from Mars was written by the Panoramic Camera's lead investigator for *Spirit* and *Opportunity,* Jim Bell. The book explores the difference between 'acquiring images' and 'taking photographs' of Mars. The Mars Exploration Rovers, according to Bell, provided scientists and visual imagers the first opportunity to consider the aesthetics of the images they captured. Bell states that 'the relation to reality is a particularly strange one for this project'; these representations are not 'abstract' but they do not represent 'a reality that any human has quite witnessed yet, either'.[7] We do not have anything to compare these images with, other than landscapes on Earth, and as such we are without Roland Barthes' 'referent'.[8] Barthes states that the photograph 'always carries the referent within itself', it is a trace of the moment it represents; indexically linked to its subject it points to the object, signifying its presence in some past moment.[9] Mars is just over 225 million kilometres (140 million miles)

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[4] Charles Baudelaire, for instance, criticised photography as a non-art form.

[5] Artist and writer Allan Sekula spoke of photography as 'the generator of a duplicate world of fetishised appearances, independent of human practice' whilst Barthes wrote that a photograph 'repeats what could never be repeated existentially'. Allan Sekula, "On the Invention of Photographic Meaning," in *Thinking Photography*, ed. Victor Burgin, 2nd ed. (London: Macmillan Press Ltd., 1982), 139; Roland Barthes, *Camera Lucida: Reflections on Photography*, trans. Richard Howard (1981; repr., London: Vintage, 2000), 4.

[6] Images are manipulated even without human interaction; auto settings within image capturing devices produce images that *translate* the thing they represent.

[7] Jim Bell, *Postcards from Mars: The First Photographer on the Red Planet* (New York: Penguin Publishing Group, 2006), 3.

[8] This is the main reason for images being manipulated to produce 'white-balanced' images, to give a sense of what these landscapes would look like under Earth-like lighting. This will be expanded in Chapter 5.

[9] Barthes, *Camera Lucida,* 5. Barthes was referring to the un-manipulated analogue photograph:

> It is often said that it was painters who invented Photography (by bequeathing it their framing, the Albertian perspective, and the optic of the *camera obscura*). I say; no, it was the

away, and data can take between 4 and 20 minutes to reach Earth.[10] As technologically manufactured representations that capture and translate unknown lands, the images of Mars demand a re-thinking of the indexical. In opposition to microscopic cellular imaging that reveals the proximal but invisible structures of our bodies, *Curiosity* offers us a vision of something distant but in a manner, some may argue, that is analogous with perception: a 'window' on a world.[11] But we are not there behind the viewfinder to compose the image before releasing the shutter, nor are we able to compare the image with reality once we've tapped the capture button on our smartphone. We are not, therefore, able to verify first-hand the referent these images signify. Although the cameras on *Curiosity* were developed to give the best possible images, how can we truly *know* this is what Mars looks like?

This chapter foregrounds the constructed nature of photographic and post-photographic technologies as a means of representing 'unseen' referents by looking at the critical and historical debates surrounding mechanical objectivity. The digital image has been subject to much criticism, so when the image before us claims to truthfully represent something as intangible as Mars, these types of images call for further interrogation. Through a series of sections that explore the image as a transparent window, as trace, as fragment, as re-presentation and reconstruction, key theories will be used to address contemporary scientific images of Mars. I shall do so by first outlining the principal technologies on board *Curiosity* and proceed by unpicking a series of examples to forge links between critical image theory and scientific representation.

The landscape of Mars is invisible to us here on Earth; firstly, we see through *Curiosity's* cybernetic eyes, and secondly image manipulation can be used to reveal features which

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> chemists. For the *noeme* 'That-has-been' was possible only on the day when a scientific circumstance (the discovery that silver halogens were sensitive to light) made it possible to recover and print directly the luminous rays emitted by a variously lighted object. The photograph is literally an emanation of the referent. From a real body, which was there, proceed radiations which ultimately touch me, who am here.

Barthes, *Camera Lucida,* 80-81. Photographs were thought of as direct and physical translations of a scene into image, comparable – according to Martin Jay – with rubbings:

> Techniques like frottage and fumage generated whatever meaning they did by a combination of indexical signification, produced by physical residue of their material source, and the pattern "discovered" in them by their viewers.

Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth-Century French Thought* (Berkeley: University of California Press, 1994), 248-49. It is precisely because a photograph is inextricably linked to a fraction of a second in time, it signifies a moment in the past. The object's presence in the here and now is thus brought into question.

[10] The time it takes signals to reach Mars depends largely on the position of Mars in relation to Earth with the minimum time delay being 4 minutes, the absolute maximum being 24 minutes.

[11] In *Camera Lucida* Barthes describes the camera as 'a sort of umbilical cord' which 'links the body of the photographed thing to my gaze: light, though impalpable, is here a carnal medium, a skin I share with anyone who has been photographed'. Barthes, *Camera Lucida,* 81.

would otherwise remain invisible to the naked eye. These are images *at work* whereby data is manipulated on a day to day basis and re-presented in different forms. Furthermore, virtually immersive images attempt to reconstruct for the viewer an experience which would otherwise be impossible here on Earth. This chapter will expand upon the theories that have acted as a springboard to the notions of 'invisible vision' and 'cybernetic eye' outlined in the introduction to propose that the scientific image is not only a re-presentation of Mars, but a reconstruction of it.

I posed two questions in the introduction; how do contemporary imaging devices affect our perception of Mars? What are the problems raised by representations of a reality we are unable to physically experience and see for ourselves? In this chapter I will substantiate how and why *Curiosity* enables *and* mediates our experience of the landscape. Subsequent chapters will explore the recapitulation of these images as virtually immersive entities; attempting to collapse the frame of the two-dimensional window, they take the notion of reconstruction to a new level.

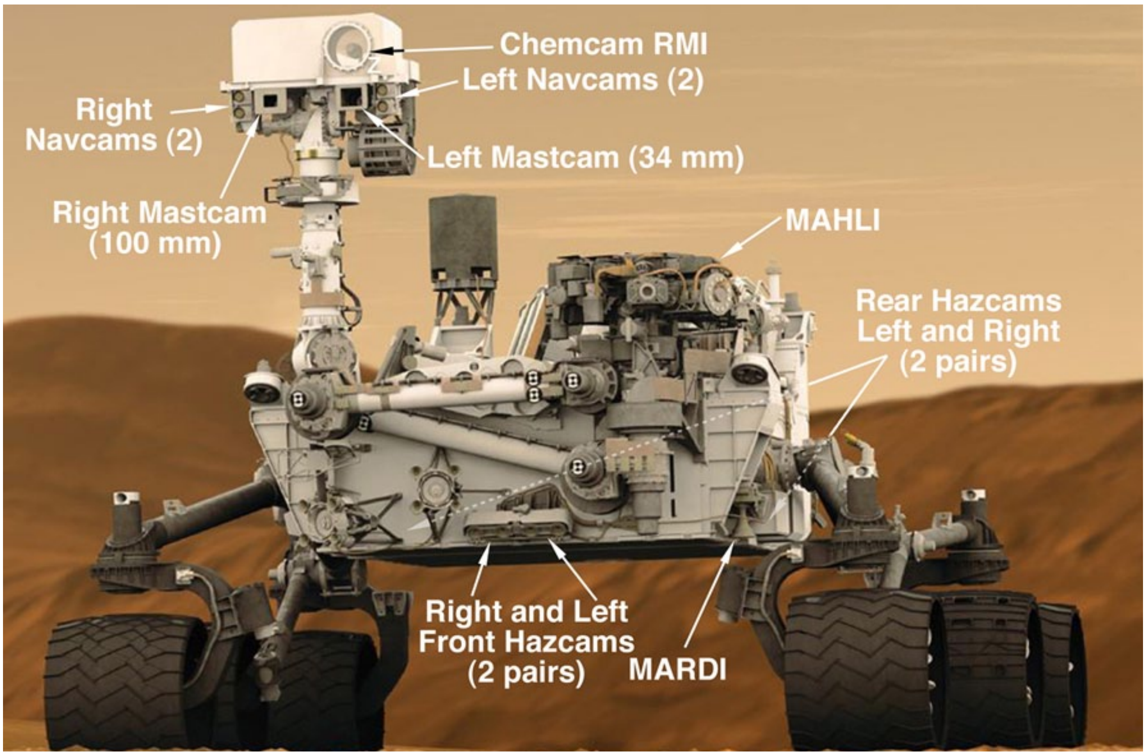

Figure 1.1. *Seventeen Cameras on Curiosity,* graphic showing the position of each of the rover's cameras. Credit: NASA/JPL-Caltech.

Figure 1.2. *Curiosity's Sky Crane Manoeuver,* artist's concept, 3 October 2011. Credit: NASA/JPL-Caltech.

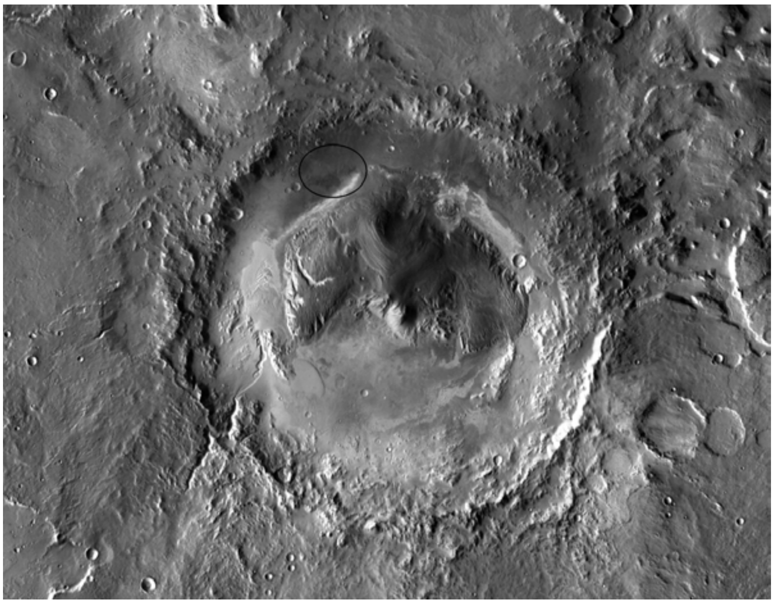

Figure 1.3. *Gale Crater.* Credit: NASA/JPL-Caltech.

Curiosity's Vision

Curiosity launched on 6 November 2011 from Cape Canaveral, Florida. After travelling 567 million kilometres over 253 days and at about 131 kilometres above the surface, *Curiosity* began its descent into the Martian atmosphere.[12] The twin Mars Exploration Rovers *Spirit* and *Opportunity* were light enough to be encased in inflatable airbags that were lowered to the surface on a parachute and then allowed to bounce until coming to a standstill. *Curiosity* on the other hand is the size of a small car, weighing 900 kilos. The airbag system was not an option, and engineers devised what became known as the 'sky crane' manoeuvre; the first soft landing technique ever attempted on Mars.

After parachutes slowed the vehicle to nearly zero velocity, a rocket powered descent

[12] NASA/Jet Propulsion Laboratory, "Curiosity's Sky Crane Manoeuvre, Artist's Concept," Mars Science Laboratory Curiosity Rover, 3 October 2011, accessed 11 August 2015, http://mars.nasa.gov/msl/multimedia/images/?ImageID=3650.

stage fired its thrusters to hover above the surface, allowing the upright rover to be lowered on a 7.5 metre tether. Once the rover's landing was complete, the descent stage blasted away to a crash landing, a safe distance from *Curiosity.*[13] This system of descent allowed for greater precision: *Curiosity* landed in the middle of the 154-kilometre-wide Gale Crater on 6 August 2012.[14]

The site was chosen because images from orbit suggested this area was once a vast lake; unlike other impact craters, Gale has a mountain of layered materials at the centre, a feature often formed by liquid depositing sediments over time. 'The record of the planet's climate and geology is essentially "written in the rocks and soil" – in their formation, structure, and chemical composition' explains NASA. *Curiosity's* instruments are designed to study these rocks and soils and detect the 'chemical building blocks of life' such as carbon, in order to assess the history of the Martian environment.[15]

Curiosity was designed to drive up to 20 kilometres across the Martian surface and the mission was initially planned to last for two Earth years.[16] Like *Spirit* and *Opportunity*, *Curiosity* has exceeded its expectations. Carrying with it advanced technologies developed and operated by over 400 scientists around the world, it is 10 times as massive as previous Mars rovers. Unlike previous missions, *Curiosity* has the facilities to gather and process samples of rock and soil, testing them in its on board laboratory with analytical instruments.[17] More importantly for this thesis, *Curiosity* is equipped with a series of cameras designed for

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[13] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: Skycrane," Mars Science Laboratory Curiosity Rover, accessed 11 August 2015, http://mars.nasa.gov/msl/mission/technology/insituexploration/edl/skycrane/.

[14] *Curiosity* landed within a 20 kilometre elliptical radius of its target. NASA Jet Propulsion Laboratory, "Curiosity's Sky Crane Manoeuvre, Artist's Concept."

[15] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: Overview," Mars Science Laboratory Curiosity Rover, accessed 11 August 2015, http://mars.nasa.gov/msl/mission/overview/.

[16] At the time of writing (March 2017) *Curiosity* has been operational for over 4 ½ years and has driven over 15 kilometres.

[17] Science instruments include: The Chemistry and Mineralogy X-ray Diffraction (ChemMin), an instrument which detects minerals by firing a beam of X-rays through powdered rock, allowing scientists to identify crystalline structures of rocks. The Sample Analysis at Mars Instrument Suite (SAM) searches for elements that are associated with life. The Radiation Assessment Detector is preparing for human exploration, helping scientists understand the effects of radiation on the surface. The Dynamic Albedo of Neutrons provides ground measurements for the detection of neutron emissions that escape as cosmic rays from space; this is one way of detecting hydrogen. The Environmental Monitoring Station reports on atmospheric and weather conditions such as pressure, humidity, temperature, wind speed, UV radiation and humidity. The Alpha Particle X-ray Spectrometer (APXS) measures chemicals in rocks and soils. More information on these science instruments can be found on the Technology page of NASA/JPL's Mars Science Laboratory Mission website. NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: In-Situ Instrumentation," Mars Science Laboratory Curiosity Rover, accessed 11 August 2015, http://mars.nasa.gov/msl/mission/technology/scienceinstruments/insituinst/.

different purposes. There are seventeen individual cameras in total on board the rover; twelve engineering cameras, four science cameras and the Mars Descent Imager (MARDI), all designed to work in sub-zero temperatures.[18]

Figure 1.4. Downlink processing for *Curiosity* comes in on the 4th floor of this building at the Jet Propulsion Laboratory in Pasadena, California. The command sequences for the rover are built on the 6th floor. Photograph taken on 2 November 2015 by author, courtesy of JPL-Caltech.

John R. Wright, a Mars rover driver working for JPL explains that capturing images isn't just a case of 'point and shoot'. Because it can take up to 20 minutes for a signal to reach Mars, the rover receives science and engineering activities on a day to day basis. Capturing images has to be built into the rover's daily command sequence along with driving activities, arm activities and other scientific experiments. These command sequences are simulated virtually before being sent up to the rover, it carries them out, and then the data comes down at the end of the day to be analysed. This data is used to plan the following day's experiments and/or drives, and the process is repeated.[19]

The image data comes down to the Multi-Mission Image Processing Laboratory, for which Bob Deen is one of the technical leads:

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[18] NASA, "Seventeen Cameras on Curiosity," 1 August 2013, accessed 10 August 2015, https://www.nasa.gov/mission_pages/msl/multimedia/malin-4.html#.WDL1qTKcZBx.

[19] John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 2 November 2015.

> We provide the data that the Mars rover drivers use. We do the image processing and terrain analysis, that's what the scientists use to figure out what's around and which targets they want to select.[20]

All data processing happens on the ground; the data comes down and is put through a series of automatic processing pipelines, with algorithms written by Deen and his team, that transfer the ones and zeroes into images. These images aren't just pictures; each is encoded with metadata logging the instrument, time, sol, camera model and geometry of the camera. All this information is what makes it a scientifically useful image rather than just a 'pretty picture'.[21]

Built using the same design as those on *Spirit* and *Opportunity*, the engineering cameras provide the first views of new terrain and are used to 'assess the traversability of the near-field terrain surrounding the rover'.[22] The images captured by these twelve cameras are used to 'characterise rover position and orientation relative to the surrounding terrain', and although providing no direct science objectives, they provide contextual support, allowing for science experiments with other instruments to be carried out and for rover traverses to be planned.[23]

The engineering cameras are all monochromatic and include four pairs of near range Hazard Avoidance Cameras (HazCams) which are mounted lower down at the front and rear of the rover, and two pairs of mid-range Navigation Cameras, mounted on *Curiosity's* Remote Sensing Mast, or 'head'.[24] These sets 'share the identical electronics design and spacecraft interfaces', the detectors being 1024x1024 pixel CCDs.[25] The HazCams use visible

[20] Bob Deen (Principal Software Developer at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2015. MIPL is different from the public outreach image division, and the Digital Imaging Animation Laboratory. John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2015.

[21] Ibid.

[22] Justin Maki et al., "The Mars Science Laboratory Engineering Cameras," *Space Science Review* 170 (September 2012): 2. Accessed 13 October 2015. http://dx.doi.org/10.1007/s11214-012-9882-4.

[23] Ibid. How rovers are driven across the surface of Mars will be explored in greater detail in Chapter 4.

[24] *Curiosity* has two completely independent on-board computers which are connected to each pair of the stereo NavCams, labelled A and B. There was no backup computer on MER, and the additional computer on *Curiosity* was added as a precaution in case one failed. This did in fact happen, and so it is only the B NavCam pair that is used. Wright, interview, 2 November 2015.

[25] Doug Alexander et al., "Camera & LIBS Experiment Data Record RDR Data Products," *Mars Science Laboratory (MSL) Software Interface Specification* (15 April 2015): 6, accessed 2 September 2015, http://pds-imaging.jpl.nasa.gov/data/msl/MSLNAV_0XXX/DOCUMENT/MSL_CAMERA_SIS_latest.PDF. James Janesick and Tom Elliott explain the process of CCD imaging:

> Imagine an array of buckets covering a field. After a rainstorm, the buckets are sent by conveyor belts to a metering station where the amount of water in each bucket is measured. Then a computer would take these data and display a picture of how much rain fell on each

light to capture black and white stereo imagery, helping to prevent the rover getting lost or colliding with obstacles. Mounted directly to the body of the rover, these cameras cannot move independently, and are equipped with a 120º field of view, otherwise known as a fisheye lens. The Front HazCams have a stereo-baseline of 16.6cm and are located 0.68cm off the ground whilst the Rear HazCams have a 10cm stereo baseline and are located at 0.78cm off the ground.[26] The rover moves forwards in short steps (nominally 35cm) and acquires HazCam images at each step, evaluating the terrain ahead.[27] It does this by using its stereo capability to map out the shape of the terrain up to 3 metres in front of it, producing a 3D "wedge" shaped simulation model that is over 4 meters wide at the farthest distance.[28] The stereo HazCam pairs 'provide the inputs to a real-time geometric model of the terrain conditions in the forward and aft directions of the rover', and the software on-board weighs up the risks of moving forward, ensuring the rover makes 'safe' decisions.[29]

Figures 1.5 and 1.6 (pg. 68) titled *Curiosity's View from Below,* and *A View from Below the Rover Deck* were captured after landing before the rover 'stretched out' its wheels into a forward position.[30] Both are cylindrical projection images; 'the simplest way to imagine a cylinder projection' states NASA,

> is to think of an image that has been wrapped around a cylinder and then flattened out. When the HazCam image is projected in this way, it creates the impression that the viewer is sitting underneath the rover and slightly behind the cameras.[31]

> part of the field. In a CCD system the 'raindrops' are the photons, the 'buckets' the pixels, the 'conveyor belts' the CCD shift registers and the 'metering station' an on-chip amplifier.

James Janesick and Tom Elliot quoted in Lisa Rebecca Messeri, "Placing Outer Space: An Earthly Ethnography of Other Worlds" (PhD diss., MIT, 2011), 25, accessed 21 August 2015, http://dspace.mit.edu/handle/1721.1/69451.

[26] Maki et al., "The Mars Science Laboratory Engineering Cameras," 9. Stereo-baseline means the distance between each camera. The further apart the cameras are, the more three-dimensional data may be acquired from the scene. Chapter 4 will explore stereo-imaging in more detail.

[27] Justin Maki, et. al., "Mars Exploration Rover Engineering Cameras," *Journal of Geophysical Research* 108, no. E12 8071 (2003): 17, accessed 13 October 2015, http://dx.doi.org/10.1029/2003JE002077.

[28] NASA/Jet Propulsion Laboratory, "Eyes and Other Senses," Mars Science Laboratory Curiosity Rover, accessed 5 October 2014, http://mars.jpl.nasa.gov/msl/mission/rover/eyesandother/.

[29] Maki et al., "Mars Exploration Rover Engineering Cameras," 16.

[30] NASA/Jet Propulsion Laboratory, "PIA16061: A View from Below the Rover Deck," Photojournal, 17 August 2012, accessed 6 August 2015, http://photojournal.jpl.nasa.gov/catalog/PIA16061.

[31] NASA/Jet Propulsion Laboratory, "PIA16060: Curiosity's View from Below," Photojournal, 17 August 2012, accessed 30 October 2014, http://photojournal.jpl.nasa.gov/catalog/PIA16060. NASA explains:

> Scientists create a cylindrical projection by remapping each pixel from the original image onto a cylinder. From the rover's reference frame, each pixel is assigned an elevation (an angle measured from the horizon) and an azimuth (a compass angle expressed in degrees, which represents direction, such as north = 0º, east=90º, south=180º, and west = 270º). Pixels in the same row of this image are at the same elevation, and pixels in the same column of this image are at the same azimuth.

The HazCams are also used to assess scientific experiments such as drill sampling (see fig. 1.7, pg. 68).

The two pairs of Navigation Cameras on *Curiosity's* mast gather 45° black and white fields of view (such as those seen in figs. 1.8 & 1.9, pg. 69) to produce stereo-images that work in cooperation with the HazCams. The NavCams have a stereo baseline of 42.4cm, enabling accurate modelling of terrain that is further away.[32] Combined, these sets of cameras provide corresponding images of the terrain, allowing team members on Earth to plan possible traverses.[33] John R. Wright explains the process of taking scientific images or larger panoramas from several frames:

> Say we are planning on driving to here, and then tomorrow we are planning on driving in this direction. So we would say we need a drive direction mosaic pointing in this direction […] we would tell the engineering camera operators that this information is needed, and if there is extra time, panoramas are taken based on NavCam images.[34]

The NavCam's engineering cameras enable scientists to plan scientific investigations with the science instruments and cameras on an accurate scale because of stereo-analysis; using images taken by stereo cameras, software on the ground automatically builds a 3D model of the space, enabling engineers to accurately hit the correct target. The laser for instance can accurately shoot a line down a drill hole from about 2 metres away.[35]

The four science cameras include the Mars Hand Lens Imager (MAHLI), the Chemical Camera, and the pair of Mast Cameras. MAHLI is a focusable colour camera located on *Curiosity's* arm (which is stowed in the graphic in fig. 1.1, pg. 61) and takes extreme close up pictures, revealing details smaller than the width of a human hair (see fig. 1.10, pg. 69). This instrument captures images up to 1600x1200 pixels with colour quality 'equivalent to that of consumer digital cameras'.[36] It can also focus on hard to reach objects, more than an arm's length away and is able to identify minerals in rocks.[37] Likened to the hand lens carried around a geologist's neck, MAHLI reveals the invisible.[38]

NASA/Jet Propulsion Laboratory, "PIA16060: Curiosity's View from Below."

[32] NavCams on MER had a stereo baseline of 20cm. Maki et al., "The Mars Science Laboratory Engineering Cameras," 12.

[33] NASA/Jet Propulsion Laboratory, "Eyes and Other Senses."

[34] Wright, interview, 3 November 2015.

[35] Deen, interview.

[36] Alexander et al., 19.

[37] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity Fact Sheet," accessed 5 October 2014, http://www.jpl.nasa.gov/news/fact_sheets/mars-science-laboratory.pdf.

[38] NASA/Jet Propulsion Laboratory, "Mars Hand Lens Imager (MAHLI)," Mars Science Laboratory Curiosity, accessed 24 Mach 2015, http://mars.nasa.gov/msl/mission/instruments/cameras/mahli/.

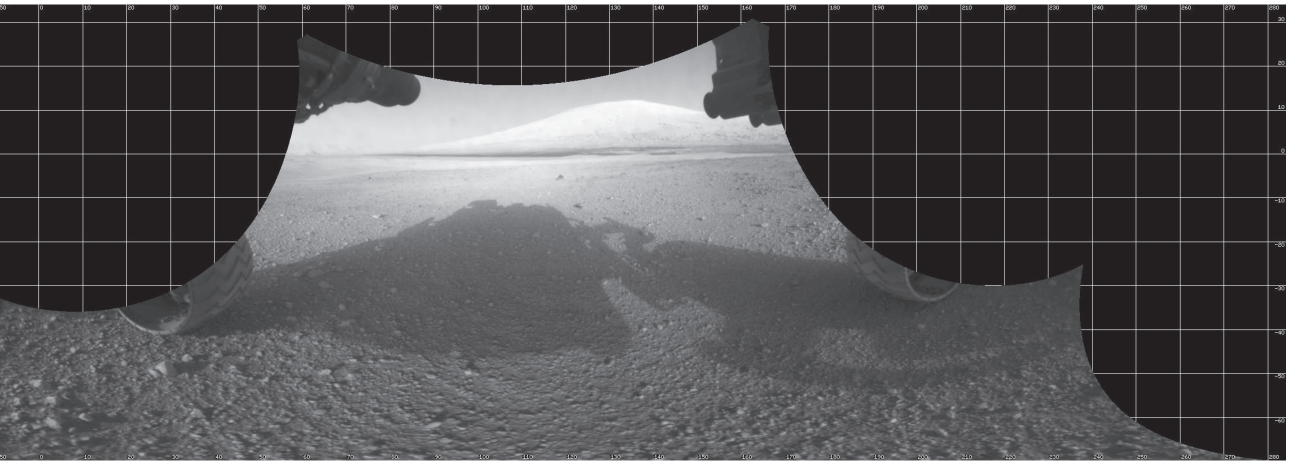

Figure 1.5. *Curiosity's View from Below,* taken by the front HazCams, 17 August 2012. Credit: NASA/JPL-Caltech.

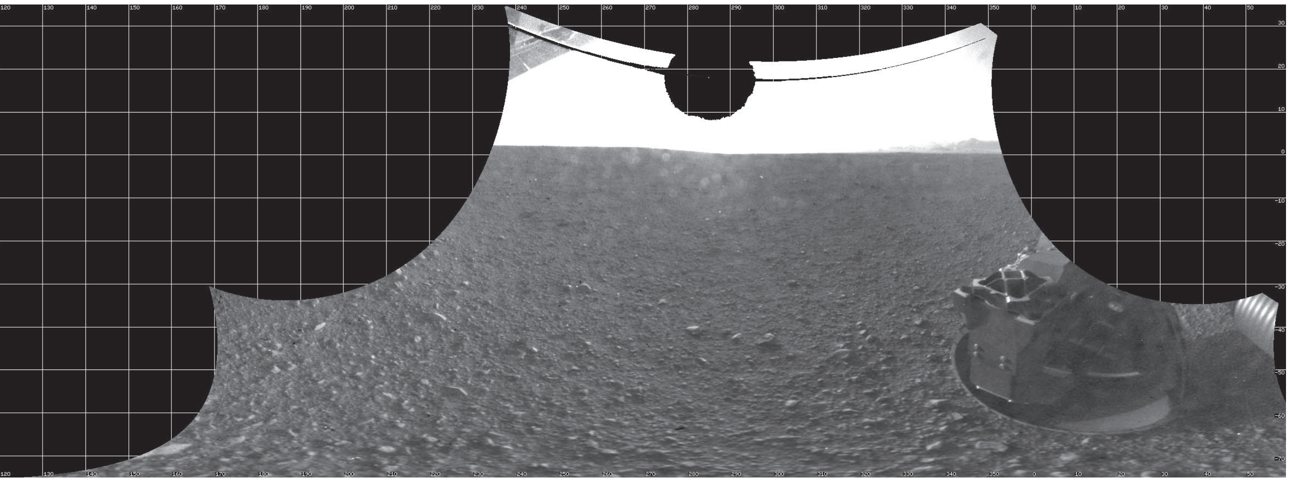

Figure 1.6. *A View from Below the Rover Deck,* taken by the rear HazCams, 17 August 2012. Credit: NASA/JPL-Caltech.

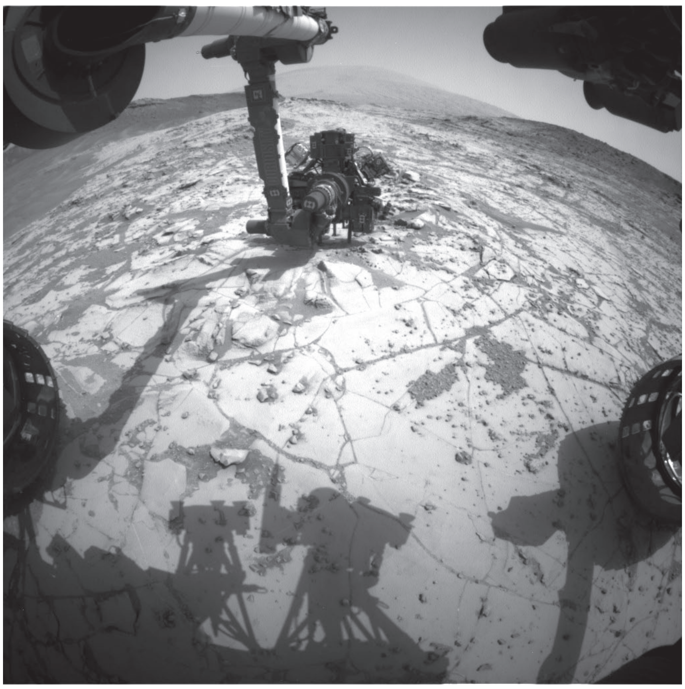

Figure 1.7. *Curiosity Conducting Mini-Drill Test at 'Mojave.'* A wide angle view taken by *Curiosity's* front HazCam showing the rover's drill in position for a mini test drill on 13 January 2013. Photojournal image addition date: 14 January 2013. Credit: NASA/JPL-Caltech.

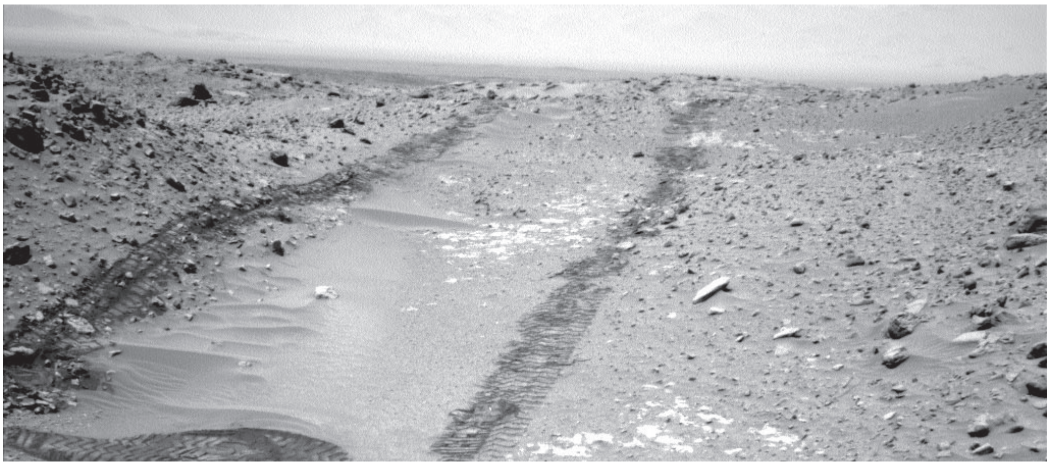

Figure 1.8. *Looking Up the Ramp Holding 'Bonanza King' on Mars,* taken by *Curiosity's* NavCam on 4 August 2014. Photojournal image addition date: 15 August 2014. Credit: NASA/JPL-Caltech.

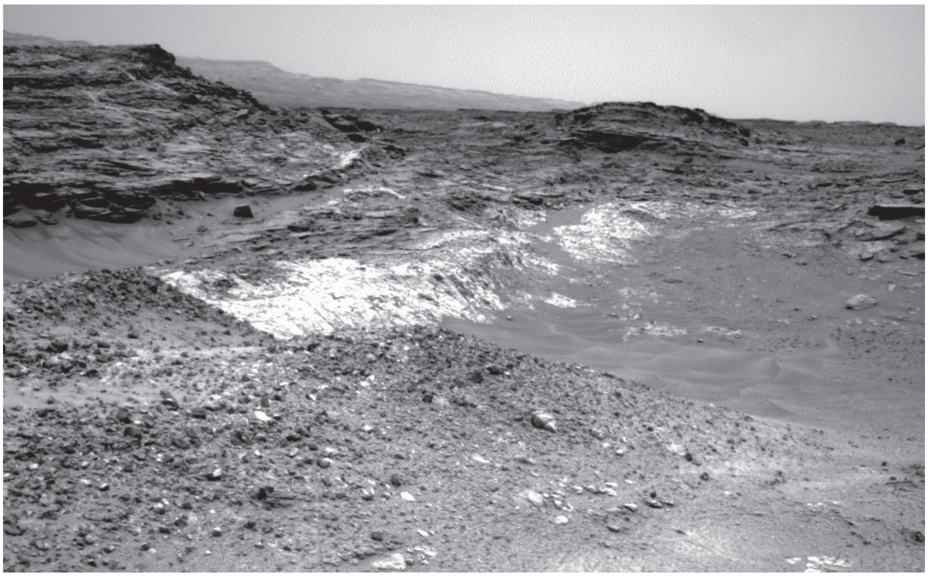

Figure 1.9. *Rover's Reward for Climbing: Exposed Geological Contact,* taken by *Curiosity's* NavCam on 21 May 2015. Photojournal image addition date: 22 May 2015. Credit: NASA/JPL-Caltech.

Figure 1.10. *High-Silica 'Lamoose' Rock,* taken by the Mars Hand Lens Imager (MAHLI) on *Curiosity* on 11 July 2015. Photojournal image addition date: 23 July 2015. Credit: NASA/JPL-Caltech/MSSS.

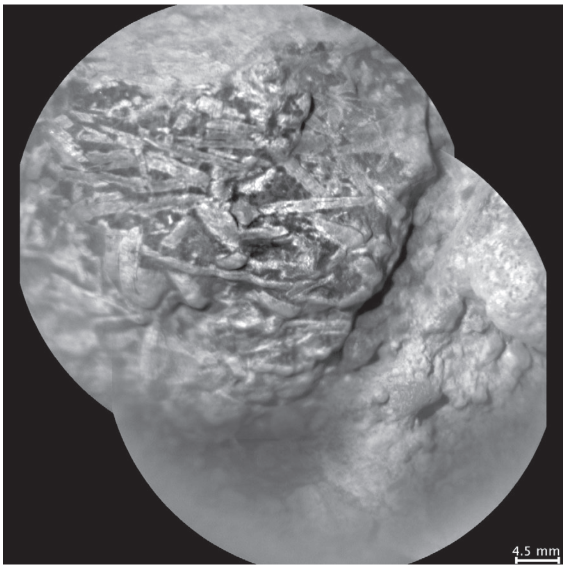

Figure 1.11. Laser-Induced Remote Sensing for the Chemistry and Micro-Imaging instrument will identify atomic elements in Martian rocks. Credit: NASA/JPL-Caltech/LANL/J.-L. Lacour, CEA.

Figure 1.12. *Crystal-Laden Martian Rock Examined by Curiosity's Laser Instrument,* captured by ChemCam on 15 January 2015. Photojournal image addition date: 29 January 2014. Credit: NASA/JPL-Caltech/LANL/CNES/IRAP/LPGNantes/CNRS/IAS.

The ChemCam on *Curiosity* is another prime example of a cybernetic eye that makes the invisible visible. Made up of two parts – the Remote Micro Imager (RMI) and the Laser-Induced Breakdown Spectrometer (LIBS) – this camera is located on the 'head' of the rover.[39] By firing a laser from up to 7 metres away, the ChemCam analyses 'vaporised materials from areas smaller than 1 millimetre on the surface of Martian rocks and soils'.[40] Using an on-board spectrograph, the ChemCam can analyse compositional data of its target to identify the type of rock, its composition, its chemical elements and whether there are water molecules in ice and minerals. There is a panel of coloured spots on the back of *Curiosity*; each spot is made from a different material and this calibration target is used by the

[39] More information on the engineering of ChemCam can be found at: https://msl-scicorner.jpl.nasa.gov/Instruments/ChemCam/

[40] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: Chemistry & Camera (ChemCam)," Mars Science Laboratory Curiosity Rover, accessed 11 August 2015, http://mars.nasa.gov/msl/mission/instruments/spectrometers/chemcam/.

ChemCam to determine the spectrum of different materials in comparison to those examined on Mars' surface. 'The camera can resolve features 5 to 10 times smaller than those visible with cameras on NASA's two Mars Exploration Rovers' and can also analyse targets at a distance. The laser is also used to clear away dust from the surface, obtain highly detailed pictures and it is often used to provide visual imagery to assist in the drilling of rocks.[41]

MAHLI and ChemCam permit a certain kind of virtual interaction with the terrain; on a microscopic and chemical level these instruments certainly engage with the notion of invisible vision. Yet these instruments rarely give an overall perspective of the landscape; we cannot project ourselves imaginatively into these miniature worlds. This thesis focuses on virtually immersive image forms of a landscape that is both familiar and alien. Analogous with 'windows on a world', the principle images under analysis in this thesis come from the cameras located on *Curiosity's* mast; the Navigation Cameras and the Mast Cameras.

Located just below the NavCams, the Mast Camera pairs translate the rover's surroundings in high resolution colour and stereo-imaging.[42] The two focusable cameras that make up MastCam's pair each have different lenses; a wide 34mm and a narrow angle 100mm lens capture images similar to those taken with a digital SLR.[43] Together, these images can acquire up to 1600x1200 pixels using Bayer-pattern filters, otherwise known as RGB.[44] These RGB filters are superimposed on the CCD resulting in colour images that are created on board the rover, generating a three band image.[45] MastCam can also capture what is called 'Z-Stack' images; combining pictures taken at different focus settings that can provide images with greater depth of field.[46]

[41] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: Chemistry & Camera (ChemCam)."

[42] *Curiosity's* MastCam was built and is operated by Malin Space Science Systems in San Diego, California.

[43] NASA/Jet Propulsion Laboratory, "Mast Camera (MastCam)," MSL Science Corner, accessed 11 August 2015, http://msl-scicorner.jpl.nasa.gov/Instruments/Mastcam/.

[44] A Bayer pattern is a 'repeating pattern of 4 pixels where each "cell" contains one red, two green, and one blue pixel. This acquires acquisition of colour without using the filter wheel.' Alexander et al., 68.

[45] Ibid., 35.

[46] Ibid.

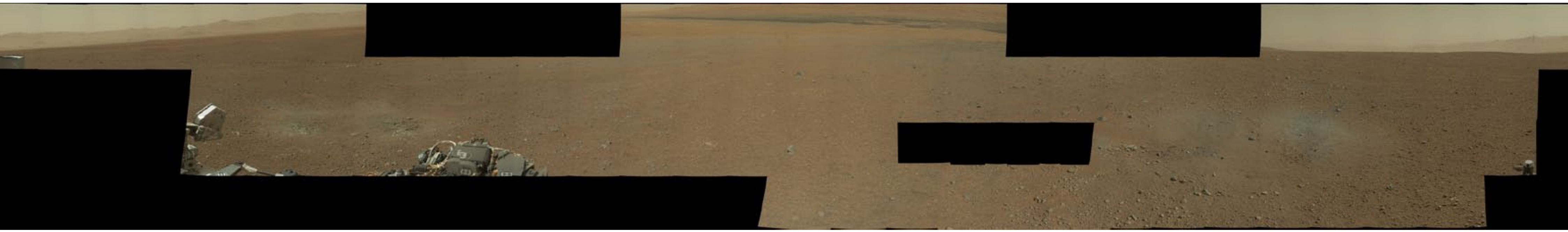

Figure 1.13. *First High-Resolution Colour Mosaic of Curiosity's Mastcam Images,* 11 August 2012. Credit: NASA/JPL-Caltech/MSSS.

It is from the images produced through the 34mm lens that panoramic visualisations like the one in figure 1.13 are constructed. Panoramic images are created by 'stitching together a collection of images of individual regions to form a more comprehensive rendering of the local environment'.[47] Figure 1.13 is the first high-resolution colour mosaic; constructed using 79 'snapshots' acquired by the MastCam over about an hour on 8 August 2012.[48] The image shows the geological features of *Curiosity's* landing site and is a prime example of how the landscape is reconstructed through digital processing, the black spaces representing sections of the landscape that, at that time, were not returned by the rover.

The MastCam also records colour video footage, is equipped with a powerful zoom lens, and has multiple filters through which to take single monochromatic images, revealing compositional terrain values. The MastCam electronics can store data 'independently of the rover's central processing unit' and an internal data buffer enables it to store thousands of images (550 thousand raw frames).[49] Located at approximately 1.97m from the ground, the NavCam and MastCam stereo camera pairs are the eyes of the rover, giving a sense of what it might be like to experience the landscape ourselves. The remainder of this chapter sets out to examine why these images of Mars, regardless of their resolution, can never truly stand in for real experience.

Objectivity and Images *at Work*

> We imagine *perception* to be a kind of photographic view of things, taken from a fixed point by that special apparatus which is called an organ of perception.[50]
>
> Anne Friedberg.

Belief in the photographic image is intrinsically linked to both its mechanical means of reproduction, and our perceptions of reality. As philosopher Stanley Cavell argues, the mechanism of the camera 'remov[es] the human agent from the act of reproduction',

[47] 'Mosaic visualisation is useful for various tasks in science planning, such as prioritisation of remote science targets or debating a number of available traverse paths in terms of safety and science potential.' Mark Powell et al., "Scientific Visualisation for the Mars Exploration Rovers," *IEEE International Conference on Robotics and Automation* (April 2005)*:* 4303, accessed 30 February 2015, http://www-robotics.jpl.nasa.gov/publications/Mark_Powell/Scientific_Visualisation_MER.pdf.

[48] NASA, "First High-Resolution Colour Mosaic of Curiosity's Mastcam Images," Mars Exploration, 11 August 2012, accessed 30 October 2014, http://mars.jpl.nasa.gov/multimedia/images/?ImageID=4421.

[49] NASA/Jet Propulsion Laboratory, "Mars Science Laboratory Curiosity, Mission: Mast Camera (MastCam)," Mars Science Laboratory Curiosity Rover, accessed 5 August 2015, http://mars.nasa.gov/msl/mission/instruments/cameras/mastcam/.

[50] Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge, MA: The MIT Press, 2006), 142.

abolishing the possibility of human intervention.[51] Jonathan Friday refers to photography as an 'extension of the eye', as opposed to paintings and drawings, which he classifies as 'extensions of the hand'.[52] The objective nature of the photographic image is equally affirmed by the notion of it as a 'transparent picture'. Kendall Walton argues that we 'see through' photographs because of this similarity between how we perceive an object and its image; the object as we perceive it in material reality more or less conforms to its photographic depiction.[53] How then might we endow *Curiosity's* images with the same level of objectivity, when the referent lies millions of miles away? Here I shall briefly explore the concept of objectivity, and introduce the notion of images *at work,* which shall become of greater relevance in subsequent chapters as images are manipulated and reformed to create immersive experiences.

Throughout scientific practices, photography has been used as a mechanical and transparent medium. Lorraine Daston and Peter Galison chart the history of scientific imagery's relationship to objectivity in their book *Objectivity,* that details the different types of images used in scientific atlases which historically set the standards for how 'phenomena are to be seen and depicted'.[54] Scientific objectivity, they argue, emerged at the middle of the 19th century, coinciding with the birth of photography.[55] Their analysis is based on three types of images; realistic drawings which are 'true to nature'; mechanically objective images, or images taken with the aid of a device; and images resulting from trained judgment, whereby data is reworked to reveal a clearer picture.[56] Claiming an image is objective implies it is 'transparent', relaying information exactly as it would appear to the eye, without the intervention of the hand. Daston and Galison argue:

> Objectivity preserves the artefact or variation that would have been erased in the name of truth: it scruples to filter out the noise that undermines certainty. To be objective is to aspire to knowledge that bears no trace of the knower – knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving. Objectivity is blind sight, seeing without interference, interpretation, or intelligence.[57]

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[51] Stanley Cavell, *The World Viewed*, (New York: Harvard University Press, 1971), 23.

[52] Photography is unlike other means of representation such as painting, which Friday termed as 'manugraphy'. Jonathan Friday, *Aesthetics and Photography* (Burlington: Ashgate, 2002), 38.

[53] Kendall Walton, "Transparent Pictures: On the Nature of Photographic Realism," *Critical Inquiry* 11, no. 2 (December 1984): 252, accessed 20 October 2013, http://www.jstor.org/stable/1343394.

[54] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 19.

[55] Ibid., 27-28. As Martin Jay notes, 'the most prominent inventor of the camera had […] been known as a master of illusion'. Jay, 128. I shall be expanding on Louis-Jacque-Mandé Daguerre's dioramas in Chapter 5.

[56] This use of 'trained judgment' with 'images at work' will be explored further in Chapter 5 in relation to false colour imagery, however the notion of 'objectivity', in any type of image, is also important for this thesis as a whole.

[57] Daston and Galison, 17.

In the context of the scientific atlas, 'the machine stood for authenticity: it was at once observer and artist, free from the inner temptation to theorise, anthropomorphise, beautify, or interpret nature'.[58] A mechanical image for Daston and Galison is 'objective', but as the next subchapter shall examine, even stating that an un-manipulated photograph is objective is problematic. Perhaps Jean Baudrillard offers further clarity of 'objectivity' in his essay "Xerox to Infinity". He states; 'by entrusting this burdensome intelligence to machines we are released from any responsibility to knowledge'.[59] Baudrillard continues with a discussion of the camera, which he argues reduces vision to a device:

> Its possibilities are no longer those of a subject who "reflects" the world according to his personal vision; rather, they are the possibilities of the lens, as exploited by the object. The camera is thus a machine that vitiates all will, erases all intentionality and leaves nothing but the pure reflex needed to take pictures. Looking itself disappears without a trace, replaced by a lens now in collusion with the object – and hence with an inversion of vision.[60]

No-one 'looks' through a viewfinder when Mars is captured by the MastCam. 'Blind sight' here is the vision of the machine, the un-manipulated image devoid of human interaction, for which, at face value, *Curiosity* may be said to represent. Yet *Curiosity's* images stand in opposition to Daston and Galison's definition of objectivity. The rover's images of Mars are not 'blind sight' in the respect that there *is* interference, interpretation, and intelligence in how they have been created. There is someone programming the rover to capture images in certain ways, and the images are edited and reconstructed on Earth to offer more expansive views of the landscape. Furthermore, the MastCam registers colour differently to how the human eye perceives, so images are often colour balanced to make up for such discrepancies.[61] Barthes wrote on the photograph that it is a 'perfect analogon', a '*message without a code'*.[62] These images are imbued with code in more ways than one and so *Curiosity* is 'blind sight' in an altogether different sense of the term; it makes visible what would otherwise remain invisible. It is our way of seeing through the darkness of space; the image data is sent via radio waves to Earth and brought to light only upon being opened on a computer. *Curiosity* points and shoots in darkness, a darkness illuminated by visual imagers at NASA and data processing technologies.

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[58] Ibid., 139.

[59] Jean Baudrillard, *The Transparency of Evil: Essays on Extreme Phenomenon*, trans. James Benedict. (London: Verso, 1993), 57.

[60] Ibid., 63.

[61] The calibration target on *Curiosity* provides an earthly referent for people working with MastCam images; knowing what the target is supposed to look like helps visual imagers adjust colour to produce more 'natural' images. This will be further explored in Chapter 5.

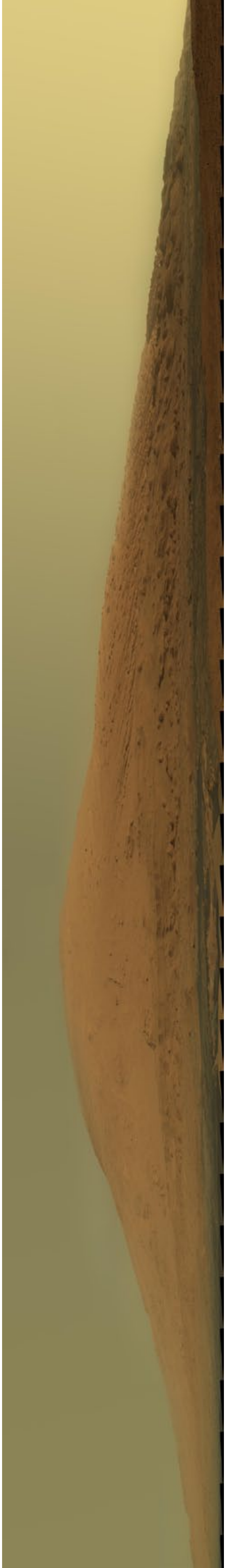
[62] Roland Barthes, *Image – Music – Text,* trans. Stephen Heath (New York: Fontana Press, 1977), 17.

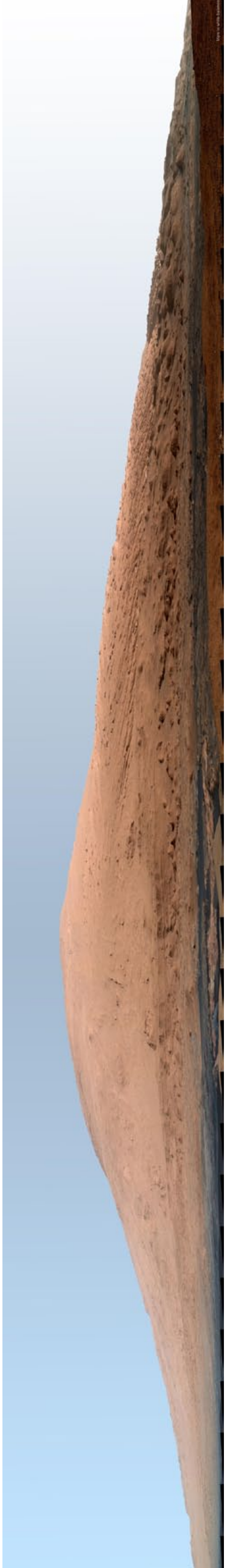
Neil Allen and Joel Snyder claim that a photographic image consists of two modes, the 'visual' and the 'mechanical'. In their essay "Photography, Vision and Representation", Allen and Snyder explain that the visual establishes similarities between the camera and the eye and 'posits that a photograph shows us "what we would have seen if we had been there ourselves"'. The mechanical on the other hand only serves to establish 'mechanical connections between what we see in a photograph and what was in front of the camera', it is only a 'reliable index of what was', not how we would have experienced it.[63] This analogy offers us an understanding as to how we might negotiate the difference between an immersive image, which tries to create the illusion of being present on Mars, and a more objective image – in Daston and Galison's sense of the word – that remains flat and un-manipulated. For example, *Rover's Reward for Climbing: Exposed Geological Contact* (fig. 1.9, pg. 69), might fall under the category of the 'mechanical'; as a 'reliable index of what was', this black and white NavCam image depicts the landscape as it appeared to the lens at that moment. *Mount Sharp Panorama in White-Balanced Colours* (fig 1.15), on the other hand, may be considered a 'visual' image; the composite nature of this panoramic image creates an expansive view of the landscape and colour balancing interprets the scene as if it were being viewed under Earth-like lighting. A further extreme of the 'visual' will be explored in Chapter 4, whereby 3D images attempt to reconstruct visual experience in and of itself.

Figure 1.14. *Mount Sharp Panorama in Raw Colours,* is the 'raw' unprocessed image showing Mount Sharp as recorded by the Mast Camera on *Curiosity,* 20 September 2012. Photojournal image addition date: 15 March 2013. Credit: NASA/JPL-Caltech/MSSS.

Figure 1.15. *Mount Sharp Panorama in White-Balanced Colours,* is the white-balanced colour adjusted version of figure 1.14 and shows the terrain under Earth-like lighting, 20 September 2012. Photojournal image addition date: 15 March 2013. Credit: NASA/JPL-Caltech/MSSS.

[63] Neil Allen and Joel Snyder, "Photography, Vision, and Representation," *Critical Inquiry* 2, no. 1 (Autumn 1975): 149, accessed 20 October 2014. http://www.jstor.org/stable/1342806.





As Mars rover driver John R. Wright points out, these images are only truthful to a degree, that is 'they convey all the information they are capable of conveying. You can't look at the image and get a sense of what the gravity is like.'[64] Despite beliefs that photographs prevent the loss of reality through a 'transparent' preservation of an object, a photograph is not a stand-in for real experience. Scientists and geologists often express their frustration with experiencing the Martian terrain through images; one cannot get a sense of the whole picture through two-dimensional fragments.[65] What cannot be known is the actuality of this formidable terrain, as our perception of this landscape remains a totally mediated experience. Looking at these images we can too easily forget the hostility of the Martian environment; if we were to step out of the image onto this familiar terrain we would perish in an instant.

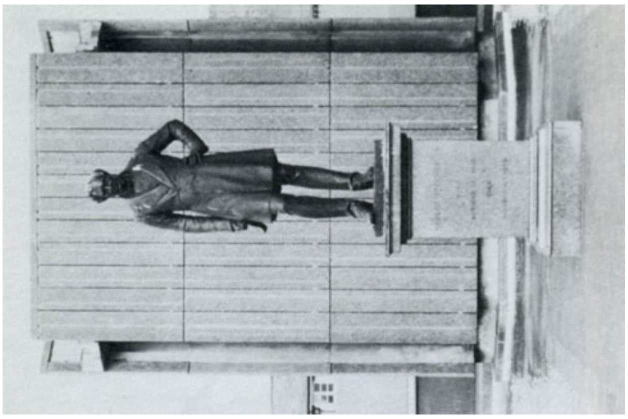
This thesis deals predominantly with the 'visual' as opposed to the 'mechanical', but it is via the mechanical that the visual might be reconstructed for us. Virtual reality technologies attempt to regain a level of presence, as mechanically produced, objective images are translated into 'images at work'.

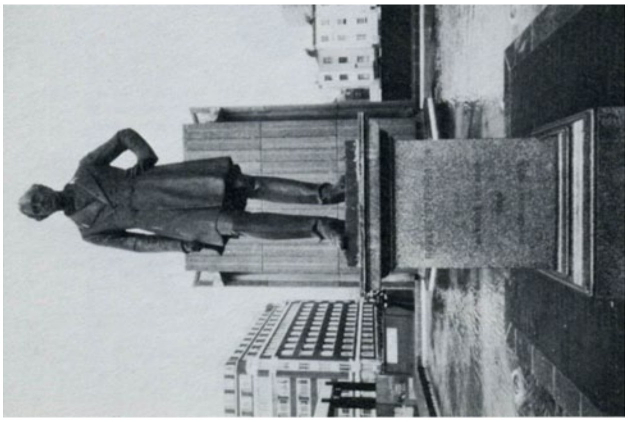
Figure 1.16. *Diverse Terrain Types on Mount Sharp, Mars, Curiosity's* right-eye camera on the MastCam, approximately white-balanced, 10 April 2015. Photojournal image addition date: 8 May 2015. Credit: NASA/JPL-Caltech/MSSS.

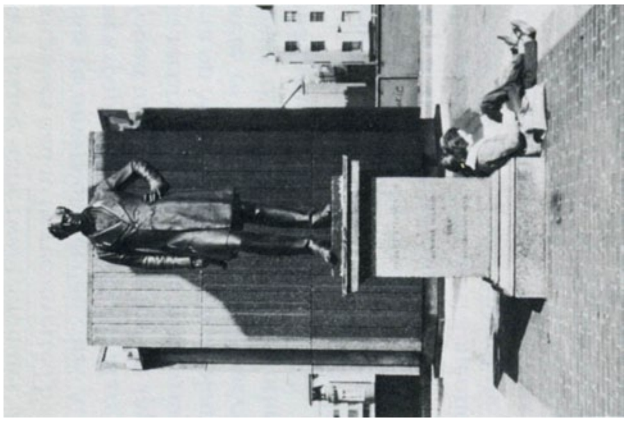
Figures 1.17 a-d.
a – Monument of Stephenson in front of Euston Station, London
b - Monument of Stephenson with reading man
c - Monument of Stephenson, wide angle
d - Monument of Stephenson, Normal view.
Images shown in Ernst H. Gombrich, "Standards of Truth: The Arrested Image and the Moving Eye," in *The Language of Images*, 4th ed., ed. William J.T Mitchell, 181-217 (Chicago: University of Chicago Press, 1980), 186-87.

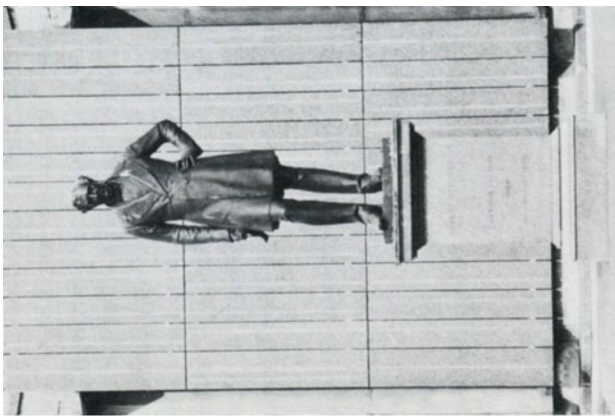
[64] Wright, interview, 3 November 2015.

[65] Sanjeev Gupta, Participating Scientist and Long Term Science Planner on the *Curiosity* mission explains that the blind spots and lack of resolution in some of the images sent back from Mars can be incredibly frustrating for geologists. It would cost something like £200,000/300,000 a day for high resolution images to be taken at every stopping point, and so *Curiosity* has to keep moving, doing 10% of the science as they would like. Sanjeev Gupta, (Professor of Earth Science, Imperial College London and Participating Scientist on the Mars Science Laboratory Mission), interview by author, London, 2 July 2015.









Framing Mars

Despite the concept that a mechanical relationship to a subject might prove more 'objective', these mechanisms arguably serve to distinguish a photograph from reality. Levels of perspective, focus, lighting and different lenses alter our perception of reality as represented in a photograph. Art historian E.H. Gombrich uses an effective analysis to illustrate this point about mechanical mediation and scale within even the analogue photographic image. Figures 1.17 a-d were commissioned by Gombrich to demonstrate how perspectival views and varying camera lenses may alter a machine-made vision and with each separate photograph, our perception of scale regarding the building in the background in relation to the statue alters completely.[66] Neil Allen and Joel Snyder state:

> A photograph shows us "what we would have seen" at a certain moment in time, from a certain vantage point if we kept our head immobile and closed one eye and if we saw things with the equivalent of a 150mm or 24mm lens.[67]

It is owing to this mechanical perception that the viewer sees the world through the lens of the camera and not through Kendall Walton's transparency. *Curiosity's* panoramas are constructed with shots taken by the 34mm MastCam lens. Figure 1.16, *Diverse Terrain Types on Mount Sharp,* shows us what we would have seen with a 34mm lens, from a single vantage point and looking in many separate directions at once.

In everyday reality we perceive all that is around us, in an image however, we perceive only what is given. The MastCam image relays only what is captured by the rover at a particular place, and as scientific investigations are often limited by engineering restrictions and the necessity to keep moving, the photographic view of things can differ wildly from true perception. We experience the landscape in fragments, as individual picture planes that, to quote Christian Metz, combine within them 'a certain presence and a certain absence'.[68] We cannot navigate around objects or see what is happening beyond the frame, we have one angle, one viewpoint, and we experience presence and absence simultaneously.

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[66] E.H Gombrich, "Standards of Truth: The Arrested Image and the Moving Eye," in *The Language of Images*, ed. William J.T Mitchell, 185-86, 4th ed. (Chicago: University of Chicago Press, 1980), 185-6.

[67] Allen and Snyder, 152.

[68] Christian Metz, *The Imaginary Signifier: Psychoanalysis and the Cinema,* trans. Celia Britton, Annwyl Williams, Ben Brewster and Alfred Guzzetti (Bloomington: Indiana University Press, 1977), 44.

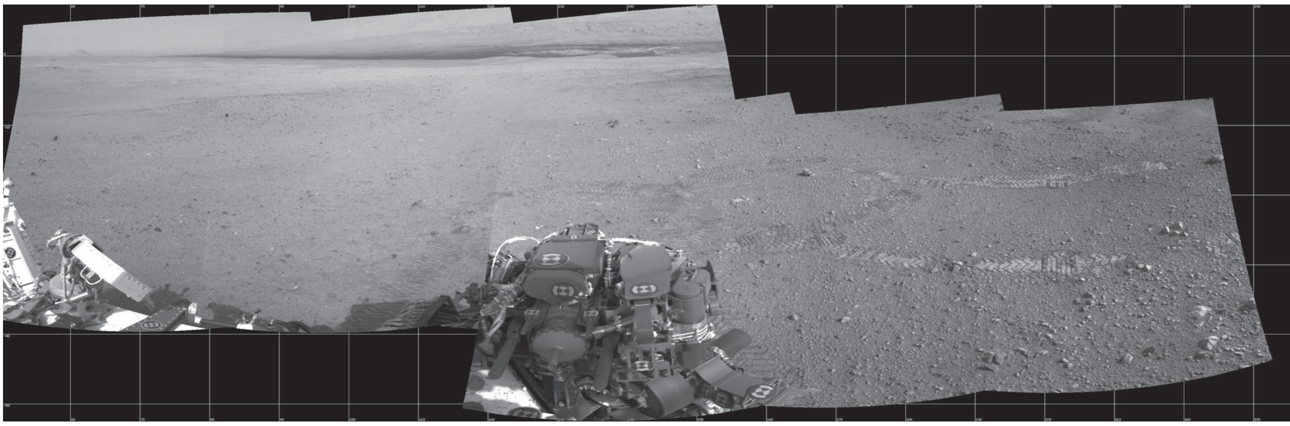

Figure 1.18. *From Infinity and Beyond,* mosaic captured by *Curiosity's* NavCams on 27 August 2012. Credit: NASA/JPL-Caltech.

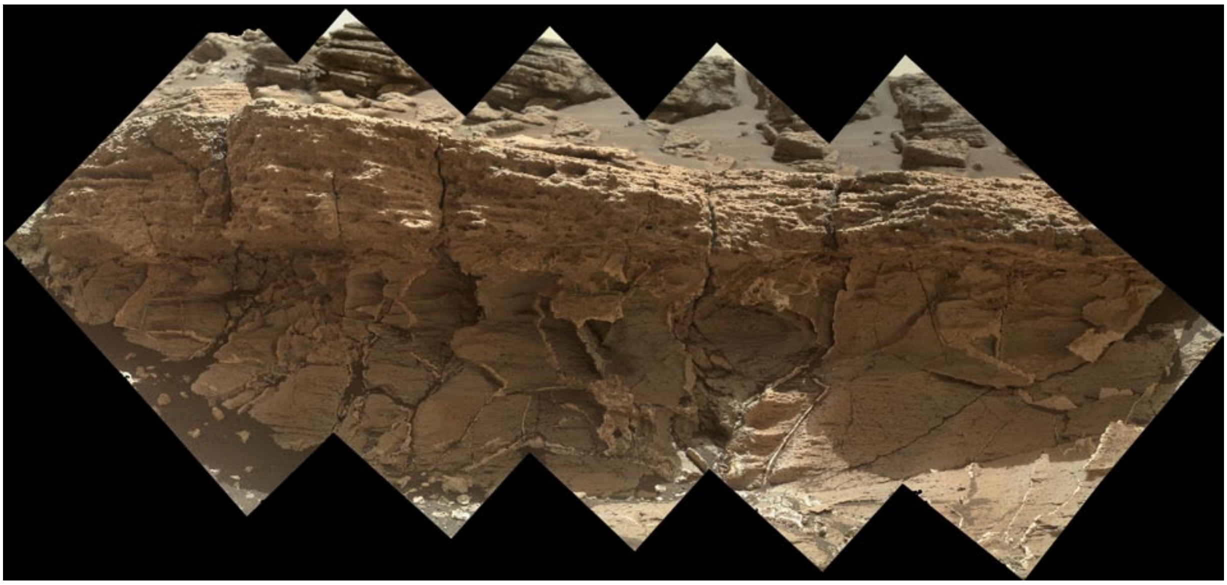

Figure 1.19. *Contact Zone: 'Missoula,'* captured by MAHLI on 1 July 2015. Photojournal addition date: 23 July 2015. Credit: NASA/JPL-Caltech/MSSS

This is apparent in the black borders surrounding many of the images of Mars. As visual imagers at NASA prefer to show the full extent of representation, image frames are montaged together on a black background. Evident in *Curiosity's* NavCam and MAHLI images above, we are made distinctly aware of what is missing. In the first image we see doughnut shaped tracks creating an infinity symbol, made by *Curiosity's* first manoeuvres on 22 and 27 August 2012.[69] The right hand side of the image is cut across by the jagged black border; access to the distant horizon is denied, eternally isolated from the scene. MAHLI has captured several high resolution frames, which have been stitched together on a black background. This blackness acts as a frame, surrounding the geological features. It is a stark

[69] NASA/Jet Propulsion Laboratory, "PIA16110: From Infinity and Beyond," Photojournal, 27 August 2012, accessed 30 October 2014, http://photojournal.jpl.nasa.gov/catalog/PIA16110.

rendition of absence that acts as a reminder; we are looking at a flat image. Testament to Roland Barthes' famous line, 'I cannot penetrate, cannot reach into a photograph. I can only sweep it with my glance, like a smooth surface. A photograph is flat', these dislocated images are only a fragment of a greater picture whereby the very nature of Mars-as-image is foregrounded.[70]

'Postcards from Mars': A Trace of Time

Mars is a terrestrial body, comparable to the deserts of the American West, the plains of Chile, and the rugged landscapes of Iceland. We have an intuitive understanding as to how it might feel to walk across its surface. Our reading of images is coded by memory, and as art historian and critical theorist Kaja Silverman notes, 'to look is to embed an image within a constantly shifting matrix of unconscious memories'.[71] Our preconceptions of reality define whether or not we trust appearances, and as Mars appears so familiar, the images are easily believed.

A straightforward photograph taken using an analogue camera and light sensitive film is 'true' insofar as the subject has been contained within the reproduction; light has physically altered the material substance of the light sensitive film, fusing a certain perspective and imprisoning that moment within what Jean Baudrillard terms 'the irrefutable testimony of the negative'.[72] For Baudrillard, capturing a scene with a digital camera marks 'the end of any suspense' as 'the image is there at the same time as the scene'.[73] There is no time, as Walter Benjamin would like, for the subject to grow into the picture as the capture and translation of light into image happens in an immaterial way. So when this immaterial transfusion of light into image occurs in an intangible environment, the concept of a trace arguably disappears altogether. Film theorist Laura Mulvey has argued that the indexical image has a 'privileged relation to time' and it is in this sense that *Curiosity's* images, having travelled 225 million kilometres for up to 20 minutes, are imbued with a different kind of trace, that of time.[74] Gaining momentum as the data speeds through space, these technological memories are familiar postcards of an unfamiliar place.

70 Barthes, *Camera Lucida,* 92.
71 Kaja Silverman, *The Threshold of the Visible World* (London: Routledge, 1996), 3.
72 Jean Baudrillard, *Why Hasn't Everything Already Disappeared?,* trans. Chris Turner (Calcutta: Seagull Books, 2009), 37.
73 Ibid., 61.
74 Laura Mulvey, *Death 24x a Second: Stillness and the Moving Image* (London: Reaktion Books, 2006), 9.

Figure 1.20. *NASA's Mars Rover Spirit's View Southward from Husband Hill,* captured during October 2005. Photojournal image addition date: 23 January 2014. Credit: NASA/JPL-Caltech/Cornell Univ.

An approximately true-colour composite taken from a larger panorama, the image above was captured in October 2005 by NASA's Mars Exploration Rover *Spirit.* As the first Mars mission to consider the aesthetic portrayal of this alien terrain, images like these undoubtedly conform to our expectations of landscape photography. In this image the photographer captures their viewpoint from a sweeping foreground littered with rocks. A sliver of translucent sky meets dark opaque slopes creating a pleasing tonal contrast. On the furthest horizon, ghostly hills fade into the distance. Depicted within a rectangle that is synonymous with landscape imaging, this picturesque landscape image is *Spirit's* 'postcard' from Mars.

In *Postcards from Mars* Jim Bell outlines the difference between 'acquiring images' and 'taking photographs' of another planet. Whereas previous missions such as *Viking* and *Pathfinder* 'acquired' images in a 'technical, science-driven, resource-limited activity', visual imagers on *Spirit* and *Opportunity* missions were allowed the 'luxury of much more time devoted to picture taking, much more bandwidth for sending pictures back to Earth, and better resolution of our cameras compared to previous Mars missions'.[75] As the 'first photographer on the red planet' Bell was allowed to 'think about the same kinds of issues

[75] Bell, 1-2.

that landscape photographers consider in their quest to capture the spirit and stories of the land'.[76] In *Dream of England: Landscape, Photography and the Tourist's Imagination,* John Taylor writes on the notion of the picturesque in the 18th century: 'landscape was not just anything seen from the top of a hill, or from a low vantage point: it should be composed, improved and imagined'.[77] Initial composition values such as framing, a sense of depth, the balance between sky and ground, and the postproduction 'darkroom' processing of lighting, colour enhancement and image montage means these images are not just technically and scientifically valuable.[78] They are also aestheticised *pictures* of Mars. In a similar manner to how landscape photographs and paintings are displayed in galleries for viewers to appreciate, MER and MSL images are displayed online for the world to see.[79]

The population of Earth are *Spirit's* distant relatives, engaging with its travels through these postcards. Bell explains the reasoning behind his use of the term 'postcard':

> I do a lot of travelling, both as part of my job and for vacation fun. One of my favourite things to do when I go to a new place is to visit the gift shop in the local airport or in the downtown mom-and-pop stores and check out their collection of postcards. Postcards are windows into the soul of the locals. Sometimes they are focused on the usual attractions; mountains or cathedrals, or the boardwalk by the ocean. Sometimes they sample the truly offbeat or just plain odd. We took a similar attitude with our first sets of images to be acquired by *Spirit.* I wanted them to be postcards – views showing the beauty of the natural environment that we now found ourselves in. We even set the first few mosaics up to be rectangular in shape, just like postcards.[80]

To be sent to friends and relatives, or kept as souvenirs, postcards are generally photographic images, memories as possessions and proof that the holiday-goer has 'been there, done that…' As such, photography is a faculty for remembering and as Sigmund Freud claims; 'in the photographic camera [man] has created an instrument which retains the fleeting visual impressions'.[81] Photographs, some have argued, are voluntary and manageable memories,

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[76] Ibid., 2.

[77] Taylor, John, *A Dream of England: Landscape, Photography and the Tourist's Imagination* (Manchester: Manchester University Press, 1994) 17.

[78] Bell, 2.

[79] The decision to make all these images open source and accessible online was made early on in the project by Bell and Steve Squyres. Entrusted with taxpayers' money, they felt an obligation to share both the successes and failures openly and honestly with the general public. In the case of the rovers, when the images are decoded at JPL from the radio signals the rovers send from Mars, a computer programme automatically generates a JPEG version of every image at the same time, and these get posted on a publicly accessible website usually within a day of being taken on Mars. Ibid., 66 & 70. For more information on MER photographic galleries and how other missions engage in public outreach through social media see: Paul Dourish and Janet Vertesi, "The Social Life of Spacecraft: The Organisation of Interplanetary Socio-Technical Systems," *LUCI* 3 (2008): 1-14, accessed 27 February 2015, https://www.academia.edu/14861257/The_Social_Life_of_Spacecraft.

[80] Bell, 70.

[81] Sigmund Freud, *Civilisation and its Discontents* (1961; repr., London: W. W. Norton & Company, 1989), 279.

to be conjured up at will.[82] John Taylor compares photography and tourism, arguing that both are 'instruments of time-travel, or "clocks for seeing"', allowing viewers access to the past.[83] Tourists, Taylor argues, 'accept the [postcard] souvenir as authentic, material evidence of either a location or the original object, and this acceptance becomes the authentic experience of tourists'. Despite images being only substitutes for original encounters, they quell an anxiety of forgetting, becoming 'the tourists' report, their narrative of exploration and proof of arrival'.[84] Similarly for Susan Stewart, the souvenir is symbolic of the 'antique and the exotic', an authentic reminder of 'events whose materiality has escaped us' and is thus 'by definition always incomplete'.[85] Embedded with a narrative but devoid of a material experience, NASA's Mars rovers beam back technological 'postcards' and daily we can follow their 'narrative of exploration' online. However, unlike the souvenir, these images are not imbued with nostalgia for the past; with each image the rover is driven forward, representing progress and the longing for future discoveries. The rovers repeat their experience to the beholder in the form of images, however, in contrast to the travel photograph or Stewart's plastic souvenir, we have no way of gaining a first-hand experience of this environment and so *Spirit, Opportunity* and *Curiosity* are the very mechanisms through which our perceptions of Mars are formulated.

Photographs can only ever act as a trigger to a memory, and our memory of something or someone is often mediated through the photographic depiction. The notion of a constructible, manageable memory is exemplified in Ridley Scott's *Blade Runner* in which the replicant Rachael – a simulacrum – looks upon photographs which conjure up false memories of herself as a child. Cinema and media theorist Vivian Sobchack describes *Blade Runner* as a film in which an 'electronic culture [is] already hermeneutically suspicious not only of photographic realism but also of any realisms at all'.[86] Photographs are for Sobchack 'material extroversions', invented memories that belong to someone else, serving as false proof that Rachael has a past.[87]

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[82] Catherine Dhavernas for instance writes on our desire to preserve memories through photography; 'there indeed seems to be a compulsion nowadays to photograph; to turn experience itself into a way of seeing'. Catherine Dhavernas, "The Aura in Photography and the Task of the Historian," in *Actualities of Aura: Twelve Studies of Walter Benjamin*, ed. Dag Peterson and Erik Steinskog (Svanesund: NSU Press, 2005), 92.

[83] Taylor's analysis is based upon visions of the English countryside and tourist hotspots like Shakespeare's Stratford-upon-Avon. Taylor, 13.

[84] Ibid., 246.

[85] Susan Stewart, *On Longing: Narratives of the Miniature, the Gigantic, the Souvenir, the Collection* (Durham: Duke University Press, 1993), 140, 135, 136.

[86] Vivian Sobchack, *Carnal Thoughts: Embodiment and Moving Image Culture* (Berkeley: University of California Press, 2004), 144.

[87] Ibid.

> Photographs are suddenly foregrounded in their objective materiality […] as utterly suspect. That is, when interrogated, they simultaneously both reveal and lose that great material and circulatory value they commonly hold for *all* of us as the "money of the 'real'" as our means of self-possession.[88]

With the time delay, the images of Mars come from the past, technological memories that enable us to 'see' and to imagine. It is through the presence of these images online that we are even able to envisage and recollect a vision of Mars.[89] When we imagine Mars then, without the aid of something visual, we do not go back in time to a perception of it as a landscape we ourselves experienced. Rather, we go back in time to envisage an *image* of Mars. Our relationship with this alien terrain is similar to Rachael's relationship with the memory of her past; it has never physically existed for us, instead it is constructed, reconstructed and re-imagined via mediations.

In a photograph, to quote Christian Metz, 'what is perceived is not really the object but its shade', a trace of an original moment.[90] Photographs hold onto the past; they exude the past's presence. Light from distant galaxies reaches us from the past tense, the images of Mars do not arrive immediately on Earth. As philosopher Simone Weil describes in the passages contained within *Gravity and Grace:*

> The past: something real, but absolutely beyond our reach, towards which we cannot take one step, towards which we can but turn ourselves so than an emanation from it may come to us. Thus it is the most perfect image of eternal, supernatural reality.[91]

The image of the Martian terrain remains fixed to the past. A trace in the past tense.

Figure 1.21. *Billion-Pixel View from Curiosity at Rock Nest, Raw Colour.* This image is a scaled-down version of a full-circle view which combines nearly 900 images captured between 5 October and 16 November 2012. Photojournal image addition date: 19 June 2013. Credit: NASA/JPL-Caltech/MSSS.

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[88] Ibid.

[89] In *Matter and Memory*, Henri Bergson argues that recollecting is not elucidating memories in our mind, but rather, a form of virtual travel into the past. Memory images are stored up in what Bergson terms the 'virtual store of time'. David Martin-Jones and Damian Sutton, *Deleuze Reframed* (London: I.B. Tauris, 2013), 86-87.

[90] Metz, *The Imaginary Signifier,* 45.

[91] Simone Weil, *Gravity and Grace* (Reading: Routledge, 1987), 155.

Digital Processes and Re-presenting Mars

As outlined in the introduction to this thesis, scientists use images as active reconstructions; constantly reworking them they are able to gain new insights. As Michael Lynch examines, these images are partially linked to reality (holding some indexical link with the thing imaged) but are partially artificial (they can differ in visual terms from the represented object). Jim Bell reflects on the image as representation and reconstruction:

> Most of the images are presented in an approximate true colour rendering, which is an attempt to simulate, as best we can, what the view would look like had you been there looking out over the landscape yourself. It's approximate because the PanCam's colour filters don't respond to colours the exact same way the human eye does, and it's a rendering because sometimes it took many days to acquire all the images in some of the panoramas. During that time the lighting or dustiness of the atmosphere may have changed, but we would often smooth over these differences, especially to avoid ugly "seams" in the sky, and render the scene in a way that simulates viewing it all at once.[92]

By referring to the image as a 'rendering', Bell encapsulates Neil Allen and Joel Snyder's visual mode, with the visual being a perceptual similarity, and the mechanical being an 'objective' depiction. In Bell's example, the mechanical connection to the landscape manifests itself in the indexical translation of each portion of landscape into each of the panorama's image segments. By stitching these fragments together and adjusting colour and lighting, the panorama 'simulates' a perception of place. Despite actually holding ties to numerous moments in time, panoramas nonetheless achieve visual connections to the landscape they represent. But this reconstruction of images implies human intent. The purpose of this subchapter is to unpick the notions of re-presentation and re-construction, particularly with regard to digital imaging and *Curiosity's Billion-Pixel View* (fig. 1.21).

In *Representation in Scientific Practice Revisited*, Michael Lynch and Steve Woolgar outline the problems associated with the term 'representation', and the preference often given to 'mediation', 'enactment' and 'visualisation' in describing scientific images and practices that are without referent or origin.[93] 'Visualisation' is a term often used in association with *Curiosity's* images, however the term 'representation' has, in some ways, greater significance for this thesis; the Latin verb *repraesentare* means 'to make present or manifest or to present again'.[94] The term then implies a 're-presentation' of material, that may be re-constituted and re-evaluated to form new re-presentations that reveal information through trained judgment; a more immersive encounter with images. Expanding the image beyond a single, objective

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[92] Bell, 3.

[93] Catelijne Coopmans, Michael Lynch, Janet Vertesi, and Steve Woolgar, eds., *Representation in Scientific Practice Revisited* (Cambridge, MA: The MIT Press, 2014), 3.

[94] Aire Rip and Martin Ruivenkamp, "Nanoimages as Hybrid Monsters," in Coopmans, Lynch, Vertesi and Woolgar, 193.

viewpoint, immersive reconstructions are the focus of this thesis. Furthermore, as social scientists Arie Rip and Martin Ruivenkamp argue, representations

> are constructed in practice, and their acceptance as representative of what is "out there" is achieved as the outcome of a process rather than a simple assertion of resemblance between a purported original and what an image shows.[95]

Representation then implies a more subjective image, whereby the appearance – and in some cases the existence – of the referent is brought into question.

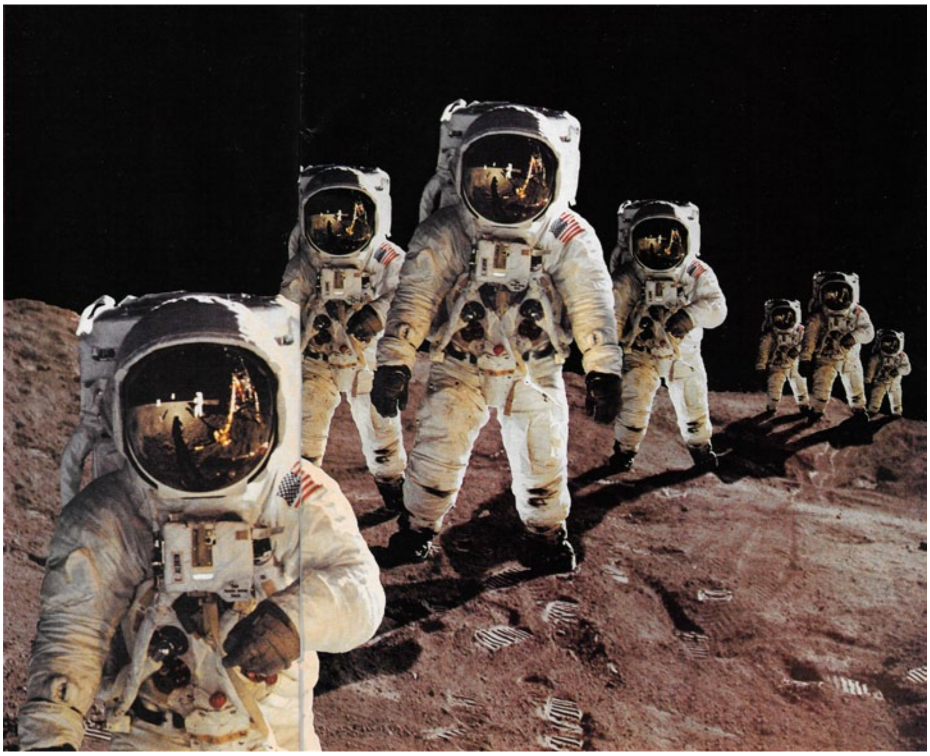

Figure 1.22. *A man on the moon becomes a lunar brigade,* credit: HBO Studio Productions. Image shown in "A Multitude of New Possibilities," *Time,* Fall, 1989, 74-75.

Published in 1989, an article in *Time* magazine titled "150 Years of Photojournalism" showed a digitally manipulated image of Buzz Aldrin walking on the moon amongst six other astronauts. Re-presented again and again, this image of Aldrin showed the ease with which photographs could be made to look as if they stemmed from reality. The image caption reads:

> this is a picture of something that never took place, though it is based on a picture of something that did […] The multiple image of Aldrin […] was produced on a computer screen. Such digital imaging systems can make changes that are virtually undetectable […] Computer retouching has already become common place in the fantasy world of advertising photography. Now many

[95] Ibid., 178

> journalists are troubled by the prospect that the practice will creep into the reproduction of news photos. A computer can remake a picture, but only people can draw the ethical lines.[96]

Playing off rumours that the moon landing was a hoax, this article demonstrates the inherent distrust of imaging technologies' claims to truth, explored in the writings of W.J. T. Mitchell, E. H. Gombrich, and Martha Rosler, amongst others.[97] It was in this context that the *Hubble Space Telescope* was launched in 1990.[98] *Hubble* records data digitally, not pictorially, and the images' appearance are the result of a combination of telescope optics, digital detectors, computer programs used to render the data, and visual imagers manually processing the data. These 'representations' are consequently the products of a series of decisions combining scientific and aesthetic concerns; it is no surprise that there are often discrepancies over how the images should 'look'.[99]

Hubble images represent the intangible; invisible clouds of dust and stars drawn out from dark space by high powered lenses. The distance between Mars and Earth is not as great, and the landscapes are not as spectacularly colourful. But this is a distance scientists have crossed with their spacecraft; *Curiosity* is on location. Despite these images' having an indexical relationship with the thing they represent, by the time they reach Earth, this relationship is warped and stretched. As photography theorist Damien Sutton argues, the digital image can easily lose its 'anchor to reality,' resulting in the 'semiotic relationship seem[ing] over-balanced towards the iconic and the symbolic'; the referent in *Curiosity's Billion Pixel View* is thus brought into question.[100] The image symbolises a link, but as Jim Bell observes, these images are renderings, closer to the symbolic than to the indexical photograph.

Figure 1.23. *MSL NavCam Mosaic Mount Sharp*, section from *Billion-Pixel View from Curiosity at Rock Nest.* Images taken from a poster showing "Pointing Correction for Mars Surface Mosaics," 2015. Credit: Bob Deen, Amy Chen, Kris Caparo, Hallie Gengl, Stirling Algermissen, Nicholas Ruoff, Oleg Pariser, NASA/JPL-Caltech.

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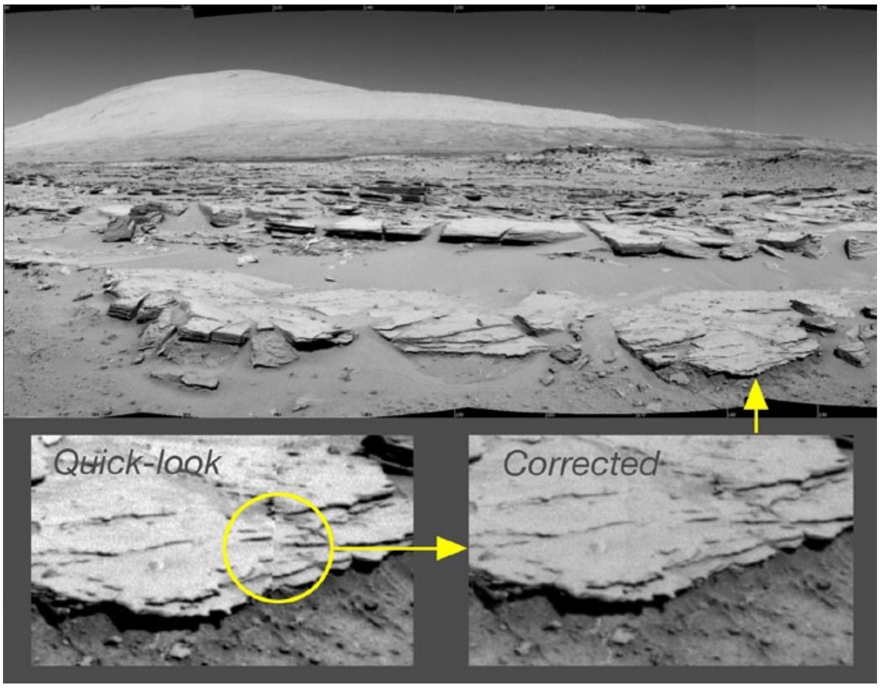
[96] Time Magazine, "A Multitude of New Possibilities," *Time,* Fall, 1989, 74-75

[97] See Mitchell's book *The Reconfigured Eye: Visual Truth in the Post-Photographic Era;* Gombrich's essay "Standards of Truth: The Arrested Image and the Moving Eye"; and Rosler's essay "Image Simulations, Computer Manipulations: Some Considerations".

[98] Vivian Sobchack, *Screening Space: The American Science Fiction Film* (New Brunswick: Rutgers University Press, 1987), 136.

[99] Elizabeth Kessler, *Picturing the Cosmos: Hubble Space Telescope Images and the Astronomical Sublime* (Minneapolis: University of Minnesota Press, 2012), 14-5.

[100] Damien Sutton, "Real Photography," in *The State of the Real: Aesthetics in the Digital Age*, ed. Susan Brind, Ray McKenzie and Damian Sutton (London: I.B Taurus, 2007), 165.



Emma Frow has detailed concerns of journal editors with the spread of biological image processing. "In Images We Trust? Representation and Objectivity in the Digital Age" outlines the 'crisis of trust' in the published image: by removing dirt or unwanted noise, the images are 'improved' or 'enhanced' and in some ways made more 'trustworthy than raw image data'.[101] It is in a similar manner that seams are blurred and colours are adjusted in the panoramic visualisation, to make up for the discrepancies between the different frames. As philosopher and theorist Marina Gržinić observes in "Exposure, Time, the Aura, and Telerobotics":

> The very technologies that are supposed to give us a "clearer" image, in an important sense, do just the opposite. By sanitising the subject, they prevent us from knowing reality itself. We lose our sense of time and place, and are left with a hopelessly stylised conception of the truth.[102]

The image *MSL NavCam Mosaic Mount Sharp* (fig. 1.23) shows the process by which panoramic visualisations are cleaned up: recorded over disparate Martian sols, the seams are smoothed over and the presence of time is erased, on the surface at least. We can sense place, yes, but it is a pieced together place, the image is not representative of what mechanically and objectively occurred. Looking at the larger picture however, the combination of greyscale and colour images in *Curiosity's Billion-Pixel View* (fig. 1.21, pg. 87) seems to

[101] Emma Frow, "In Images We Trust? Representation and Objectivity in the Digital Age," in Coopmans, Lynch, Vertesi, and Woolgar, 249.

[102] Marina Gržinić, "Exposure, Time, the Aura, and Telerobotics," in *The Robot in the Garden: Telerobotics and Telepistemology in the Age of the Internet,* ed. Ken Goldberg (Cambridge, MA: The MIT Press, 2000), 220.

highlight this displacement of time and place and is perhaps a more realistic impression of the combination of mechanical and visual imagery, and reconstruction.

Figure 1.24. Close up of *Floor Mosaic with a Lion Attacking an Onager* (detail), Stone and glass, A.D. 150, on view at the Getty Villa, California. Photograph by author, courtesy of the Getty Open Content Program.

The *re-presentation* of something has temporal implications, 'presenting again (and again and again, indefinitely)'.[103] *Curiosity's* panoramic image is the outcome of a long drawn out process, and although it might very well hold perceptual ties to the landscape it represents, the image does not depict a mechanical snapshot moment. Drawing on the ancient practice of rendering an image through the careful composition of fragments (seen in fig. 1.24), the term 'mosaic' is often used to describe *Curiosity's* composite images. On face value this seems like a fitting term; the implication of mosaic however, is that each image fragment butts up against each other in a jigsaw like construction. This would leave no room for error; if a sliver of the landscape was missed by *Curiosity's* lens, there would be a gaping hole in the image. In capturing a panorama then, *Curiosity* takes more images than is perhaps necessary, ensuring that each one overlaps with the last. Although this is not actually visible in the final outcome, this overlaying of information gained from different camera angles in the image making process means that the image gains another dimension: time. It has taken time to capture the panorama, but in the overlapping of images, moments in time are brought

[103] Michael Lynch, "Representation in Formation" in Coopmans, Lynch, Vertesi, and Woolgar, 324. The genealogy of representation is explored by Mark B. Brown in *Science and Democracy: Expertise, Institutions and Representation* (Cambridge, MA: The MIT Press, 2009), 4-7.

together. This repetition is eventually flattened, but traces of the representational process are left behind; inherent in the panorama's history then is this trace of time.

When we take a photograph of something on Earth, we are able to compare the referent with its representation. The crisis of trust described by Emma Frow seems heightened in images of outer space and other planets; how can we accept the image as true if there is no human present in the space in which the device operates, no-one to validate the indexical link? This data does not present us with the actual landscape, geological feature or particle of dust, instead they *re*present these things in image form. Michel Foucault examines the problem of representation in his analysis of Magritte's painting *Ceci n'est pas une pipe* and speaks as if he is the painted pipe:

> What you see here, the lines I form or that form me, is not a pipe as you doubtless believe; but a drawing in a relation of vertical similitude to the other pipe (real or not, true or false, I do not know) that you see over there – just above the painting where I am, a simple and solitary similitude.[104]

We know Mars is indeed real, but the truth of its appearance in representation can indeed be questioned. As with Jim Bell's approximate renderings, we cannot fully distinguish their claims to truth. Foucault continues:

> What you see floating before your eyes, beyond space and without fixed foundation, this mist that settles neither on canvas nor on a page, how could it really be a pipe? Don't be misled: I am mere similarity – not something similar to a pipe, but the cloudy similitude […] This is a graphism that resembles only itself, and that could never replace what it describes.[105]

Magritte's pipes are 'graphisms', 'divorced from what they name' and *Curiosity's* images are imbued with the same level of detachment.[106] As 'cloudy similitudes' in need of cleaning up they refer to nothing we can truly know. Intangible mists of representation, these images are no longer present in their originating landscape, neither are they at home on Earth. Mars is seen only through its image; its essence evaporates as representation takes over.

Through representation, the Martian aura dissipates, and Mars becomes its own image. For Jean Baudrillard:

> It is no longer a question of imitation, nor of reduplication, nor even parody. It is rather a question of substituting signs of the real for the real itself.[107]

The image of Mars lacks a referent; it is foreign to us, invisible. In his 1936 seminal essay "The Work of Art in the Age of Mechanical Reproduction" Walter Benjamin argues that by

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[104] Michel Foucault, *This is Not a Pipe,* ed. and trans. James Harkness (Berkeley: University of California Press, 1983), 48.

[105] Ibid.

[106] Ibid.

[107] Jean Baudrillard, *Simulations,* trans. Phil Beitchman, Paul Foss and Paul Patton (Cambridge, MA: Semiotext[e], 1983), 4.

using photography to reproduce a work of art, the aura of the original is lost. Benjamin defines aura as the work's 'presence in time and space', claiming that re-contextualising an art object depreciates the 'quality of its presence'.[108] How then might we re-imagine 'aura' in relation to scientific images, particularly of places we are unable to visit for ourselves? Aura here may represent the quality of a landscape's presence, related to an experience of being within that landscape. In relation to Benjamin's writings on reproducibility and Baudrillard's writing on the *simulacra* arguably two things happen in the representation of Mars. For Benjamin, the essence of Mars, its presence in space and time, dissipate. For Baudrillard, a form of substitution takes place; there is no authentic original from which these images deviate and reproduce. We cannot line up and experience this landscape first-hand as we might with Leonardo da Vinci's *Mona Lisa;* Mars only exists for us in the form of an image and is thus representative of Baudrillard's hyperreal: a sign without a referent. We are, to quote historian and theorist Martin Jay, 'seduced by images that are signs of nothing but themselves'.[109] Furthermore, Baudrillard proposed the idea of a map so detailed that it covers an entire territory.[110] In the case of Mars, the map 'precedes the territory', it is the 'precession of simulacra'.[111] 'It is dangerous to unmask images' states Baudrillard, 'since they dissimulate the fact that there is nothing behind them'.[112] For Baudrillard then, the aura of Mars is *in* the image.

Marina Gržinić relates the time-lags on live internet video feeds to Benjamin's aura and the same may be said of the missing information and the composite nature of the image of Mars:

> Benjamin understands the aura as an appearance or semblance of distance. Telerobotic time-delay brings about precisely such an appearance or semblance. It reminds us of the distance that separates us from the subjects of the images we see. It forces us to think about the network of modems, routers, servers, and telephone lines that the image must travel in order to get to us, and so reaffirms our sense of spatial relations between those subjects and we, the viewer […] As we gain a sense of time, so too do we gain a sense of space.[113]

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108 Walter Benjamin, "The Work of Art in the Age of Mechanical Reproduction," in *Art in Theory*, *1900-2000,* ed. Charles Harrison and Paul Wood (Oxford: Blackwell, 2003), 521. An example is Leonardo da Vinci's *Mona Lisa*; an infinitely reproduced painting, many spectators come away from the Louvre disappointed by its size and the inability to view the painting properly due to the hordes of people.

109 Jay, 544.

110 Jean Baudrillard, *Simulations,* 1.

111 Ibid., 2

112 Ibid., 9

113 Gržinić, 221-22.

Scientists dealing with interactive image forms are always talking about latency, how the time-lag might be reduced, and how this lag affects the user's experience.[114] As Gržinić theorises, 'time delay bears witness to something that lies beyond the image, and so begins to restore to objects their aura, their distance'.[115] It is through such visual 'glitches' that the image foregrounds its own materiality and this will be discussed in greater depth in the next chapter.

An analogue photograph contains the world insofar as it is a physical rendition of light upon the surface of a negative, containing a trace of the moment it recollects. The digital image on the other hand is made up of immaterial points of light subject to the computer user's specific desires.[116] Its construct then is very different; as Baudrillard affirms, 'the image is merely a product of an instruction and a programme'.[117] Limited by the rover's power resources, its on-board storage system and the positioning of Mars in relation to the Earth, *Curiosity's* images are sent to Earth as radio signals in the form of ones and zeroes and this data is captured by radio telescopes all over the world. [118] As Wolfgang Ernst has stated, 'the computer renders data visible in a time-based way: the static notion of the image is replaced

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[114] Kenji Kato (Senior Research Engineer, at NASA Ames Research Centre, California), interview by author, Moffett Field, 9 November 2015.

[115] Gržinić, 222.

[116] Jacques Derrida spoke about 'de-paperising'; the 'withdrawal' of paper into the document on screen and this presents the idea of the digital image as ephemeral, intangible, and fragile, there is always the potential for it to change, or for it to be changed. Dawne McCance, "Introduction: Beyond the Paper Principle," *Mosaic* 39, no. 3 (August 2006): vii, accessed 7 May 2014, http://www.umanitoba.ca/publications/mosaic/issues/_resources/intro_39_3.pdf.

[117] Baudrillard, *Why Hasn't Everything Already Disappeared?,* 49.

[118] Because Mars spins and Earth is only 'up' for 12 hours a day, direct Mars to Earth communications are only possible for 12 hours a day. Bell, 51. Unlike the one in Houston, Texas (which is used by at least 20 people per day to look after astronauts on the International Space Station) the mission control room at JPL is quiet on a day to day basis, filling up only at spacecraft launches and landings. One person is usually in charge of sending up and receiving data to individual spacecraft and rovers, called the Ace. After scientists have figured out what they want to do, and engineers have planned the traverses a command sequence is written and sent to the Ace, who acts as a liaison between the scientists and engineers and those in the control room. People in the control room run NASA's Deep Space Network, an infrastructure of antennas built for communication. Jet Propulsion Laboratory, public tour attended by author, Pasadena, CA, 2 November 2015. As Jim Bell points out:

> there is a small armada of spacecraft wandering around the solar system, and NASA keeps up with the using a series of large radio telescopes around the Earth. There are outposts in Goldstone, California; Madrid, Spain; and Canberra, Australia. This is the Deep Space Network, or DSN, and it operates twenty-four hours a day, seven days a week for two-way communication with the armada. Time on the DSN is precious and carefully negotiated, especially on the most sensitive 70-metre-diameter radio telescopes, because so many spacecraft require commanding and monitoring and some of them need to be in continuous contact with Earth during critical manoeuvres, flybys, or landings.

Bell, 51.

by a dynamic one'.[119] Travelling at the speed of light (186 thousand miles per hour) image data is flung from Mars, bounced around the world, and subject to numerous editing procedures.[120] This notion of a dynamic image is certainly prevalent in *Curiosity's* images. These images are not just mediated by their creators, and the process of representation, they are also mediated by the very technologies that enable their production.

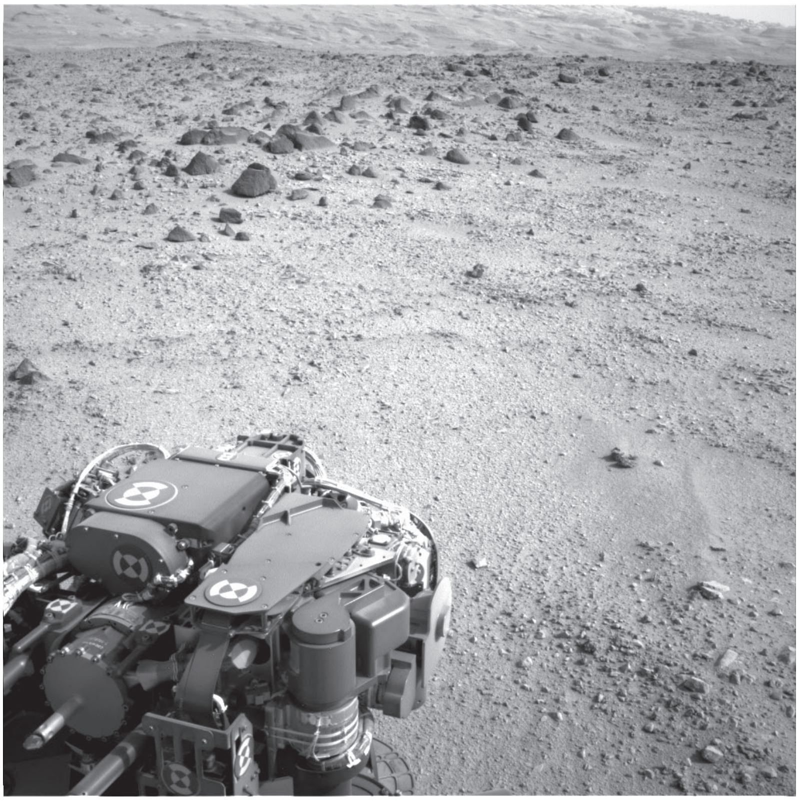

Figure 1.25. *Heading for Mount Sharp, Sol 329*, 11 July 2013. Credit: NASA/JPL-Caltech.

(Tele)presence, Landscape and Familiarity

Jim Bell outlines the human desire to project our knowledge of Earth onto another planet:

> There is a sense of familiarity in these images from Mars. There's an "I've seen that place before" feel of looking out the window across a long drive in the desert somewhere. Rocks, hills, sky – it's all very Earthlike and comforting, in a way. But it's an illusion. It's 30 to 50 degrees below zero (°C or °F, it doesn't matter) on average out there; the air is almost entirely carbon dioxide, with only a trace of oxygen; and it hasn't rained for something like 2 to 3 billion years, if ever. There's not a hint of a cactus or tortoise, or a wispy contrail from a passing jet. When you take a closer, more careful look at the landscape, you realise how truly ancient this terrain really is. The rocks have been carved and moulded by sand and dust grains carried by the wind blown for billions of years. The ground is peppered with circular holes both large and

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[119] Wolfgang Ernst quoted in Andreas Brogger and Omar Kholeid, eds. *Vision, Memory, and Media* (Liverpool: FACT, 2010), 81.

[120] Travelling at the speed of light would mean you could run around the equator 7.5 times per second.

> small – impact scars formed when asteroids or comets crashed into the planet long ago […] The land is imbued with a sense of time, of age, of processes that have been at work for longer than even most geologists can conceive. By comparison, our home planet is young, geologically virile, and ever-changing. It is difficult and often risky for us to extend the geologic experience we've gained from living on such a young planetary surface to such an ancient place on Mars. It's only human nature, however, to want to feel like there's a little bit of home in every place we visit.[121]

It seems intuitive to want to understand the unknown by way of our own experience. This subchapter demonstrates how Mars, whilst unexplored by humans, might still be considered landscape. This planet is not known by boots on the ground, but through rovers that facilitate *telepresence.*

In *The Robot in the Garden: Telerobotics and Telepistemology in the Age of the Internet* Ken Goldberg defines telepresence as different from virtual reality. He states that 'although [William] Gibson's term "cyberspace" encompasses both, the distinction is vital: VR is simulacral, TR is distal', meaning situated away from the body.[122] This is expanded by Lev Manovich:

> Telepresence allows the subject to control not just the simulation but reality itself. Telepresence provides the ability to *remotely manipulate physical reality in real time through its image* […] Thus the essence of telepresence is that it is antipresence.[123]

Although scientists cannot interact with Mars in 'real time', Manovich's definition of telepresence is an important one. This thesis deals with Goldberg's concept of virtual reality and not telerobotics, however it is only through the presence of these robots on Mars that virtually immersive image forms can be created. These image forms play a crucial role in the context of Manovich's statement; they attempt to fill the void of experience, Manovich's 'antipresence'.

Art historian and theorist Joy Sleeman has written on the correlation between land art of the 1960s and 1970s and the moon landing, highlighting that for most, the experience of both was through a screen or in reproduction. She describes a photograph taken by her father of the moon landing on television:

> […] you see Neil Armstrong stepping onto the moon's surface. This one confirms the date and time (reinforced by my Dad's calendar on top of the TV) but my mum in her pink dressing gown is rather more evident in the reflection on the screen than Armstrong's first steps. At talks and events when I present work around the moon landing I am often asked what I think about conspiracy theories that say we've never been to the moon at all and it was filmed somewhere in a film set (by Stanley Kubrick) or in the high desert of the USA. Although I do think men landed on the moon in 1969, in the context of my own work on land art and the moon landing

[121] Bell, 76.
[122] Goldberg, 5.
[123] Lev Manovich, "To Lie and to Act: Potemkin's Villages, Cinema and Telepresence," in Goldberg, 175.

> it seemed more important to focus on the fact that the moon landing took place on television, at this particular time and place, in the familiar environment of my living room.[124]

A sense of familiarity is formed through these human relationships with the image of the moon. Although Sleeman's father's photograph – a reproduction of a reproduction – mediates the moon landing to such a degree it becomes almost unrecognisable, it effectively brings an experience of outer space down to Earth.

Humans have yet to venture to Mars and robotic surrogates have been sent in our place. Similar to Sleeman's example, William J. Clancey argues that it is through the image that scientists can experience Mars in the 'first person'. When looking at a photograph of *Spirit's* tracks in the sand, scientists liken the marks to the scuffing of their boots: 'we have been there and we did this. These are our marks – our boots on the ground of another planet.'[125] As 'surrogate explorers' these scientists become the rovers, referring to aspects of the landscape as if they were stood there themselves.[126] As cited above, MAHLI has been referred to as the hand lens carried around the geologist's neck; in a metaphorical extension of a ground work tool, the rover embodies the human geologist. Clancey quotes MER scientist Oscar Biltmore: 'These things have been our eyeballs out there and our legs and our arms […] it has kind of morphed into us, or we've morphed into it.'[127] And as Rob Manning, Chief Engineer on the *Curiosity* mission has pointed out, 'we're not sending robots to Mars. We're sending extensions of ourselves. These machines are *us.*'[128] By anthropomorphising the rovers in this way, and by depicting their bodies in the foreground of the images, we gain a sense of 'being there'. Mars is made graspable in the imagination.

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[124] Joy Sleeman, "Connections Between Earth, Space and the Moon," unpublished lecture notes for a paper presented at Against Nature, Camberwell College of Art, London, 21 May 2014, 5.

[125] Clancey, *Working on Mars,* 103.

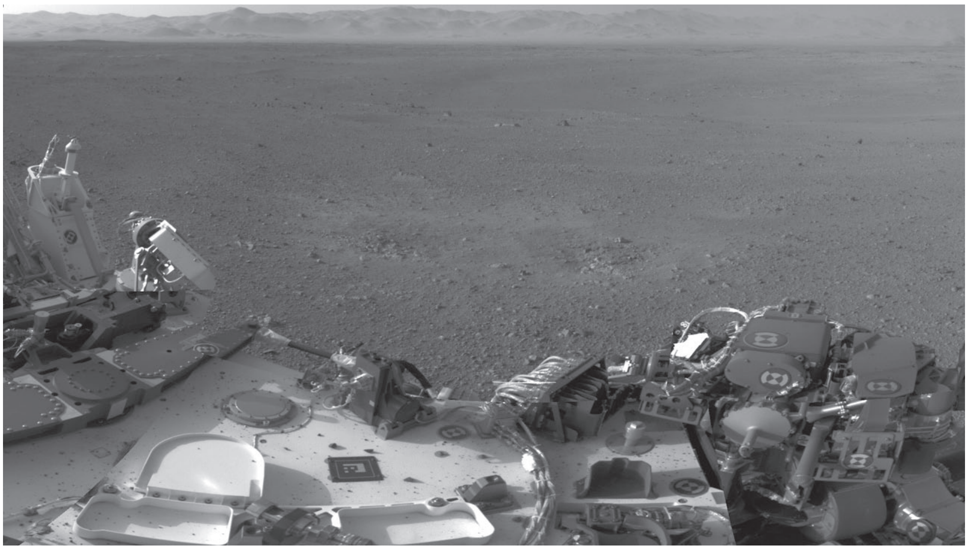
[126] William J. Clancey, "Becoming a Rover," in *Simulation and its Discontents,* ed. Sherry Turkle (Cambridge, MA: The MIT Press, 2009), 114. Clancey also explores the use of such phrases as 'where are *we* going to go' or 'are *we* going to stay here?' to explore how each scientist projects themselves onto and into the body of the rover. Ibid., 107-27, 115.

[127] Ibid., 118.

[128] Rob Manning and William Simon, *Mars Rover Curiosity: An Inside Account from Curiosity's Chief Engineer* (Washington: Smithsonian Books, 2014), xvi.

Figure 1.26. *Studio portrait of the young Franz Kafka,* photographer unknown.

Figure 1.27. *Traces of Landing,* mosaic showing left hand side of *Curiosity* and the blasts made by the descent stage thrusters, captured by NavCams on 7 August 2012. Photojournal image addition date: 10 August 2012. Credit: NASA/JPL-Caltech.



Walter Benjamin favoured portraits taken in the very early stages of photography because ‘during the considerable period of the exposure, the subject grew into the picture’.[129] Comparing early photography to a studio portrait of the young Franz Kafka, Benjamin remarks that instantaneous photographs – taken in a split second in the studio, with props that do not usually inhabit the sitter’s everyday life – throw the sitter into an artificial environment in which they appear ‘utterly estranged’.[130] If objectivity – as defined by Daston and Galison– is ‘blind sight, seeing without interference, interpretation, or intelligence’ what happens when we can see the imaging device of *Curiosity*? We have all experienced that moment when, after having taken a photograph in a hurry, we realise our finger was partially obstructing the lens, producing an alien pink blur in one corner of our familiar family snapshot. *Curiosity* is the finger on the lens, but in this remote landscape the rover becomes

[129] Dhavernas, 80.
[130] Ibid.

the presence of the familiar in an alien environment. The inclusion of *Curiosity* in figure 1.27 draws this alien terrain home; it gives us a sense of scale; it is the one constant throughout the rover's thousands of images. Yet at the same time this rover's body is alien to the landscape it inhabits, and the landscape is alien to us. Emerging as distorted, stretched, and larger than life due to the angle of the lens, *Curiosity* is Roland Barthes' finger, a terrifying 'trigger' of and on the lens.[131] Appearing as an 'estranged' robotic explorer, this is a window marred by its creator.

The landscape of Mars is without referent, yet it is chillingly familiar. We intuitively correlate this vision with something known; an unidentified monotone desert. It is not only *Curiosity* that makes this alien landscape familiar, it is the very manner in which it recalls the surface of Earth. Anthropologist Lisa Messeri writes about representational practices and their ability to transform Mars from planet to 'place'. Her PhD thesis, "Placing Outer Space: An Earthly Ethnography of Other Worlds" draws on work by exoplanet astronomers at the Chilean Observatory, the Mars 'Mapmakers' of the World Wide Telescope project, and geologists at the analogue Mars Desert Research Site in Utah.[132] Using these examples, Messeri demonstrates how Mars and Earth are 'entwined'; through the activities carried out by scientists, the notion of 'place' is 'a tool of knowing, a way of making sense'.[133] It is through images and language that these unknown worlds are imbued with a sense of the familiar; the alien terrain becomes a cognitively perceivable landscape, a place.[134] When describing the moon, Buzz Aldrin for instance could 'only fall back on the most basic language of aesthetics: "beautiful, just beautiful"'. With this word, claims Sleeman, the alien

[131] Barthes, 15.

[132] An exoplanet is a planet that orbits a star different to our own. The World Wide Telescope is a Microsoft technology that enables your computer to function as a virtual telescope. Users may explore maps of the Earth, the moon and Mars, as well as images of deep space. The software may be downloaded here: http://www.worldwidetelescope.org/. Mars analogue sites are important scientific testing grounds, usually located in barren landscapes such as deserts. At these sites habitats are often set up to simulate future Martian exploration by humans. The sites are used to test scientific equipment, geological theories, and the effects of isolation on small teams of people.

[133] Messeri, 3 & 12.

[134] Messeri articulates how exoplanet scientists use language and metaphors to try and comprehend and picture their targets:

> even when the data suggest exoplanets are like nothing known, astronomers persistently comprehend these planets through allusions to familiar planets in our Solar System. Exoplanet astronomers transform abstract data into planets through visual and linguistic representations. Visually, astronomers experiment with many different kinds of representation attempting to give a "seeable" presence to unseen planets. Rhetorically, astronomers discuss and write about exoplanets using metaphors from our own, familiar, Solar System. When combined, the linguistic and visual semiotics used by exoplanet astronomers create a cosmos teeming with planetary places. These scientific practices facilitate seeing planets and making places.

Messeri, 44.

moonscape is made familiar: 'a view is framed in the camera and we see moon terrain, horizon and sky [...] A landscape panorama rather than a waxing or waning disc in the sky'.[135]

There are no humans on Mars to directly relate an experience of landscape, and some may argue that Mars cannot be a landscape because it lacks this level of human interaction. Philosopher Edward Casey for example insists that the body must be present for a site to become a place.[136] This is mirrored by Rachael Ziady DeLue and James Elkins, who state that the root of the word landscape in Nordic, Germanic and old English outlines a

> combination of meanings that associate a place with the people who dwell there, past and present. Land means both the physical features of a place and its population […] There is a notion, embedded in the original word, of a mutual shaping of people and place: people shape the land, and the land shapes the people.[137]

Similarly, the artist Tacita Dean states that 'landscape is the land transformed, whether though the physical act of inhabitation or enclosure, clearance or cultivation, or the rather more conceptual transfiguration of human perception'.[138] This *conceptual* transfiguration is what Messeri explores in her thesis; suggesting that 'remote presence facilitated by telescopes, satellites, and surface robots allow for sufficient perception of other planets', these alien terrains become landscape through their comparison with the familiar, 'by understanding a distant object through a terrestrial lens'. [139]

Paul Meacham, Principal Systems Engineer of ESA's *ExoMars* Rover Vehicle Project, explains that engineers do not use the term 'landscape' in relation to the rover:

> We mainly use the term terrain because, from an engineering perspective, it is the ground immediately in front of the Rover that we are interested in – for autonomous navigation and locomotion reasons […] it is not something that is really relevant for us. My opinion is that

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[135] Sleeman, 1.

[136] Casey states:

> The more we reflect on place […] the more we recognise it to be something not merely characterisable but actually experienced in qualitative terms. These terms, for example, colour, texture, and depth, are known to us only in and by the body that enters and occupies a given place. Site may be bodiless – it entails a disembodied overview, a survey – but there can be no being-in-place except by being in a densely qualified place in concrete embodiment. Indeed, how can one be *in* a place except *through* one's own body?

Edward S. Casey, *The Fate of Place: A Philosophical History* (Berkeley: University of California Press, 1998), 15. This reflects Maurice Merleau-Ponty's thinking, as outlined in the introduction.

[137] Rachael Ziady DeLue and James Elkins, *Landscape Theory* (London: Routledge, 2008), 92.

[138] Tacita Dean and Jeremy Millar, *Place* (London: Thames and Hudson, 2005), 3. This is also described by John Taylor who argues that

> the category of 'landscape' is primarily not a phenomenon of the natural lie of the land, or human geography, but an attribute of sight […] Walking in the landscape, or taking in the view, required learning and time. The landscape was not to be seen at a glance but had to be brought into focus and 'read' in order to be seen.

Taylor, 12-13.

[139] Messeri, 26 & 29.

> landscapes refer to the large scale features of Mars and the area around us, rather than the small-scale features in front of the Rover.[140]

Similarly, rover driver John R. Wright states:

> I don't call it a landscape, I use the term terrain, which terrain by definition means terra, which means Earth, so it's not really right […] but I do also sometimes call it geographic, aerographic environment, or surrounding. Landscape seems more like a public outreach thing than a technical term.[141]

For a geologist on the other hand, the overall environment is the subject matter, and landscape is a more fitting term, which seems to affirm academic, novelist and critic Raymond Williams statement: 'the very idea of landscape implies separation and observation'.[142] Professor Sanjeev Gupta, Participating Scientist and Long Term Science Planner for *Curiosity* explains:

> I tend to use the word landscape because that's what we're looking at. We are looking at how this landscape formed and obviously the rocks represent an ancient landscape. So my job is to look at the rocks and try and work out what ancient landscape they represent […] *Landscape* describes the shape of the land.[143]

Sweeping hills, rocky outcrops and dusty planes, the images at the centre of this thesis represent a larger picture of Mars. In terms of this study then, 'landscape' seems like a fitting term to describe what these images represent. Furthermore, it is through our perception of it, our desire to experience Mars in an immersive manner, that this unfamiliar terrain becomes a landscape we may inhabit in our own imagination.

Physically however, Mars is a landscape we can only inhabit with our machines. Through the eyes of *Curiosity*, the Martian terrain is subject to Dean's conceptual transfiguration of human perception. 'Like the body,' claim DeLue and Elkins, 'landscape is something we inhabit without being different from it: we are in it, and we *are* it'.[144] By transforming *Curiosity's* images into ones we can perceive more readily, we may inhabit the landscape in a different sense; virtually. The next chapter will set up notions of the glitch; as reminders of the process of representation, glitches manifest themselves in different forms. As pervasive triggers to our Earthly reality, we are only able to inhabit the *image* of Mars.

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[140] Paul Meacham (Principal Systems Engineer, *ExoMars* Rover Vehicle Project), email message to author, 9 June 2014.

[141] Wright, interview, 2 November 2015.

[142] Raymond Williams, *The Country and the City* (London: Paladin, 1975), 149.

[143] Gupta.

[144] DeLue and Elkins, 69.

In the introduction I outlined how different forms of writing will be used as a research method; from this point onwards such interludes will come into play. Descriptive, imaginative and speculative, these pieces of writing will offer moments of contemplation through prolonged periods of looking. This thesis explores the more immersive image forms used in Mars exploration, each of which attempts to envelop the viewer in an image. As I outlined in the introduction, Maurice Merleau-Ponty's studies on perception emphasise the importance of experiencing the world from 'the inside'.[1] As Mars cannot be stepped onto physically, it is the image that must be stepped into, imaginatively and at times physically. These speculative intervals will consider what it may be like to step into the image as an imaginative and immersive encounter. It is through these prolonged encounters with the image forms of Mars that glitches gradually reveal themselves. As distillations of thought and tasters of what's to come, these short texts will complement and engage with the ideas being explored in Chapters 2, 3, 4, and 5.

[1] Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 178.

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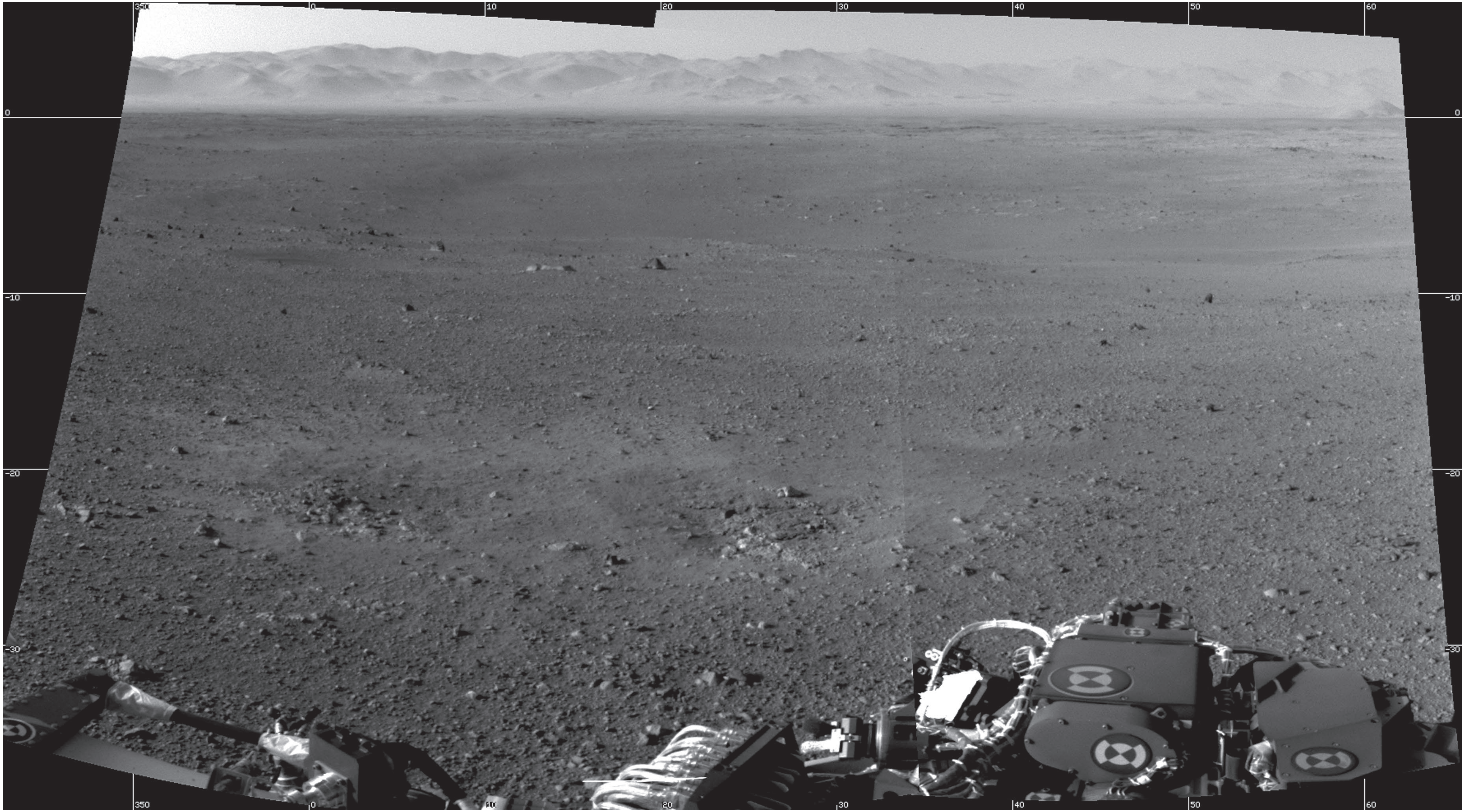
Chapter 2

Curiosity's New Home: Stepping through a Fractured Window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Imagine being swept through the frame into this monochrome landscape. Already virtual illusion has been broken, already we are aware of the landscape's blatant reconstruction into image. Through its greys a screen is thrown up, the red dirt has become pallid and ghostly through the photographic veil of black and white so that the dust hangs in the smoky atmosphere like ash. The mountainous landscape looms ahead, draped in a fabric of the finest particles, its translucency becoming densely opaque as it gathers to form a thick haze at the base. A landscape blanched of all its colour, washed in grey.

Curiosity's New Home *resembles a stage set, constructed through the bringing together of two images, the landscape here becomes a collage, a fractured image, a cracked illusion. The frame here is quite literally on the point of collapse, will it fall upon the ground, disturbing the landscape's stillness with plumes of dust and debris? Will it drag us with it into image space?*

Two images join in a mismatch of information, this is the point of both extended representation and failed illusion. Alberti's grid pierces through the translucent film of representation, the two pieces join uneasily in the middle forming a rift in image space. On closer inspection this join is actually an overlay, it is not two pieces of an ill-formed jigsaw but two fragments superimposed in a patch-worked illusion. The space of the image attains another dimension; not a window and no longer flat, it occupies a strange space between the two. The picturing of the machine brings the image closer to the foreground, closer to us. We must step over it, onto the surface of this other land. But the landscape has been transformed through this overlapping, no longer a window onto the world, but two windows each fighting to come to the fore. The chasm in image space is inescapable, the images cannot be melded together. Standing as proof of construction as reconstruction, of an accumulation of vision from constituent parts that match in landscape form but not in tone, the seam rushes forwards, a traumatic bulge in vision; a rupture in a reassembled landscape. It is a glitch in the composite image.

Figure 2.1. *Curiosity's New Home,* 8 August 2012. Credit: NASA/JPL-Caltech.

> What happens if we think about the elusive whatever-it-is that lies at or beyond the periphery of vision? What happens if we attend to that which we don't quite see?[1]
>
> John Law.

On 6 August 2012, NASA's rover *Curiosity* landed in the middle of Gale Crater. The image above is a composite – like many of those discussed in Chapter 1 – of the first two full resolution images of the Martian surface the rover captured with its Navigation Cameras, located on its 'head'. The mountainous rim of Gale Crater can be seen beyond the pebbly ground in the distance and the foreground shows two distinct zones of excavation likely carved out by blasts from the rover's descent stage thrusters. As the first clear image of its new surroundings, the title, *Curiosity's New Home,* is embodied with romantic notions of exploration and things to come.[2]

Stripping the Martian terrain of its colour and sweeping the red haze from the sky, the Navigation Cameras on *Curiosity* re-present Mars as a familiar 'snapshot'; if the distorted body of the rover were removed, we could easily be tricked into believing that this is a place on Earth. But we cannot have the same relationship with this terrain as we might have with a landscape as represented in a souvenir photograph; we have no way of gaining a first-hand experience of this environment and so the rover remains the mechanism through which our perceptions of Mars are formulated. By capturing Mars in black and white, and through the amalgamation of two images, *Curiosity's New Home* is a stark reminder of how pictures play a crucial role in our perception of unknown terrains. Through the camera's lens the Red Planet has been framed as monochrome landscape, breaking all possibility of virtual illusion and forcing an awareness of the landscape's reconstruction as image.

In many ways *Curiosity's New Home* has formed the basis of this thesis; there is something so innately familiar about this monochrome landscape, yet the composition of the image presents itself so readily, standing in the way of complete immersion. *Curiosity's New Home* is a simple yet striking image, and is an ideal entity with which to introduce the notion of 'glitch' set out in the introduction and alluded to throughout Chapter 1. It will be important to compose a thorough understanding of this concept, which will become instrumental in deconstructing the virtual image forms explored in the chapters that follow. This chapter then will set up key ideas on the glitch taken from Jacques Lacan, Slavoj Žižek

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[1] John Law, "Indistinct Perception," in *Representation in Scientific Practice Revisited,* ed. Catelijne Coopmans, Michael Lynch, Janet Vertesi and Steve Woolgar (Cambridge, MA: The MIT Press, 2014), 337.

[2] NASA often give their images such names, labelling surface features or sites after influential people. *Curiosity's* Bradbury Landing site for instance is named after science fiction writer Ray Bradbury.

and Rosa Menkman. Through the presence of the glitch – a break in the transparency of the image manifest here in the seam, the veil of black and white and the presence of the rover – the image as construction reveals itself, making us aware that we look at this landscape through many mediating screens and in turn through our own subjective lens. This chapter continues with an analysis of the frame as a glitch and using Jacques Derrida's writing on the *parergon* I argue for the necessity of the frame to indicate absence, revealing the distance and darkness through which this image has had to travel to reach our eyes. Fracturing Alberti's notion of the image as a 'window' the glitch highlights the materiality of the image and the interface, of the image as the real thing; the *image-as-image*.

Figure 2.2. Albrecht Dürer, *Draftsman Drawing a Reclining Woman,* Woodcut, 1525.

Mars through Alberti's Veil

In 1435 Leon Battista Alberti wrote the first modern treatise on painting, *Della Pittura*. Building on Brunelleschi's discovery of linear perspective, circa 1420, Alberti used the pyramid as a visual cue; the flat base being the picture plane and the tip being the most distant object in the scene, what became known as the vanishing point.[3] Breaking with traditions of the Middle Ages, this system helped to develop a new practice of painting (and drawing) that used the aid of a mechanism to re-present a scene piece by piece. Illustrated in Albrecht Dürer's famous 1525 woodcut print, Alberti's drawing machine used a square wooden frame with vertical and horizontal threads stretched at regular intervals to form a grid.[4] Described

[3] Leon Battista Alberti, *On Painting*, trans. John R. Spencer. (1435-1436, New Haven: Yale University Press, 1970), 19-21.

[4] A rod was always placed in front of the frame at the 'same height as the distance from the bottom of the frame to the middle of the grid'; this ensured that, 'by lining up the eye with the rod and the centre of the grid, the eye is always fixed in the same position'. National Portrait Gallery, "The Drawing Machine," accessed 2 October 2015, http://www.npg.org.uk/learning/digital/portraiture/perspective-seeing-where-you-stand/the-drawing-machine.php.

by Alberti as an 'intersection' it was made up of a thin, finely woven veil, with larger threads marking out the parallel lines.[5] The artist looked through this frame and copied each segment onto matching gridded paper. Thus, a frame was imposed upon the subject at the beginning of the work's inception and the artist was given a mechanical means to reproduce the surface of the visible, not unlike photography. The painter, according to Alberti, should be 'concerned solely with representing what can be seen' and 'has nothing to do with things that are not visible'.[6] Likewise, *Curiosity's New Home* is a mechanical realisation captured by a camera frame by frame, an image that reveals what is visible for the rover at a given time. Nature is thus reconstructed via a mechanical gaze, supposedly with little human intervention. However, as discussed throughout Chapter 1, even the simplest image is subject to various levels of mediation.

Developments in the fields of phenomenology and psychoanalysis in the 20th century further complicated the study of framing devices and their relationship to the image, the visible, and structures of consciousness. Five centuries after Alberti's *Della Pittura*, the psychoanalyst Jacques Lacan described the transformation of vision and the image. His theory is especially important here as it helps to set up the notion of an image as a means by which the viewer becomes aware of their own act of looking. The image in this case defies Alberti's concept of a 'window'. Lacan writes:

> Vision is ordered according to a mode that may generally be called the function of images. This function is defined by a point-by-point correspondence of two unities in space. Whatever optical intermediaries may be used to establish their relation, whether their image is virtual, or real, the point-by-point correspondence is essential. That which is the mode of the image in the field of vision is therefore reducible to the simple schema that enables us to establish anamorphosis, that is to say, to the relation of an image, in so far as it is linked to a surface, with a certain point that we shall call the 'geometral' point. Anything that is determined by this method, in which the straight line plays its role of being the path of light, can be called an image.[7]

This combination of art and science is true of Alberti's painting method and photography; reducing vision into image via a 'simple schema' that utilises the reflection of light off an object, into the eye of the viewing subject.

Figure 2.3. Jacques Lacan, diagrams from seminar "The Line and Light," in *The Four Fundamental Concepts of Psychoanalysis,* ed. Jacques-Alain Miller, trans. Alan Sheridan, 5th ed. (London: Penguin Group, 1994), 91.

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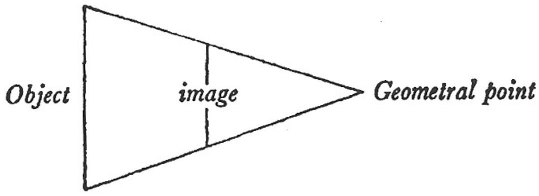
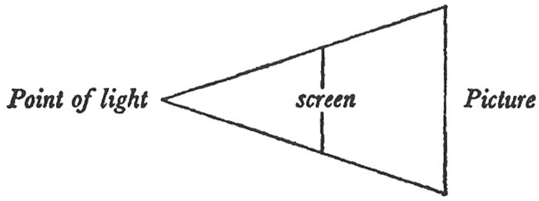
[5] Alberti, 26-27.
[6] Ibid., 8-9.
[7] Jacques Lacan, *The Four Fundamental Concepts of Psychoanalysis,* ed. Jacques-Alain Miller, trans. Alan Sheridan, 5th ed. (London: Penguin Group, 1994), 86.





Lacan called for a deeper understanding of the construction of pictures, and claims that Alberti's method 'merely yielded a geometrical mapping of three-dimensional space rather than an adequate understanding of the libidinal dynamics of embodied human vision'.[8] Referring to Maurice Merleau-Ponty, Lacan observes that 'the regulation of form' is governed

> not only by the subject's eye, but by his expectations, his movement, his grip, his muscular and visceral emotion – in short, his constitutive presence, directed in what is called his total intentionality.[9]

To illuminate this, Lacan drew a series of diagrams in order to demonstrate his impression of a 'picture', namely to show that we are both a viewing subject, and viewed by others as a picture. In Lacan's first diagram, rays of vision spill out in the shape of a triangle to encounter the object from the viewer's eye (the geometral point) and the image sits midway between the subject and the eye. In the second diagram we see light emanating from the object; 'illuminated by the light of the world', 'it turns *me* [the subject] into a picture'.[10] Lacan uses an analogy of a tin can floating at sea: 'it was looking at me at the level of the point of light, the point at which everything that looks at me is situated'.[11] He continues:

> I must, to begin with, insist on the following: in the scopic field, the gaze is outside, I am looked at, that is to say, I am a picture. This is the function that is found at the heart of the institution of the subject in the visible. What determines me, at the most profound level, in the visible, is the gaze that is outside. It is through the gaze that I enter light and it is from the gaze that I receive its effects. Hence it comes about that the gaze is the instrument through which light is embodied and through which – if you will allow me to use a word, as I often do, in a fragmented form – I am *photo-graphed*.[12]

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[8] Steven Z. Levine, *Lacan Reframed* (London: I.B. Taurus, 2008), 80-81.
[9] Lacan, 71.
[10] Levine, 81; Lacan, 105.
[11] Ibid., 95.
[12] Ibid., 106.

The screen, which Lacan calls a 'stain' or 'spot' (*la tache*), is the subjectivity of the viewer, a pre-existing 'set of signifiers' that affects *how* one looks upon an object. For philosopher and cultural theorist Slavoj Žižek, we can never experience reality as 'whole' (just as we cannot experience ourselves as whole beings without the mirror image), not because, he writes 'a large part of it eludes me, but because it contains a stain, a blind spot, which signals my inclusion in it'.[13] 'The screen is here the locus of mediation' and Lacan's final diagram (created by laying the two triangles on top of one another) highlights the mediation that occurs between the viewing subject (the seeing eye) and the image.[14] It is through a 'lack' that we become aware of our own subjectivity and the impossibility of seeing through another's gaze: 'I see only from one point, but in my existence I am looked at from all sides.'[15] For Lacan, this encounter with the picture makes evident the subjective positioning of the viewer and also its limitations and essential difference. In this scopic regime, the act of seeing is not given, but constructed, continually mediated through the screen.[16] Through the picture, we may see ourselves seeing ourselves and simultaneously become aware that we can never see ourselves through the eyes of the other. It is through this process that we become aware of the act of looking.

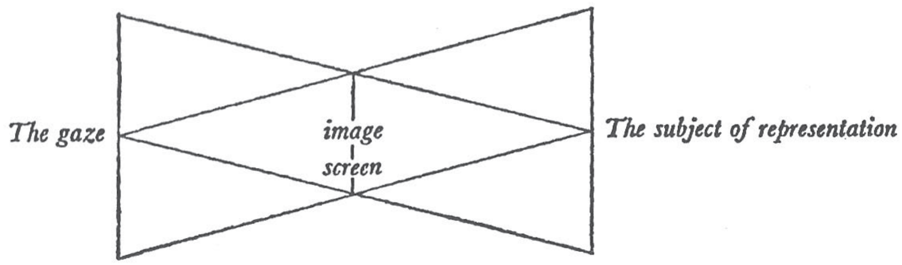

Figure 2.4. Jacques Lacan, diagram from seminar "What is a Picture?" in *The Four Fundamental Concepts of Psychoanalysis,* ed. Jacques-Alain Miller, trans. Alan Sheridan, 5th ed. (London: Penguin Group, 1994), 106.

[13] Slavoj Žižek, "The Tickling Object," The Parallax View, accessed 15 February 2016, http://www.lacan.com/zizparallax.htm. When the infant identifies herself in the mirror she recognises this perfect, whole complete self, so the self becomes a kind of object that we strive for, the object of desire. But a whole complete self is impossible to obtain, as we experience ourselves on a day to day basis from the inside, as a mass of body parts, emotions and thought.

[14] Lacan, 107.

[15] Ibid., 72.

[16] The term 'scopic regime' was first coined by the French film theorist Christian Metz in *The Imaginary Signifier: Psychoanalysis and the Cinema* (French 1975). What distinguishes cinema from theatre is lack; the absence of the thing represented. Christian Metz, *The Imaginary Signifier: Psychoanalysis and the Cinema,* trans. Celia Britton, Annwyl Williams, Ben Brewster and Alfred Guzzetti (Bloomington: Indiana University Press, 1977), 61.

In *Curiosity's New Home,* we look out towards the mountainous rim of Gale Crater through the lens of *Curiosity.* The image that we encounter is both a mathematically prescribed 'window', a term used by Alberti, but also a subjective interpretation of the scene. The image is not whole and it is clear some information is missing; it is up to us as viewers to navigate the unknown edges this picture fails to show. In a sense, *Curiosity* becomes a form of Lacan's *tache*, a reminder that we view the Martian landscape through the mechanical gaze of the rover's lens before our own. *Curiosity* is the other, whom we may gaze upon, but because we are not able to conceive it in its entirety, and because it is the lens (the screen) through which our perception of this other land is mediated, we become inscribed in the picture through a complex web of vision.

Alberti believed paintings constructed via his method could be considered as windows 'piercing a wall through which the spectator can look into an interior'.[17] This window, according to Hubert Damisch, author of *The Origin of Perspective,* could also be a door:

> Whereas the image of the "window" implies a solution of continuity between the ground supporting the observer and that upon which the representation sits, this does not hold for a *door,* even when its threshold is preceded by a few steps or opens onto a sunken interior.[18]

We look through a window frame, yet we may step into the space beyond a door. The absent information in *Curiosity's New Home* seems to call for us to step beyond the frame, over the body of the rover and into the image.

<u>The Glitch: Revealing the Real</u>

Rosa Menkman's *The Glitch Moment(um)* is a study of the theory, practice and social context of 'Glitch Art', in which the digital glitch is discussed both as a break in the transparent portrayal of information, and as an aesthetic. Menkman proposes that the glitch manifests itself through any break in the medium's transparency and builds on the assumption that 'technology can be "see through", or does not intervene into the process of sending or perceiving information'.[19] She states:

> I describe the 'glitch' as an (actual and/or simulated) break from an expected or conventional flow of information or meaning within (digital) communication systems that results in a perceived accident or error. A glitch occurs on the occasion where there is an absence of (expected) functionality, whether understood in a technical or social sense. Therefore, a glitch, as I see it, is not always strictly a result of a technical malfunction.[20]

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[17] Hubert Damisch, *The Origin of Perspective,* trans. John Goodman (Cambridge, MA: The MIT Press, 1994), 102.
[18] Ibid.
[19] Rosa Menkman, *The Glitch Moment(um)* (Amsterdam: Institute of Network Cultures, 2011), 14.
[20] Ibid., 9.

As Anthony Bryant and Griselda Pollock observe in *Digital and Other Virtualities*, 'when a medium is new, it is often used to simulate old media'.[21] A glitch can be applied as an aesthetic, a manifestation of failure or to evoke a sense of nostalgia for analogue technologies. Glitches and filters are staged in order to feign some kind of authenticity and the recent influx of apps like Instagram and iGlitch are examples of this trend.

Of greater relevance to this study is the origin of the term glitch; predominantly referring to failure, it was first used by astronaut John Glenn in 1962 to describe unknown and unspecified problems, an 'unexpected occurrence, unintended result, or break or disruption in a system'.[22] The term then is inherently digital, signifying a rupture, a loss of transparency which creates an awareness of the interface. With virtual reality 'we are dealing with the loss of the surface which separates inside from outside' but the glitch makes this surface apparent, throwing us back into our physical reality.[23]

The glitch might also be seen with reference to the Lacanian 'blind spot' as described by Slavoj Žižek in *The Plague of Fantasies* (1997). The glitch functions for Žižek as a means to distinguish between the real and the artificial; in the context of *Curiosity's New Home* the glitch reveals the difference between landscape and its image. Žižek claims that virtual realities undermine the 'difference between "true" reality and semblance' and this 'loss of reality' is occurring with the growing hyperrealism of images.[24] He suggests that the difference between reality and the artificial is being undermined by systems that make living beings 'technically manipulable'. In techno-biology for instance, it is possible to alter genetic information to change the baby's sex or hair colour: the natural and the organic become simulated and controllable and so 'virtual' here can be seen in the context of the artificial masquerading as real.[25] Žižek argues that because these images have become visually limitless (i.e. there is nothing standing in the way of making something unreal appear real) there is no longer, to use Lacan's term, a '*blind spot* in the field of vision'.[26] Referring to Lacan, Žižek writes:

> the subject's gaze is always-already inscribed into the perceived object itself, in the guise of its "blind spot", that which is "in the object more than object itself", the point from which the object itself returns the gaze. "Sure, the picture is in my eye, but me, I am also in the picture."[27]

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[21] Anthony Bryant, and Griselda Pollock, eds., *Digital and Other Virtualities: Renegotiating the Image* (London: I.B. Taurus, 2010), 13.
[22] Menkman, 26.
[23] Slavoj Žižek, *The Plague of Fantasies* (London: Verso, 1997), 134.
[24] Ibid., 133. As I outlined in the Introduction, Jaron Lanier defines 'virtual' in 1987 as meaning both 'not really existing' and 'almost the same'. Bryant and Pollock, 11.
[25] Žižek, *The Plague of Fantasies,* 133.
[26] Ibid.
[27] Žižek, "The Tickling Object."

For Lacan the picture is always 'stained' by our language and subjective positioning, which forms a 'blind spot', meaning we can never fully 'see' the picture or object in its entirety. Might the glitch be considered Lacan's 'blind spot'? Piercing the screen, it is a point of rupture and disturbance, preventing us from being able to disappear into the world of the image, pushing us back to the surface.

The glitch in *Curiosity's New Home* takes several forms; firstly, there is the frame, which clearly designates the visual limit, what can be seen and what cannot. Secondly there is the seam; running down the middle, our smooth window is sharply interrupted as we are reminded of its materiality. Thirdly we have the body of *Curiosity,* the machine that enables this vision, but also becomes a part of it; we cannot see below its body and at the ground where it stands. The rover is engulfed in its own shadow, simultaneously giving access to, whilst withholding a full view of the terrain. The representation of landscape in black and white is arguably another manifestation of the glitch, veiling the dusty browns of Gale Crater and the pink haze of the sky.

Žižek argues that without an 'elusive point from which the object returns the gaze' we do not see something for what it is in reality, rather 'the field of vision is reduced to a flat surface, and "reality" itself is perceived as visual hallucination'.[28] In Lacan's later work, the gaze refers to the uncanny feeling that the object looks back at us and he uses Hans Holbein's painting *The Ambassadors* to exemplify this point. Realising that there is more to the painting than initially meets the eye, we observe the anamorphic skull upon going to leave the room to the right hand side of the painting, and casting a glance back. We are no longer objective observers; our presence and position are essential to the understanding of the painting. The skull, when viewed face on, does seemingly not belong; it is a 'blot' on the trompe-l'oeil, 'denaturing' the painting and calling for interpretation, just as the seam calls for the viewer of *Curiosity's New Home* to distinguish the image as a composite.[29]

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[28] Žižek, *The Plague of Fantasies,* 133. This is further exemplified by Žižek in *The Pervert's Guide to Ideology*, in which Žižek uses clips from popular culture cinema to illustrate his points. In the opening discussion, we watch the protagonist of the 1988 film *They Live* put on a pair of dark sunglasses: donning these, the character is able to see the true messages behind advertisements, magazines, and even money. For Žižek the 'glasses function like a critique of ideology […] they allow you to see the real message […] when you put the glasses on, you see dictatorship in democracy, it's the invisible order which sustains your apparent freedom'. Revealing the truth is a painful experience, which the film reveals in the protagonist fighting with his best friend to put on the glasses: it is a 'painful experience to step out of ideology'. The glasses, like the seam in *Curiosity's New Home* 'shatter your many illusions'. Slavoj Žižek, *The Pervert's Guide to Ideology,* dir. Sophie Fiennes, aired 4 October, 2013, on Channel 4, DVD (2013).

[29] Slavoj Žižek, *Looking Awry* (Cambridge, MA: The MIT Press, 1991), 91.

Figure 2.5. Hans Holbein the Younger, *The Ambassadors,* oil on oak, 1533.

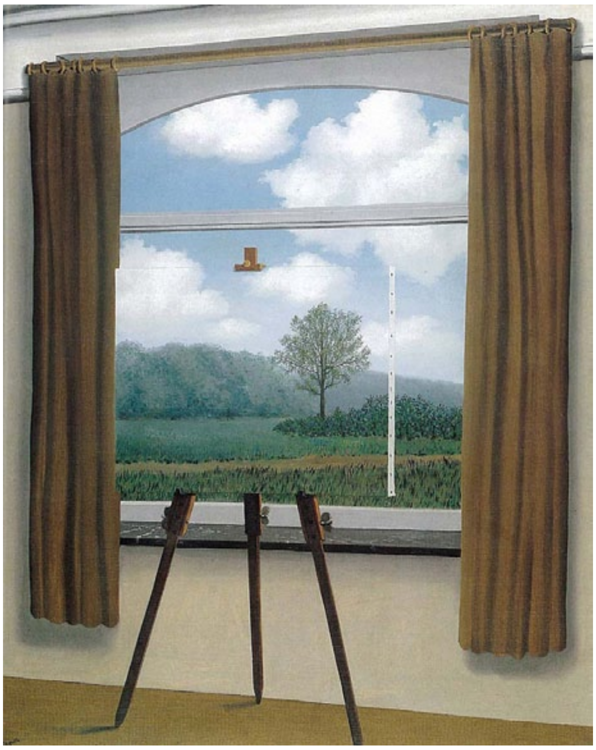

Figure 2.6. René Magritte, *La Condition Humaine,* oil on canvas, 1933.

In *Curiosity's New Home*, the two-part image signifies a projected and symbolic landscape; without a referent for Earthbound viewers, this landscape is always necessarily imaginary. These glitches are blots on the representation, meaningless to and overlooked by the scientific onlooker, yet they inevitably reveal the image as a screen. The seam in *Curiosity's New Home* disturbs the transparency of the image in the same way that the raw edge of René Magritte's canvas in *La Condition Humaine* disturbs the view through a window. Steven

Levine writes on the painting that the canvas edge 'openly proclaims the artificial status of the work as a Symbolic representative of an Imaginary representation of the world'.[30] The materiality of the image is revealed by Magritte in the white strip of raw canvas, the hovering tip of the easel, and the way the curtain is cut off by the edge of the painting. Similarly, the *image-as-image* is revealed in *Curiosity's New Home* by the dark shaded strip resulting from the overlapping of images. The seam hints at Lacan's *tache*, a chasm that simultaneously acts as an ostensible indication of flatness, forcing an awareness of our own position as viewing subject. This is the moment when the image fails to represent its own picture, becoming undone. Like the viewer of Holbein's anamorphic skull, we become unsettled, aware of our own fragile position as a viewer.

There seems to be a correlation here between the glitch and Roland Barthes' '*punctum*'. In *Camera Lucida* Barthes writes on what he feels are two essential aspects of photography; the *studium* and the *punctum*. Deriving from Latin, *studium* is defined as an 'average affect' brought about by photographs. The *studium* is the reason why we have a general interest in images, be they political or historical and it is because of a 'kind of education' that we may 'encounter the photographer's intentions'. But it is the *punctum*, derived from the Latin to 'prick' which 'rises from the scene, shoots out of it like an arrow, and pierces me'. For Barthes not all photographs have a *punctum*, but the odd one might be 'punctuated' by these 'sensitive points' or 'wounds', bringing out the true nature of photographs.[31] The *punctum* is revealed during subjective encounters with images; for Barthes it might be the presence of a woman's lace-up pumps, a child's teeth or a necklace, and these features serve to draw us *in* to photographs.[32]

Unlike the *punctum* the glitch functions to push us *out* of images and Žižek suggests that such glitches are necessary in bringing us back into the realm of the Real; in the case of *Curiosity's New Home* the fracture in illusion reminds us that we are looking at an object of representation and not at the landscape itself. Rosa Menkman writes:

> A glitch represents a loss of control. The 'world' or the interface does the unexpected. It goes beyond the borders of its known and programmed territories, changing viewers' assumptions about technology and its assumed functions […] and it comes to seem profoundly irrational in

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[30] Levine, 108. Lacan's psychoanalytic triad of ideas, developed in his 1950s lectures in Paris, can be a means to understand the glitch in *Curiosity's New Home* as a revealing device. Lacan's Symbolic-Imaginary-Real idea is 'rooted in the Freudian Oedipal stage and the process of uncovering the unconscious through language and association which ties notions of subjectivity with individual perceptions and how these are affected by the external world'. Amanda Loos, "Symbolic, Real, Imaginary," The University of Chicago, Theories of Media: Keywords Glossary, Winter 2002, accessed 15 February 2016, http://csmt.uchicago.edu/glossary2004/symbolicrealimaginary.htm.

[31] Roland Barthes, *Camera Lucida: Reflections on Photography*, trans. Richard Howard (1981; repr., London: Vintage, 2000), 26-27 & 57.

[32] Ibid., 43, 45.

> its 'behaviour'. The glitch makes the computer itself suddenly appear unconventionally deep, in contrast to the more banal, predictable surface-level behaviours of 'normal' machines and systems. In this way, glitches announce a crazy and dangerous kind of *moment(um)* instantiated and dictated by the machine itself.[33]

The glitch enables us to see past the glossy interface of the screen and into the construction of the image, into the mechanism of the device used to construct it. For Menkman, as for Žižek it is the break in illusion that unveils the real thing, the presence of the image rather than the landscape it represents. The 'digital break' throws the viewer into a 'more risky realm of image and non-image, meaning and non-meaning, truth and interpretation' whereby the viewer is consciously aware of the act of looking.[34] Unlike a trompe-l'oeil painting, which attempts to trick the viewer into believing the representation is reality, *Curiosity's New Home* is aware of its own materiality.[35]

In *The Logic of Sense,* Gilles Deleuze writes on the 'crack' as an energetic form which creates movement between inside and outside:

> The real difference is not between inside and outside, for the crack is neither internal nor external, but is rather at its frontier. It is imperceptible, incorporeal, and ideational. With what happens inside and outside, it has complex relations of interference and interfacing, of syncopated junctions – a pattern of corresponding beats over two different rhythms […] Conversely, the crack pursues its silent course, changes direction following the lines of least resistance.[36]

The edge created by the overlain images in *Curiosity's New Home* is at once flat and three-dimensional, integral to, but hovering above the image space, it trembles like Deleuze's crack. Ready to step out onto the terrain, the Martian landscape suddenly flickers, the join in image data becoming the Real frontier, the crack through which seeps the presence of *Mars-as-image*, and our futile endeavour to feel the dust and pebbles beneath our feet. By showing the seam and presenting the image against a black border it does not try to say 'this is Mars' but instead 'this is an image of Mars'.[37]

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[33] Menkman, 41.

[34] Žižek, *The Plague of Fantasies*, 151; Menkman, 31.

[35] This type of trickery is exemplified in the ancient story of Greek painters Zeuxis and Parrhasius. Challenging each other to a painting contest, Parrhasius painted grapes so lifelike that birds flew up to the painting to peck at them. Turning to Zeuxis's work, Parrhasius requested the curtain be drawn to reveal the painting, only to discover it was the curtain that was the painted illusion.

[36] Gilles Deleuze, *The Logic of Sense,* ed. Constantin V. Boundas, trans. Mark Lester (London: The Athlone Press, 1990), 155.

[37] Mars is an inhospitable place: we would die in an instant if we were to land there and walk across its surface unprotected. *Curiosity's* images act as boundaries between us and a formidable terrain. When humans land and live on Mars, boundaries of a different kind will be essential for survival such as spacesuits and pressurised living quarters, or 'habs'. This need for maintaining boundaries is dramatically illustrated in Ridley Scott's 2015 blockbuster film *The Martian* in which, after being stranded on Mars, protagonist Mark Watney 'sciences the shit' out of what is to hand.

The Frame as Permeable Void

Professor of photography and imaging Fred Ritchin observes that 'unless obviously montaged, the photographic attraction resides in a visceral sense that the image mirrors palpable realities'.[38] *Curiosity's New Home* defies this notion of the image as mirror through the shattering of Alberti's perfectly whole window pane. This landscape is not palpable, to use Ritchin's key term and it is through the impurity of the image make-up that we are reminded of this landscape's intangibility. But it is not only the join between the two image fragments that withdraws the landscape from us, moreover there is a direct withdrawal of image space behind the blackness of its frame. But is this space to be seen as positive or negative? Does it frame the image, pushing it back, or can it be seen as a black void behind the image space? A chasm with steep sides and the image as its peak, from which everything else not captured by the camera falls away into blackness.

Figure 2.7. Pere Borrell del Caso, *Escaping Criticism,* oil on canvas, 1874.

Unpacking potatoes saved for Thanksgiving dinner, Watney plants and grows these in the hab. The middle of the film is marked by a catastrophe; a sudden de-pressurisation of the habitat causes the door to blow off and Watney's crops are exposed to the harsh Martian atmosphere and sub-zero temperatures. The crops freeze instantly, and crumble in Watney's hand. It is at this moment we gain a true sense of the inhospitable nature of Mars, the fragility of life on an alien planet, and the absolute necessity of keeping the outside at bay. Boundaries play an important part, both in the film, and in current human spaceflight. *Curiosity's* images allow us to look upon this terrain from the safety and security of our homes and offices: protecting us from the real Mars, it is distance that acts as a boundary here.

[38] Fred Ritchin, *In Our Own Image: The Coming Revolution in Photography* (New York: Aperture, 1990), 2.

Like the boy in Pere Borrell del Caso's *Escaping Criticism,* the seam in *Curiosity's New Home* draws our attention outward, to the surrounds of the picture. The surrounds of each are integral to, but separate from, the picture itself and it is in this regard that Jacques Derrida's *parergon* may be considered in relation to *Curiosity's New Home.* The concept of the *parergon* is used by Derrida in a number of ways, primarily as a cipher in order to deconstruct Kant's third book *Critique of Judgment,* especially with regard to the construction of the idea of beauty.[39] Kant's own examples of *parerga* are explored, but the concept is furthered by Derrida to suggest a discursive framing as well as a physical one, delineating inside from outside, which may also be applied to the way texts are framed to suggest things that can never exist solely on their own, in and of themselves.[40]

Derrida takes Kant's example of the drapery on stone figure statues to illustrate the *parergon* in the first instance. Here the *parergon* adorns the work (otherwise known as the *ergon*), however, being an extension of the stone and of the subject's dress, it is never totally exterior to it.[41] A *parergon,* according to Derrida, is 'against, beside, and above and beyond the *ergon* […] But it is not incidental; it is connected to and cooperates in its operation from the outside.'[42] Derrida refers to the drapes in order to posit the *parergon* as a form of ornamentation, to refer to it as not 'interior or intrinsic' but belonging to an 'extrinsic fashion', 'as a surplus, an addition, an adjunct'.[43] The drapery on statues 'simultaneously adorns and veils their nudity', 'clinging to the work's edges as to the body represented' but 'not a part of the representative whole'.[44] Portrayal of these drapes in the same material stuff as the represented body, this *parergon* hovers on the edge of exteriority (to the human figure) and interiority (to the work, being part of the representation). Adorning the edges of the grey-scale image and providing a necessary surround for the image to fit into a standard rectangle, the black frame of *Curiosity's New Home* can be seen as a *parergon*, 'a detachment which is not easily detached'.[45] The image is made of the same – this time immaterial – stuff (ones and zeroes) and shown on the singular substrate of the screen, yet we are able to delineate

[39] Derrida first examines Kant's notion of judgment of taste, stating that it is not logically constructed, but rather subjective, aesthetic, therefore relating to affect. Interest, states Derrida, is 'always related to the existence of an object' and pertinent to Kant's judgment of taste is the concept of disinterestedness, beauty being defined by 'pure and disinterested pleasure'. Thus the person must remain disinterested if s/he is to form a pure judgment of taste. Jacques Derrida, "The Parergon," trans. Craig Owens, *October* 9 (Summer 1979): 11-12, accessed 7 January 2015, http://dx.doi.org/10.2307/778319.

[40] Ibid., 20.

[41] Ibid., 18.

[42] Ibid., 20.

[43] Ibid., 21.

[44] Ibid., 22.

[45] Ibid.

between two implied surfaces. The frame and the image are interpreted visually as representing two totally different entities.

The second example of a *parergon* taken from Kant is the columns holding up buildings: this example offers a further complication for Derrida in that the division between outside and inside, between *parergon* and *ergon*, cannot be delineated as easily as that between the body and cloth.[46]

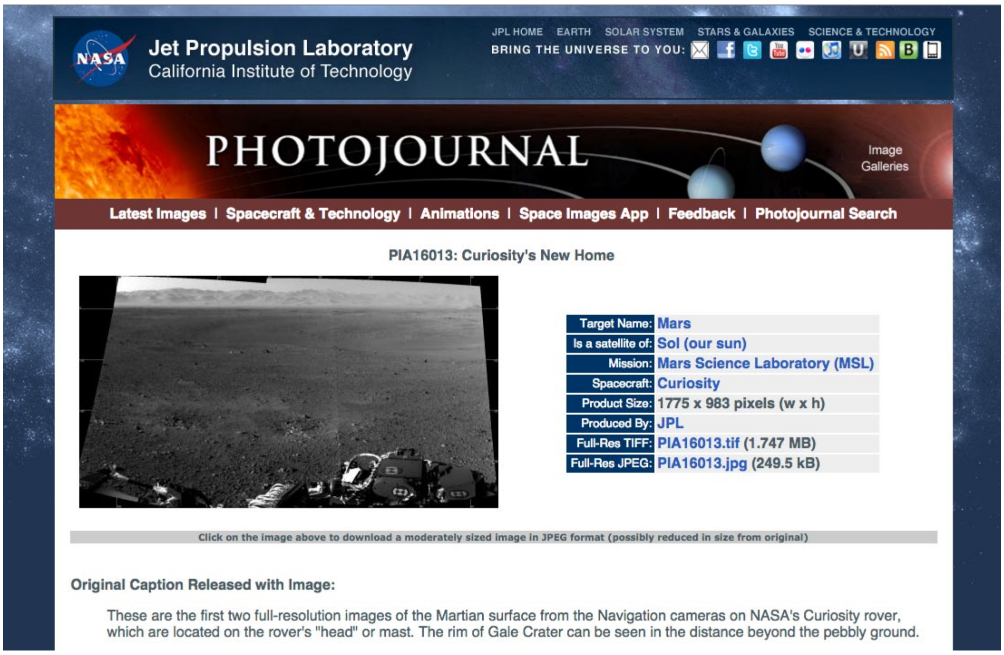

Figure 2.8. Screenshot of *Curiosity's New Home* image page on NASA/JPL-Caltech's *Photojournal* online image archive.

As a third example most relevant to *Curiosity's New Home*, Derrida explores the *parergon* as frame, specifically as a frame to a painting. Again, the *ergon* is both distinguishable and inseparable from the *parergon*:

> The incomprehensibility of the border, at the border, appears not only at the inner limit, between the frame and the painting, the drapery and the body, the column and the building, but also at its outer limit. *Parerga* have a thickness, a surface which separates them not only, as Kant would have it, from the body of the *ergon* itself, but also from the outside, from the wall on which the painting is hung, the space in which the statue or column stands.[47]

The *parergon* is essential for *Curiosity's New Home* in that it is both a frame and a space for contemplation. This incomprehensibility, represented by blackness and gridded with fine white lines, becomes another space altogether, both within the image and exterior to it, it

[46] Ibid.
[47] Ibid., 24.

holds the two-part image of Gale Crater in place, preventing either image from displacing and slipping down to reveal an inner working. This frame also provides a secondary function, transforming the fractured 'window' into the substrate of a digital image, an object with four right angles, which may be readily presented on screen in a further 'window' of the viewer's web browser (fig. 2.8). In this regard the frame is somewhat imperceptible. For Derrida the framing device does not mean the ground on which the image is painted, yet it should, in a similar manner to the ground, be invisible, determined by its 'disappearing' and 'sinking in'.[1] It is in this respect that the *parergon* may 'augment the pleasure of taste', contributing to the 'intrinsically aesthetic representation itself' but it mustn't hold its own charm: the gilded frame for example diverts our attention toward the *parergon*, thus it must always remain pure 'without colour, free from all sensible, empirical materiality'.[2]

Framing is important for immersive image forms; it holds the illusion in place, yet at the same time must be invisible, allowing the viewer to step imaginatively past the frame and into the image. A frame is, according to Derrida, 'constructed and therefore fragile, this is the essence or truth of the frame'.[3] The black frame of *Curiosity's New Home* is a non-space, the edge and limit of the image, a space of pure invisibility, interrupted only by the white lines that point towards the image's technical construction. A border between what is seen and unseen, it makes sense that such images emerge from darkness, against a space of infinite blackness. We see through the unknown, through the void of space; the border also represents the distance these images – sent as radio signals to Earth – have had to penetrate. It is in this space we realise the frailty of the act of representation in visioning the unknown.

In this case revealing the frame means to reveal the image as no longer a window but a screen. We strain to see into the blackness of the invisible, to reach around and discover what lies behind its borders. William J. Clancey comments on these limitations of viewing Mars through images and relays one scientist's take on experiencing Mars second hand through the rover as 'trying to make our way through a dark cluttered room with nothing but a flashbulb'.[4] Clancey continues:

> Those of us who were not working on Mars see the planet through photographs, but the scientists are also aware of the blank spaces in between that have not been imaged or studied in such detail.[5]

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[1] Ibid., 26.
[2] Ibid., 27.
[3] Ibid., 33.
[4] William J. Clancey, *Working on Mars: Voyages of Scientific Discovery with the Mars Exploration Rovers* (Cambridge, MA: The MIT Press, 2012), 232.
[5] Ibid.

The seam in *Curiosity's New Home* draws our attention upwards, to where the two images overlay, creating a jagged edge against the background that is void of pictorial information. This is a darkness a flashlight has yet to penetrate, a blank space unstudied and unidentifiable, a gaping blind spot, a lack of information. For Lacan, lack relates to desire; we long to see what remains forever hidden in *Curiosity's New Home,* and this blackness represents the frustrations of our desire to explore and to make visible the invisible. The image never satisfies what a first-hand experience could.

Figure 2.9. Miroslaw Balka, *How It Is,* 2009.

Miroslaw Balka's Turbine Hall commission, *How It Is*, was a 30 metre long, 10 metre high steel chamber mounted on supports, installed in Tate Modern in 2009. Upon entering via a ramp, the visitor became engulfed in darkness. As with *Curiosity's New Home,* darkness in Balka's chamber represents the unknown, an imageless place of disillusion and emptiness. For Balka, darkness is a 'cut in reality', acting as a 'vibrant signifier of the unsayable, of the socially obliterated, of what has been placed under a process of visual disappearance'; his installation therefore creates a 'lack', a perceptual loss and it is in this sense that Balka 'inverts the modern function of art: rendering visible'. [53] Instead it is invisibility itself that instils the

[53] Paulo Herkenhoff, "The Illuminating Darkness of *How It Is,"* in *Miroslaw Balka, How It Is,* ed. Helen Sainsbury (London: Tate Publishing, 2009), 52 & 54.

'presence of the intangible'.[54] This 'volume of darkness' is contained by the steel structure, enveloping the viewer and dislocating them from the outside world so that one loses all sense of proportion, the upper reaches of the chamber could be very near, or very far away: darkness turns space into a formless void.[55] The black border surrounding *Curiosity's New Home* is the 'presence of the intangible', 'dislocating' the image from the Martian world it functions as a reminder of how much more there is still to see and explore in the darkness of space.

Lacan claims that it is the 'rupture, split, the stroke of the opening' that 'makes absence emerge – just as the cry does not stand out against a background of silence, but on the contrary makes the silence emerge as silence'.[56] In a similar manner to the way in which the boy in del Caso's *Escaping Criticism* appears to pierce through the very surface of the painting, the seam in *Curiosity's New Home* performs a kind of opening up to another dimension; the collaging of two images implying a material nature, foregrounding the multi-dimensional make-up of the on-screen image, held behind the smooth interface of the glass. An interplay between surface and depth, the two overlaid images of *Curiosity's New Home* hint at Lacan's rupture, drawing us through the grey veil of Martian terrain and into the silent shadows beneath. To quote Menkman: 'the glitch is an uncanny or overwhelming experience of unforeseen incomprehension'.[57] The space around the image of *Curiosity's New Home* is an imageless place of the unknown. The flatness behind the picture plane is starkly rendered as void, and it is into this gaping depth that the visible recedes, immobilised by darkness.

The glitch in *Curiosity's New Home* manifests itself in a number of ways. We look through a cut out opening in the blackness upon a landscape that emerges behind a thick grey-scale screen. This is the first glitch in *Curiosity's New Home.* In order to view the scene, we must navigate the ghostly crevice in the centre of the image; a crack, an overlay, and a gateway to another dimension. This is the second. Thirdly we must avoid being sucked deep past the grey-scale image and into the black chasm beyond. But we are protected, in part, by the fissure that shimmers above the image, and the friendly body of the rover, reminding us of the image's materiality and flatness. Sewn up this fissure is almost impenetrable, yet it remains, and through it slowly seeps the presence of the *image-as-image*.

[54] Ibid., 90.
[55] Ibid., 50.
[56] Lacan, 26.
[57] Menkman, 41.

Chapter 3

Panoramic Visions: Mars as Image

Figure 3.1. *Cahokia Panorama,* captured by NASA's Mars rover *Spirit* in 2004. Panorama is comprised of 470 images that were acquired over a 10-day period (sols 213–223). Displayed in NASA Ames Research Centre's FutureFlight Central on 9 November 2015. Photograph by author, courtesy of NASA Ames Research Centre.

Everything was white. The floors, the walls and the ceilings. A rabbit warren of offices leading to a full panoramic window upon Mars. A glass fronted door marked the transition between bright light and darkness. Climbing up a staircase I emerged from the blackness beneath. I blinked and before me lay Mars, in full 360°, imposing and glowing from behind the glass.

I had risen up from the belly of a spacecraft, which procured me an elevated viewpoint above the scene. I looked out across the terrain through its many windows. These were not windows to look into, but windows to look out through. I was at the centre, the Martian landscape safely behind 12 panels of thick glass. 12 individual windows out onto Mars, each veiling, withholding the landscape beyond, securing me from an instant demise.

Trapped as an image, within an image, a dusty haze shimmered upon this iridescent scene. And then the landscape moved, rotated to the right. Its horizon shifting by a simple tap of the finger from the central command station. I whirled around, keeping a distant hilltop in my gaze in an attempt to stabilise my viewpoint within the security of the spacecraft. There was no release, my body trapped in the spinning, glittering space of the image.

I moved to the edge of the window and looked out and down behind the workstations, but I could not see the ground. Floating atop nothingness it was through the process of looking and trying to come to terms with what I was sensing, that I became the rover, seeing the Martian terrain through its eyes. But this space had been stretched, the single point of the camera's lens transformed into a wide circular viewing platform. What I could glean of the rover, a body I experienced as both object and subject, was also distorted, magnified, gigantic and imposing. The rover morphed into me, I into it, my body pulled out and warped across this space.

As my eyes adjusted to the light I became aware that the glimmering of this landscape was not caused by the haze, rather it was the dazzling screen of technological vision. Where the windows joined the image seeped like bleach from the crevices, the reflected light faded this space like sun upon an old photograph.

A figure shifted to my right, I was not alone. My immersion in the landscape suddenly disturbed, the desk space and computers returned to view. I was back on Earth.

Figure 3.2. *Endurance Crater* captured by NASA's Mars rover *Opportunity* in 2004 over a 7-day period (sols 117-123). Endurance Crater is 130 meters in diameter and is located half a mile from *Opportunity's* landing site. Panoramic image displayed in NASA Ames Research Centre's FutureFlight Central on 9 November 2015. Photograph by author, courtesy of NASA Ames Research Centre.

FutureFlight Central (FFC) at NASA Ames Research Centre in Moffett Field, California was developed in the late 1990s as a joint project between NASA and the Federal Aviation Administration. Designed as a two-storey facility, the upper level houses 12 screens which construct a 360° image space, giving the impression one is looking out upon a scene from a central viewing platform. Although this facility is primarily used as a virtual air traffic control tower (so controllers can test procedures and software before implementing them in real life) FFC has also been used for viewing images of Mars, enabling scientists from the Jet Propulsion Laboratory to gain a different perspective for images usually viewed on smaller scale desktop computers.[1] The static panoramas of Mars, viewed for the first time in FFC in June-July 2004 (the Mars Exploration Rovers landed in January 2004) gave scientists a 'totally different level of situational awareness'.[2] The purpose of this visit was to work in collaboration with NASA Ames scientists and telerobotic engineers, and to carry out visual analysis.

FutureFlight Central uses an all-encompassing method to immerse the viewer in image space, one comparable to the painted panoramas of the late 18th and early 19th centuries. It is in a similar respect, albeit not so immersive, that the large *Mars Window* (see figs. 3.16 & 3.17, pg. 157) at Greenwich Maritime Museum's *Visions of the Universe* exhibition (2013) attempted to immerse the wide-eyed public viewer in a landscape both remote and familiar. Although the audiences of the image forms differ, one scientific, the other public, the resulting image displays share the same sense of awe and spectacle. Both reflect an innate desire to reconstruct a landscape – so often seen on small scale computer screens – on a more 'life-like' scale.[3] It is in this desire to make palpable the unknown, to become a virtual tourist of this distant land, that both the Mars panorama in FFC and the *Mars Window* at *Visions of the Universe* hold deeper connections to the painted panorama with regards to subject matter. Before travel had become a viable hobby, and before the invention of photography in the 19th century, painted panoramas became a retreat from city life, taking visitors on journeys to the unknown and unexplored.

This chapter draws connections between historical painted panoramas and contemporary panoramas of the Martian landscape, as displayed in FutureFlight Central and at *Visions of the Universe*. Through comparative analysis this chapter seeks to demonstrate that

[1] Boris Rabin (Group Lead, Visual Database Design for Simulations, NASA Ames Research Centre, California), interview by author, Moffett Field, CA, 9 November 2015.

[2] Ibid.

[3] This is the term used by *Visions of the Universe* curator Marek Kukula on describing the *Mars Window.* Dr Marek Kukula (Public Astronomer at Royal Observatory, Greenwich), email message to author, 21 January 2014.

what is common to the painted panorama and the digital panorama of Mars is the virtual reconstruction of time and place in an illusion that attempts to collapse and conceal the framing mechanism. It is their success in doing this – to immerse the viewer in a frameless image – that will be interrogated throughout this chapter. Central to this discussion is art historian Oliver Grau's writing on the painted panorama as a virtual space of illusion and immersion:

> The essence of the panorama was the assumption of being entrapped in the real. This game with deception was its chief fascination; whether the observer was oblivious, as in the early years, or regarded it as a source of aesthetic pleasure, as later.[4]

As I outlined in the introduction, Grau characterises immersion as a suspension of disbelief, a 'diminishing critical distance to what is shown and [an] increasing emotional involvement in what is happening'.[5] With FFC and the *Mars Window* we are not 'oblivious' to illusory tricks; instead we must *knowingly* suspend our disbelief and project ourselves *imaginatively* into the Martian landscape.

As discussed in the previous chapter, the glitch surfaces to reveal our own position as a viewing subject; it is a visible break in the surface of the illusion, undoing the seamlessness of the image. In the Martian panorama the glitch takes several forms but it manifests itself most predominantly in the frame, in the presence of the rover and through the positioning of the viewer's body. This chapter argues that the glitch uncovers the panorama's failure to 'entrap' the viewing subject in the reality of Mars. It is through prolonged periods of looking and an attempt to reveal greater detail by physically moving closer to the image that the constructed nature of the illusion exposes itself; despite an attempt to see Mars as all-encompassing, it remains trapped within a flat image. This chapter argues that the Martian panorama screens Mars, and its image, within the very frame the illusory form seeks to hide. We cannot step past this divide; the landscape remains intangible, the image impenetrable. The panorama entraps the viewer in the *image of Mars* as a form of *virtual* travel, producing a virtual experience. Despite offering an illusion of 'being there', the two-dimensionality of this spectacular display only serves to reinforce our realisation of the current human impossibility of ever stepping out onto this alien terrain.

I begin by comparing conceptual similarities that the panorama of Mars shares with its 18th century panoramic counterpart; the reconstruction of a time and place within an image, noting the importance of being able to physically move about and experience an image in full 360°. However, as I will argue, it is due to the very nature of the panorama's

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[4] Oliver Grau, *Virtual Art: From Illusion to Immersion*, trans. Gloria Custance (Cambridge, MA: The MIT Press, 2003), 70.

[5] Ibid.

construction that we do not witness Mars as a whole image but as fragments of time stitched together in an illusion that does not necessarily account for atmospheric conditions.

Increasing the scale and physicality of the image in NASA Ames' FutureFlight Central allows scientists greater situational awareness for the Martian terrain. This chapter continues with an exploration of the control room at FFC as a form of *faux terrain* which conceals the frame and prevents the viewer from getting too close to the image. Here *faux terrain* enables us to step imaginatively into virtual space, giving us a greater sense of looking out through a panoramic window on Mars. But in scrolling up and down to reveal what lies beyond the border, the frame reveals itself and our immersion in the image is disturbed.

Collapsing the frame and stepping into the construction of illusion at the *Panorama Mesdag* in The Hague enables greater understanding of the painted panorama's construction. By stepping beyond the frame of a painted panorama we can see how integral it is to the illusion. For the 19th century viewers of the *Panorama Mesdag,* and for the viewers of Mars in FFC, the frame acts as a boundary between what is visible and invisible; the image remains impenetrable, and our experience is dictated by the framing mechanism.

The *Mars Window* at *Visions of the Universe* played on the notion of travelling to distant lands through the image so prevalent in panoramic paintings. Drawing similarities between battle scene panoramas and the *Mars Window* I demonstrate that both enable a form of virtual travel, allowing access to history and scientific information through the translation into immersive images. We see through the eyes of the rover; Mars and its image remain perpetually mediated.

Finally, the concept of Maurice Merleau-Ponty's *chiasm* will be used to address the viewer of the *Mars Window* not as a body that links oneself with the landscape of Mars, but a *chasm* which draws forth the materiality of the projected image and the surface upon which it cannot be fixed. Seeing the Martian terrain through the eyes of the rover, an awareness of its body triggers an awareness of our own in front of the fragile, immaterial space of the digital image. It is in our desire to step ever further into the image and travel imaginatively to these remote places that we as viewers become part of the image itself.

As discussed in the previous chapter, the glitch has many forms; it is manifested here in the presence of the frame, our body and that of the rover. Each betray the illusion, forming a glitch and forcing an awareness of the *image-as-image*.

<u>The Panorama: A Virtual Reconstruction of Time and Place</u>

The traditional painted panoramas were the first 'mass medium' before the invention of film in 1890. Their intention was to install the observer *in* the picture, and the term *panorama* is derived from the Greek 'an all-embracing view'.[6] The panoramas consisted of a painted canvas hung on circular walls inside a specifically designed rotunda and the viewer stood at the centre of a platform completely surrounded by a 360° painted picture. The first panorama opened in Leicester Square in 1793 and was the invention of Robert Barker, who in June 1787 patented his idea under the name '*la nature à coup d'oeil'* or '*nature at a glance'*, which later became known as 'panorama' in 1792.[7] The visitor stood on a viewing platform (the 'inclosure') behind a balustrade (the 'interception') which prevented them from determining the upper and lower limits of the picture, thus preserving the illusion.[8] Diffused from above through frosted glass, the source of light was veiled so that the painting often appeared to be itself the illumination, making it difficult for the viewer to distinguish between what was real and what was painted.[9] Panoramas in their traditional sense were, to cite the *Dictionary of Building*, 'faithful reproductions of what a place looks like when viewed from all angles and from as far as the eye can see', thus, they were *reconstructions* of landscapes and events at moments in time.[10] However, the depth of a painted space is nevertheless experienced only in the mind and as the scientist and mathematician Alexander Gosztonyi claimed: one can '"enter" the space virtually, i.e., in thought or imagination, whereby the distances are not actually experienced but rather assumed'.[11]

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[6] Stephan Oettermann describes the panorama as the first 'mass medium' in *The Panorama: A History of Mass Medium*, trans. Deborah Lucas Schneider (New York: Zone Books, 1997), 7. As a source of public entertainment, subjects for the painted panoramas were selected for their popular appeal, often reflecting the interests of wealthier societies due to the high admission fees. Charlotte Bigg outlines the panorama as an 'all-embracing view' in "The Panorama, or La Nature A Coup d'Oeil," in *Observing Nature – Representing Experience: The Osmotic Dynamics of Romanticism 1800-1850*, ed. Erna Fiorentini (Berlin: Reimer, 2007), 73.

[7] Ralph Hyde, *Panoramania!* (London: Trefoil Publications in association with Barbican Art Gallery, 1988), 17. The term, *panorama* is now widely used, often with little association to its origin. Robert Barker's patent expired in 1801, and a number of rival panoramas appeared. Barker died in 1806 and the business was passed onto his son, in turn succeeded by Robert Burford who ran the rotunda in Leicester Square until his death in 1861. Ibid., 20. Barker developed a 'system of curves on the concave surface of a picture so that the landscape, when viewed from a central platform at a certain elevation, appeared to be true and undistorted'. Grau, *Virtual Art,* 56.

[8] Hyde, 17.

[9] There is an interesting correlation here between the painted panorama and the projected Mars panorama in FFC and at *Visions of the Universe*; whereas the painted panorama *appeared* to be the source of lighting, the Mars panorama, being projected, was made up of light itself.

[10] Quoted in Bernard Comment, *The Panorama*, trans. Anne-Marie Glasheen (London: Reaktion Books, 1999), 7.

[11] Alexander Gosztonyi quoted in Grau, *Virtual Art,* 16.

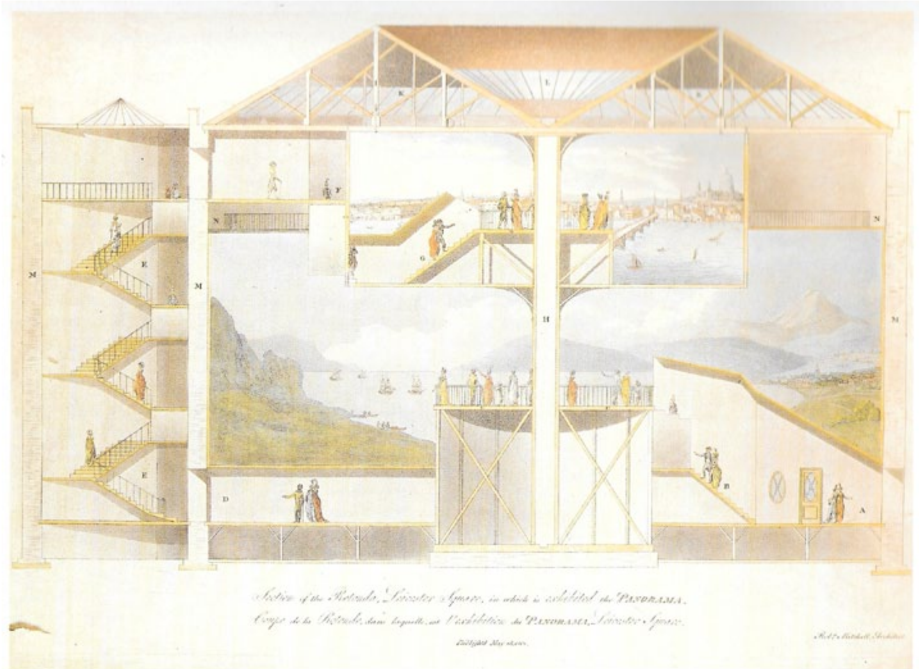

Figure 3.3. *Section of the Rotunda, Leicester Square, in which is Exhibited the Panorama,* Robert Mitchell Archt, coloured aquatint, 1801. Barker's rotunda was designed by architect Robert Mitchell to accommodate two panoramas at the same time. The canvas in the upper circle was 2,700 square feet, and the canvas in the lower circle was 10,000 square feet. Image shown in Ralph Hyde, *Panoramania!* (London: Trefoil Publications in association with Barbican Art Gallery, 1988), 22.

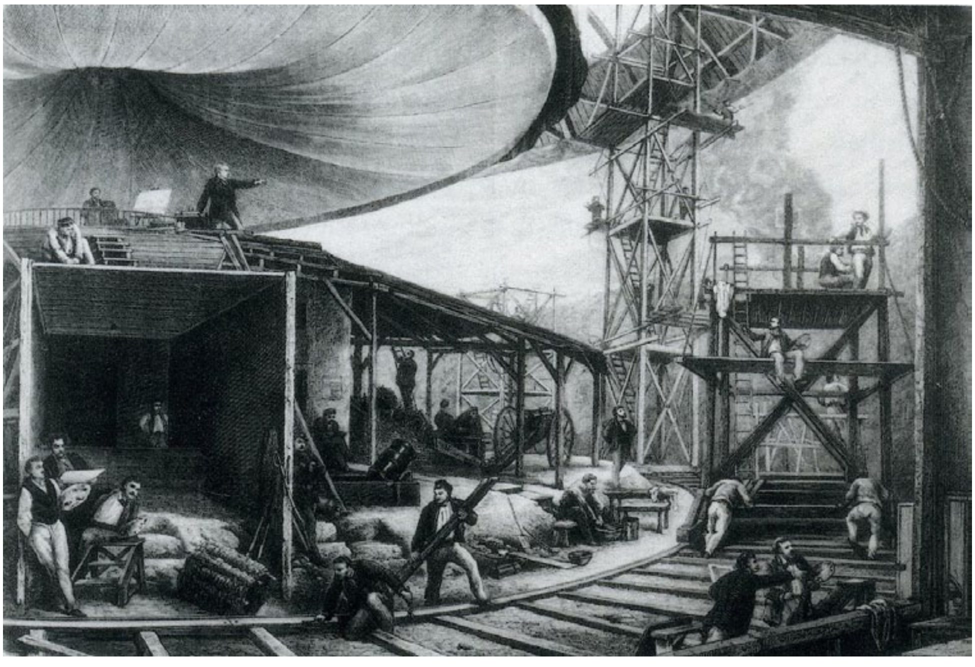

Figure 3.4. Félix-Emmanuel-Henri Philippoteaux overseeing the production of his *Panorama of the Champs-Elysées,* engraving from *Le Monde Illustré*, 2 November 1872. Image shown in Bernard Comment, *The Panorama*, trans. Anne-Marie Glasheen (London: Reaktion Books, 1999), 17.

Because the paintings could take up to two years to complete, specialised teams of people were involved in every aspect of construction – from devising the subject matter and making the initial drawings, through to specialists in portraiture and landscape painting as well as fabricators of faux terrain.[12] It is this spirit of collective endeavour that also make Mars panoramas possible; scientists, engineers and software developers work together with the objective of reconstructing for the viewer a 360° window upon the surface of Mars. Similarly, the ultimate aim of the painted panorama was accuracy to nature so artists initially worked with camera obscuras and Claude glasses, and later with photography and projection in order to split the landscape into frames.[13] The image-as-grid was then reconstructed, enabling artists to plot terrains with accuracy and transform actual terrain into pictorial representation.[14] By reducing the scale and majesty of the landscapes, these techniques placed the subject matter under artistic control. It is in a similar manner that the images of Mars are composed from numerous individual frames taken by the rover as a virtual reconstruction of a place.

Chapter 1 offered an overview as to how panoramic visualisations are reconstructed using digital processes and the re-presentation of image data. That chapter discussed the reconstruction of Mars through the 'mosaic' method and argued that through this process a conception of time, on the surface at least, was erased. Such panoramas are acquired over long periods, and a minimum of 10 to 12 images are needed to create a full 360° view of the rover's surroundings, however, due to overlaps, this number is usually closer to 20.[15] Often images are stacked on top of one another vertically, to create a more expansive view of the landscape including the sky, terrain and body of the rover.[16] The pieces making up the

[12] Bigg, 74.

[13] The *camera obscura* was 'an apparatus mounted on a revolving stand and adjusted precisely to the horizon with a level; once in its place, all the artist had to do was trace the outlines of the picture of the external world that appeared inside the camera'. Later the *camera lucida* was invented which was much lighter and easier to transport; 'it contained a prism that reflected an object or scene onto drawing paper in such a way that its outlines also had merely to be traced'. In 1830 the *camera lucida* was developed and named a 'diagraph'; it was an instrument that corrected in advance the distortions in perspective of representing a curved scene on a flat surface. Oettermann, 51-52.

[14] A few years before his patent, Barker had invented a device for drawing circular perspective; the device was mounted on a fixed point and could swivel to take partial views, which when joined together formed the panorama. Barker's first panorama was a 180° view of Edinburgh, funded initially by William Wemyss, a military strategist interested in how this technique could be useful for military surveying and planning. Although this new technique of a mobile representational instrument for military planning did not go any further, it was a combination of both media and military history that culminated in the inception of the panorama. Grau, *Virtual Art,* 56-57.

[15] The NavCams can produce panoramas with 8 individual frames, the left MastCam with roughly 36, and the right MastCam with 90-100. Bob Deen (Principal Software Developer at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2015.

[16] Deen, interview.

panorama are beamed down individually, and can be viewed in a programme called Mars Viewer, which logs images according to their sol (Martian day).[17] Once all the individual frames are downlinked, a programme called Mars Tie is used to mosaic the images using tie-points.

Jim Bell examines the discrepancy between a real experience of a place, and a panoramic visualisation:

> Not only do the shadows change from one part of the panorama to another, but the sky colour and brightness also change from hour to hour and from sol to sol because of variations in the atmospheric dust. The result is that when all are merged into one big mosaic, the seams and brightness changes from image to image can make it look very different than if you were standing there, just looking around.[18]

Curiosity's Billion Pixel View (figure 3.5) was taken over a month and encompasses 900 images, showing the surrounding landscape in very high resolution. The quality difference of the individual frames was determined by the time of day, as imaging software developer for JPL Bob Deen explains:

> Rocks look different if they are pictured at different times of the day. They scatter light differently. If light is coming from different directions, it can seem to invert the object, so it's very difficult to correct.[19]

In the painted panorama and in the digital panorama of Mars, time is condensed into one moment and one place, but the evidence of the passing of time remains on the surface of the image in the form of the seams, which highlight its reconstructed nature.

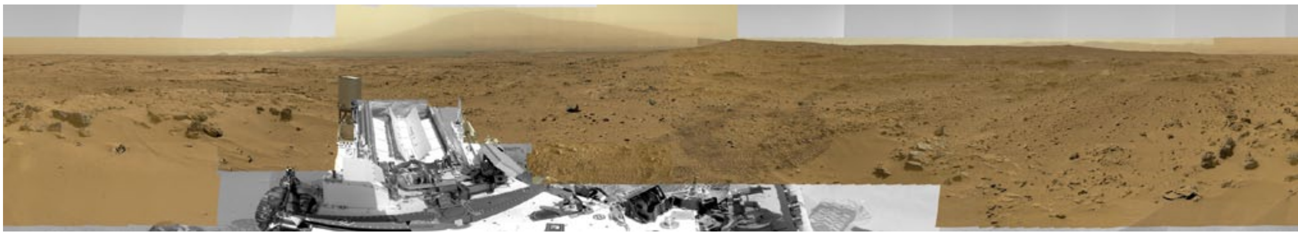

Figure 3.5. *Billion-Pixel View from Curiosity at Rocknest, Raw Colour,* captured over several days between 5 October and 16 November 2012. Photojournal image addition date: 19 June 2013. Credit: NASA/JPL-Caltech. (See figure 1.21 on page 87 for a larger version)

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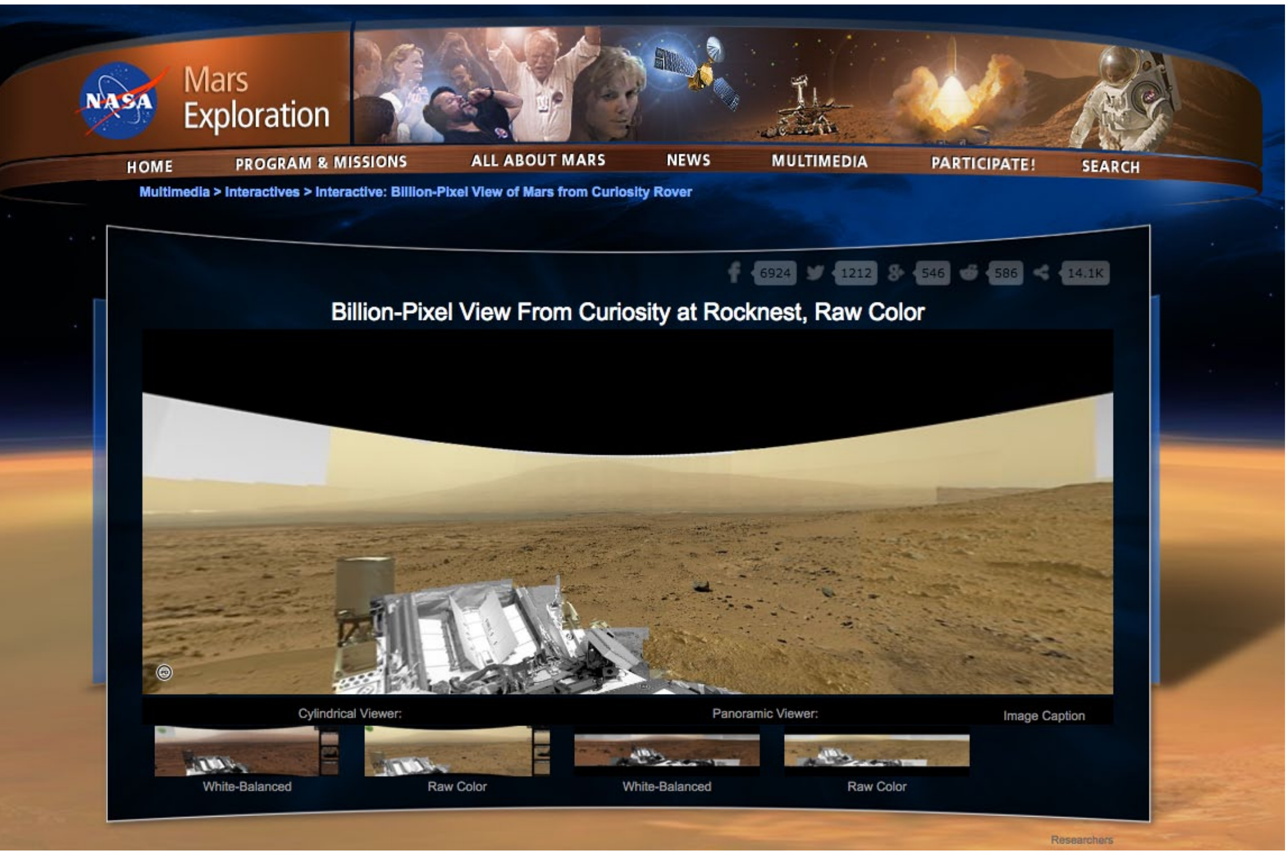
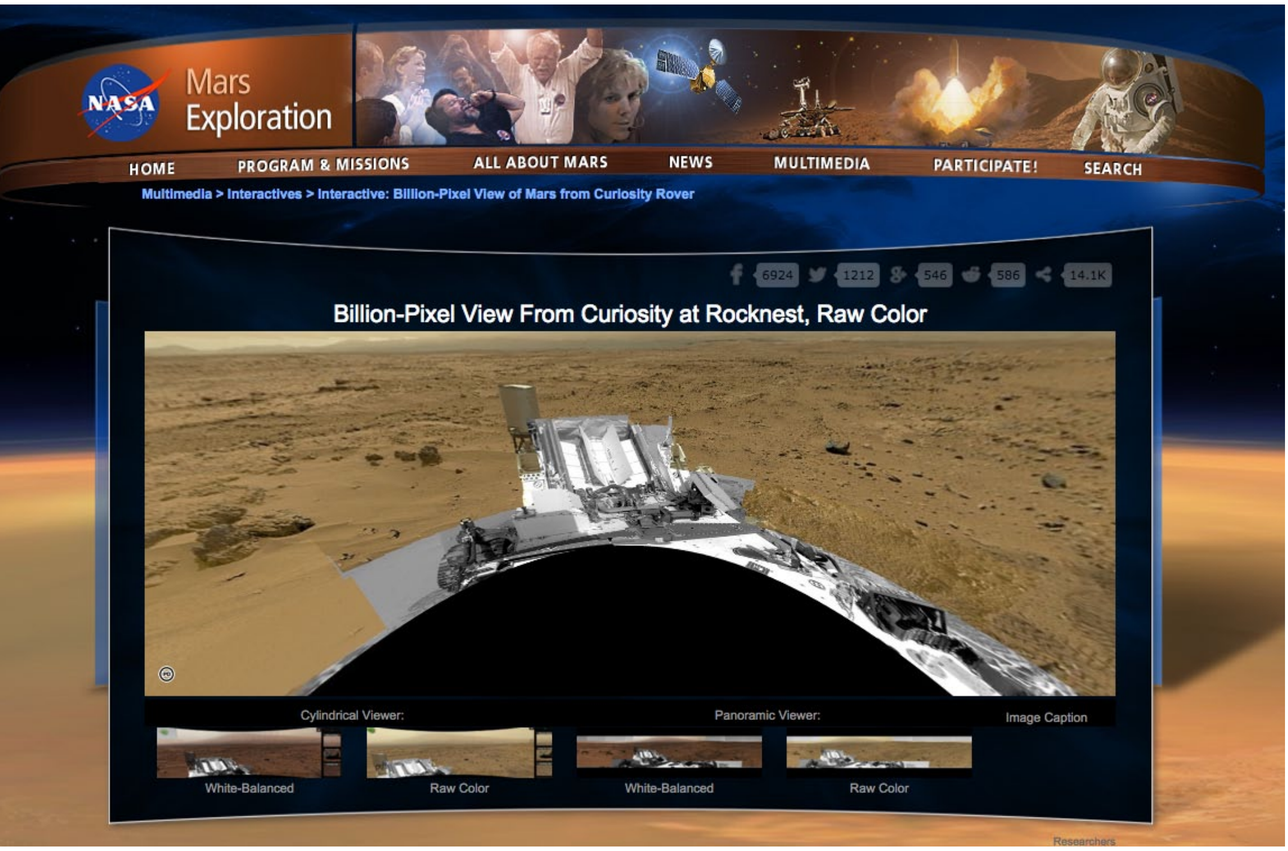
[17] The individual image names are usually in the label for the mosaic on NASA's Planetary Data System, but because mosaics are often captured over disparate days, they appear in different data sets. Mars Viewer is available to the public to download, and scientists at JPL are currently working on a version for the iPhone and iPad. Bob Deen examines: 'This application will use a giro to stabilise the image, so if you swing around it'll swirl over […] it gives a much better feeling of "here's a window on a world."' Deen, interview.

[18] Jim Bell, *Postcards from Mars: The First Photographer on the Red Planet* (New York: Penguin Publishing Group, 2006), 75.

[19] Deen, interview.





Figures 3.6 a-b. Screenshots of *Billion-Pixel View from Curiosity at Rocknest, Raw Colour* displayed on the NASA Mars Exploration website.

Another major difference between viewing a panoramic image and real life experience is the sense of immersion; Mars panoramas are displayed on NASA's Photojournal as flat images, but they represent a 360° view. This results in a distortion of information, particularly evident in the stretched out body of the rover and the terrain in the foreground. You also don't get a sense for how either end of the image joins up; the furthermost points of the image are actually closest together. Deen examines *Curiosity's Billion Pixel View*:

> The Giga-pan is a full 360. But you don't think of it like that, you think of it as a window. There's a mountain there and a rock over there, but this is behind you. This is part of what makes it hard to interpret. If you zoom in you get more of a natural view, and if you spin around you kind of get the feeling you are looking in multiple directions.[20]

Curiosity's Billion Pixel View is also displayed on the NASA website as a cylindrical panorama (figs. 3.6 a-b) whereby the image rotates around the central axis point of the rover.[21] As visitors to this image we can choose to pause the rotation and zoom in upon features of interest. Our focus point can also be shifted up and down to reveal the upper and lower limits of the panorama, and we have a better sense of how this landscape might wrap around us as viewers. Nevertheless, we still perceive the image as flat. Immersion is heightened in a facility like FutureFlight Central; you are able to physically turn around and experience all viewpoints. There is no right, left, or centre part of the image, and you do not have to swipe with your finger to reveal what is behind you; it is all encompassing.

Writing on the painted panorama, Stephan Oetterman comments that 'it is the paradox of this era that landscape appeared more directly itself and more accessible to the artist only through the imposition of optical instruments' and there is certainly truth in this statement from a scientific point of view.[22] As we can see in the billion-pixel image, composing the image from fragments allows for a final image with higher pixel content and greater detail. Yet collaging an image nevertheless means that it is not a whole landscape captured and shown, but one that has been reconstructed from constituent parts, that often mismatch in their tonal range and colour. This construction of panoramic vision from very precise particles is reminiscent of Thomas Hornor's 1827 panorama of London observed from the top of St Paul's Cathedral. Hornor's panorama is 'more precise and complete than the real London could ever be' due to the artist's obsession with detailing even the smallest and most distant objects in complete accuracy and clarity.[23] The photographic apparatus on *Curiosity*

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[20] Deen, interview.

[21] A similar experience is gained in the application MPlanets whereby the user can view a 360° environment of the Martian terrain on a smart phone or tablet. As they tilt their device or physically swivel on the spot, the image pans around to reveal what is above, below and behind the rover at that particular panoramic scene.

[22] Oettermann, 33.

[23] Ibid., 137.

relays high levels of image content; scientists and engineers are always striving for greater resolution and the panorama's fragments are captured at similar times of day to reduce discrepancies between frames caused by variations in lighting. Bordering on mania, Hornor's 'optical inventory' was recorded only in the early mornings when the city was free from smog, often with the use of a telescope to record distant houses.[24] This results is an effect seen today in digital simulations; for W.J.T. Mitchell such image composites are 'too real', not accounting for the effects of distance, fading and the blurring of details.[25] The glitch in Hornor's painting is not the breakdown of information, but the exhaustive construction of a reality that exists only on the canvas, and perhaps a little in the artist's mind. For Marina Warner in her writing on *Phantasmagoria*, Hornor's work highlights the 'distinction between sight and its image'.[26] We are confronted with an image that shows everything in focus, which does not account for the limited field of view of our eyes. In this sense Mars is made 'too real' and the seams act as glitches, disrupting the flow of illusion and returning us to the flat space of the image. The impossibility of seeing Mars first-hand means that we can only ever experience this uninhabitable planet as image. *Curiosity's Billion Pixel View* can be enlarged and we can scroll across the smallest details in the distance and view them with great clarity. But through this process the aura of the landscape's presence dissolves as the landscape is constructed and reconstructed into image.

Figures 3.7 a-b. *Cahokia Panorama,* captured by NASA's Mars rover *Spirit* in 2004 and displayed in NASA Ames Research Centre's FutureFlight Central on 9 November 2015. Photographs by author, courtesy of NASA Ames Research Centre.

[24] Ibid.

[25] William J. T. Mitchell, *The Language of Images* (Chicago: The University of Chicago Press, 1980), 199 & 202.

[26] Marina Warner, *Phantasmagoria: Spirit Visions, Metaphors, and Media into the Twenty-first Century* (Oxford: Oxford University Press, 2006), 151. *Phantasmagoria* focuses more on fantasy and deception in relation to spirit forms such as ghosts, angels and zombies. Warner looks at how Victorian technologies – such as the phantasmagorical magic lantern shows and early waxworks – were used to create illusory spectacles. The book is more about ideas of the self and consciousness and less about reconstruction, virtual travel and physically immersive image forms.

Concealing and Collapsing the Frame

The sense of immersion in *Curiosity's Billion-Pixel View* depends very much on the viewer's ability to project themselves imaginatively into a flat image. The circular form of a blacked out void in figures 3.6 a-b (pg. 136) represents our viewing arena and swivelling the image around onscreen to see what is 'behind us' remains a two-dimensional experience. The experience of the Mars panorama is totally transformed in FutureFlight Central; it is in this space, in which the image physically wraps around the viewer, that we might gain a greater situational understanding for this alien terrain. Instead of using a track-pad or mouse to rotate the panoramic image, we may *actually* turn around and look at the image from different viewpoints. Instead of our peripheral vision being taken up by the surround of our computer screen and desk space, in FFC the image of Mars fills our peripheral vision.

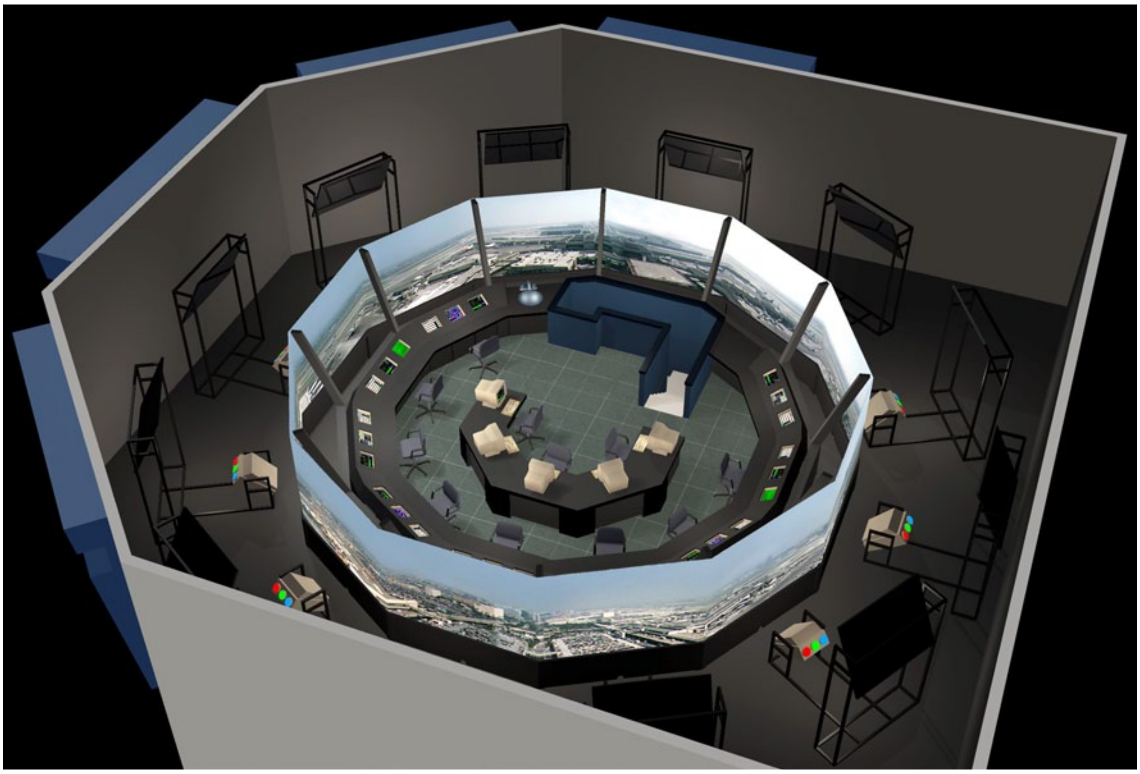
Visitors to the facility at NASA Ames must climb up a short staircase into the circular room. The room is 37.8 metres in circumference, the diameter being 11.2 metres, and at the centre stands a cluster of tables with the main control computers on them. Between the carpeted floor and the screens are desks with individual work-stations and beyond these tables are the screens, vivid and imposing. There are 12 screens in total, positioned vertically behind individual sheets of glass that tilt away slightly at the top, the base of which falls behind the desks, meaning the image continues out of sight. The glass is held by thick dark frames and, positioned about 1.2m away from the desks, one has to lean over the desk space to peer behind. Each screen is brought to life by a Sony rear screen short throw-distance laser projection system. Positioned about a foot and a half behind a thick pane of glass, these specialised lenticular Fresnel screens even out the light field across each image.[27]

This facility is one of few in the world that can provide a 360° simulation for controllers. As Boris Rabin, the group leader of visual database design for simulations at NASA Ames explains, it is a 'full human-in-the-loop type of environment because we have not just controllers working upstairs, but just like a real airport, they are in communication with pilots'.[28] The 'pseudo pilot room' on the lower level is where 'pilots' simulate the control of aircrafts, seen upstairs by controllers on the big screens.[29]

[27] Kenji Kato (Senior Research Engineer, at NASA Ames Research Centre, California), interview by author, Moffett Field, 9 November 2015.

[28] Rabin explains: 'If you walked into this room during the Chicago simulation, or any other simulation, you would feel like you were in the tower not just because of the visuals, but because of the constant chatter going on between the controllers and pilots.' Rabin, interview.

[29] Rabin continues: 'Sometimes we have about 25 people here controlling up to 10-15 different aircraft models. We have all the major airports […] and in order to provide a realistic environment we need to run up to 100-120 operations per hour like take-offs and landings.' Rabin, interview.



Figures 3.8 a-b. Simulation of the lower and upper floors of NASA Ames Research Centre's FutureFlight Central. Although the overall structure and positioning of the screens is still the same today (and the computers have been upgraded!), the second of these simulations represents the previous projection system which used mirror bounce projectors (the mirrors were used to "fold" the projection distance in half because throw distance of the old projectors was longer than the space behind the screens). Although correct at the time of my visit, in 2016 this system was updated to a rear screen short throw-distance laser projection system. Showing an impossible vision of the front and back of the screen, this simulated view of FutureFlight Central heightens the flatness of the screen, collapsing the illusion and revealing the artifice.
Credit: Boris Rabin, NASA FutureFlight Central, 1999.

The workstations in FFC act as a sort of barrier to the panoramic image; they are Robert Barker's 'interception' preventing the viewer from stepping too close to the image. In the painted panoramas, *faux terrain* in the form of rocks, branches, modelled people, pots and grass were used to enhance the illusion of the experience and collapse the painted space into real space. Although these types of props had been used previously in illusory spaces such as in the chapels at Sacro Monte, faux terrain was not introduced into the panorama until 1830 by Charles Langlois, a French battle scene specialist.[30] Here, props were 'constructed on a wooden framework between the painting and the viewing platform [and were] almost imperceptibly joined to the image for the visitor, who was fifteen metres away'.[31] As the human eye is only able to spatially perceive objects up to twelve metres away, *faux terrain* was used as a sort of stage set, to collapse the frame, 'negating the pictorial character' and changing the picture into an 'image space where the observer was physically present'.[32] In painted panoramas there was often a blank space in between the edge of the faux terrain and the painted surface, and this is represented in FFC by the 1.2 metre gap between the edge of the desk, and the glass 'window', which falls behind, giving a sense of continuity and enhancing the feeling of being on a platform. Each of the 120" x 90" screens sit about half a metre behind a thick pane of glass, withholding the image behind a literal window. In FFC we get the sense we are controllers of a spacecraft, who, landing on the surface of Mars, can look out upon this vast, barren landscape. The desk space acts as an interception, separating us from the image, preventing us from reaching out and touching it. The barrier between body and image highlights the sense of touching the untouchable. If we were to physically make contact with this representation of Mars, we would be faced with the cool touch of the flatness of the screen. The impossibility of ever stepping onto Mars – for now at least – is made evident here through the *image-as-image*. It is the ultimate flatness, of this image and of all depictions of Mars, that consistently renders the unimaginable actuality of such an experience. Here, the *image-as-image* is also the *image-as-glitch* because the presence of the

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[30] The chapels at Sacro Monte are examples of diorama-like illusionistic image spaces being used to strengthen people's beliefs in Christ. In total, 43 chapels were built, each depicting stages in Christ's life which people visited in the thousands, demonstrating, according to Stephan Oettermann, that the panorama was the 'first optical mass medium.' Oettermann, 9. Guadenzio Ferrari worked on Sacro Monte between 1490 and 1528 and used lifelike objects such as terracotta pots, hair and glass eyes in front of the fresco to heighten the sense of three-dimensional space. Halves of figures were even used in order to offer the eye an excess of images to 'render differentiation impossible.' The effect was that the faux terrain appeared to grow out of the picture, extending its limits and increasing the illusion of three-dimensions. Grau, *Virtual Art,* 44.

[31] Ibid., 59 & 106.

[32] Dolf Sternberger, "Panorama of the 19th Century," trans. Joachim Neugroschel, *October* 4 (Autumn 1977): 5, accessed 28 January 2014, http://dx.doi.org/10.2307/778476; Grau, *Virtual Art,* 59.

image itself is bound up with the knowledge that this vision is inaccessible to human eyes. The image functions as a glitch, because it reveals itself as only, ever, being image. This window onto Mars is only for looking at, never to be traversed.

In this case the faux terrain of the workstations conceals the frame; a virtual reconstruction in the guise of a spacecraft, we are physically present in this *imaginative* space. The viewing platform as a vessel reinforces the sense that viewers partake in a form of virtual travel, whilst also enhancing the idea of the physical space as a continuation of image, thus merging the frame into image. Charles Langlois contributed to the 'totalising' impact of the painted panorama; in his 1831 *Naval Battle of Navarino*, (a huge 15 metres high and 38 metres in diameter), Langlois replaced the traditional platform with a ship's poop deck that had actually taken part in the battle, thus reinforcing the illusion and placing a piece of reality into the image space.[33] The visitors were transported, virtually, into the centre of the action.

> The site was transformed into a fully armed and rigged vessel, the end of which gradually merged with the canvas at the back with the help of the authenticity of the relief, the shapes of the bas-reliefs and the painting.[34]

Langlois also transformed the entrance halls of the panorama into seamen's quarters and ship's corridors so that from the very beginning 'he plunged the spectator straight into the atmosphere he wanted to create'.[35] In this sense faux terrain ensured that the construction of the image space eluded the visitor but more importantly ensured that the visitor actually stepped *into* the space of the image. Most art forms 'limited themselves to the presentation of a fragment' but the panorama was a 'painting without borders'.[36] This stepping into a reconstructed landscape was made possible by the continuity of image into actual space and the tactility of the faux terrain, yet for FFC the visitor does not enter through a series of stage sets and props, but more of a museum setting. The contrast between the stark white corridors of NASA Ames Research Centre's Human Systems Integration Division and the soft, dark interior of the lower floor of FFC does act as a sort of buffer, but this space is set out more as a promotional museum, with information boards on the various projects carried out in FFC. From the beginning, we are aware of our immanent deception, of the virtual experience upon which we are about to embark. In this case the museum setting acts as a framing device, ensuring we are aware of the artifice.

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[33] Comment, 47.
[34] Jacques Hittorff quoted in Comment, 49.
[35] Comment, 50.
[36] Evelyn Onnes-Fruitema and Ton Rombout, "The Origin of the Panorama Phenomenon," in *The Panorama Phenomenon*, ed. Tom Rombourt, trans. Ingrid Birtwistle (The Hague: Panorama Mesdag; the International Panorama Council, 2006), 27.

The screens in FutureFlight Central fall behind the workstations, thus concealing the borders of the projected image to a degree. But because of the limited field of view of the screens in FFC (being 120" x 90") the screens are not high enough to encompass the full height of the panorama; the image is larger than the frame that conceals it. From the central command station, the image can be moved up and down, and also rotated. For Research Engineer at NASA Ames Kenji Kato, this gives a 'sense of what it was like there and here (in different locations along the path of the rover)'.[37] However the instability of the image is disorienting, a dizzying experience that gives the sense that the illusory spacecraft in which we stand is in motion: the alternating backdrop mirrors the experience of navigating through space. But this only happens on the visual level and our body's other senses do not feel this motion; it thus serves to highlight the frame in which the illusion is projected.[38]

Accounts of the painted panorama relayed similar experiences for viewers in the 19th century. For some the painted panorama could cause nausea; this was either because the visual appearance of reality contradicted the sensory experience, or in extreme cases, because the illusion was so real that it induced physical sickness. In 1805 Johann August Eberhard stated:

> I sway between reality and unreality, between nature and non-nature, between truth and appearance. My thoughts and spirits are set in motion, forced to swing from side to side, like going round in circles or being on a rocked boat. I can only explain the dizziness and sickness that befall the unprepared observer of the panorama in this way.[39]

Popular magazines recounted women fainting and suffering from vertigo and Princess Charlotte, on viewing Barker's *View of the Fleet at Spithead* in 1874, reported feeling seasick due to suddenly being surrounded by water.[40] Both Eberhard and Princess Charlotte's reactions to the panorama are examples of becoming unbalanced in terms of one's grip on reality; for Eberhard it wasn't quite real enough but for Princess Charlotte the deception was so strong as to physically affect her. For the mobile spectator of the immobile panoramic painting the body is trapped in a space in which the visual contradicts the sensorial. The experience is of a different kind in FFC; the artificial motion of the image – which we experience as static spectators – inadvertently heightens the awareness of the frame; we see

[37] Kato, interview.

[38] One criticism of the panorama was its inability to portray movement; soldiers, birds and foliage were depicted with 'unnatural stillness', and the absence of sound impeded upon its realism. In the early 19th century, moving panoramas and dioramas were invented. Although these weren't all encompassing in form, their 'movement and development in time' engaged the viewer on a different level and proved competition for the circular panoramas. Dioramas and the play of light upon the surface of an image will be discussed in Chapter 5. Hyde, 32 & 21.

[39] Johann August Eberhard quoted in Grau, *Virtual Art,* 63-64.

[40] The platform had also been designed to look like the decks of a ship, thus immersing the viewer on a further level. Comment, 24.

Mars through a device that is unable to give us the whole picture at any one time. Immersed in the vast spectacle of Mars in FFC we are not oblivious to the 'game of deception', and we do not experience physical sickness because we feel 'entrapped in the real', as in the case of Princess Charlotte. Rather we are entrapped in a swirling virtual simulation that on many levels induces 'aesthetic pleasure'.[41] It is down to this that we are able to imaginatively experience the panorama of Mars as both a scientific image and a virtually immersive experience of an alien landscape. In this case faux terrain conceals the frame, and we might imagine it as a window out upon Mars. However, the image is larger than the frame that conceals it and must be shifted up and down to reveal further information. It is in this movement of the image that the frame simultaneously collapses *and* pushes to the fore, disturbing our sense of place within the illusion. The frame here remains rigid and imposing, a reminder that we can never hope to reach out and touch this intangible landscape; Mars is imprisoned behind the screen of the impenetrable image.

Collapsing the Frame and Revealing the Glitch at the *Panorama Mesdag*

The painted panorama attempted to conceal the framing mechanism in the guise of faux terrain; thus the frame collapsed into illusory space. But a tour 'behind the scenes' triggers an idea of the collapsing of the frame in an altogether different sense. Stepping out beneath the viewing platform and into the workings of the image at the *Panorama Mesdag* in The Hague reveals many similarities between painted and digital panoramas in terms of the glitch; by stepping behind the scenes the presence and physicality of the image is revealed.

Initially the panorama was believed to create an 'illusion totale', which was the opinion of the *Report of the Panorama* published by a commission set up by the Intuit de France and chaired by Antoine Duforny. The commission believed that art had come closer to its 'goal of perfect illusion' through its alliance with science, creating a frameless image in which the viewer was 'completely subjected to deception'.[42] But it was also believed that the longer one spent inside, the less persuasive the illusion became; when one's eyes adjusted to the light for example, the painting no longer appeared true to nature and its materiality was gradually revealed.

In 1800, the German poet and novelist Henrich von Kleist wrote a letter to his fiancé stating his disappointment with the panorama; referring to its construction, he claimed that you walk knowingly into the space, aware that you were about to be deceived. He did however believe that it would be possible to create a full illusion in the future, when the

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[41] Grau, *Virtual Art,* 70.
[42] Ibid., 64.

visitor would stand on the painting itself and be unable to discover a point which was not part of the painting.[43] In this sense von Kleist sought to overcome the fracture in image space brought about by the separation of painting and viewer. In 1891, an international jury visited *The Battle of Sedan* and it was

> only by climbing into the pictorial space and touching the canvas that they convinced themselves the lamp was simply painted and its effect not due to artificial devices, transparency, light, or anything of that sort.[44]

In this respect von Kleist's prediction was turned on its head; instead of the illusion coming forth and enveloping the viewer in image space, the jury, not believing themselves to be deceived, stepped into the image to become part of the image itself, but in so doing, fractured the illusion. We cannot experience such close proximity with the panoramic image of Mars in FFC; we cannot reach out and touch the grains of sand or the textures of the rocks, as any attempt to do so is interrupted by the thick panel of glass. This space which separates the viewer from the image becomes a physical space, trapped between glass and screen, a body of invisible air that prevents our reaching hands from caressing the surface of the image. Whether or not we are permitted to touch the illusion – the image, or the parts of the spectacle that comprise it – in both instances ultimate experience is mediated. These are not time machines nor spacecraft capable of transporting us into distant times or to faraway planets, but artists' and scientists' imaginings of spaces and places that can only ever be experienced second-hand in the contemporary moment.

Oliver Grau claims that immersive artforms such as panoramas enable viewers to detach themselves from the framing device and step into the 'belly of the image'.[45] Here Grau is referring to an all-encompassing image which places the viewer at the centre of the visual experience; such is the viewer's encounter with the panorama. But we can also interpret the 'belly of the image' as a place from which the construction of illusion becomes evident, where its true surface is revealed. Like the jury visiting *The Battle of Sedan,* placing ourselves at the very heart of the image's formation enables us to collapse the frame and see the glitch from an alternative perspective. For the visiting researcher today, this is possible at Henrik Willem Mesdag's panorama in The Hague.

Painted in 1881 this panorama is a historical representation of the local area of Scheveningen. Depicting a view from the Seinpost dune, the panorama is a protest against

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[43] Ibid., 63.
[44] Sternberger, 7.
[45] Oliver Grau's 1999 essay "Into the Belly of the Image: Historical Aspects of Virtual Reality" is a prelude to his 2003 book *Virtual Art: From Illusion to Immersion.* Oliver Grau, "Into the Belly of the Image: Historical Aspects of Virtual Reality," *Leonardo* 32, no. 5 (1999): 365-371, accessed 3 March 2014, http://www.jstor.org/stable/1576818.

plans to develop the village into a seaside resort.[46] The duplication of actual towns and nearby places was a popular subject for the panorama as a way to regain control as landscapes transformed during the Industrial Revolution.[47] To quote Stephan Oetterman on this subject:

> After land reform, one might even see a parallel between the displaced farmer and the panorama visitor: one was separated from the land by a fence, the other from the painted landscape by the "false terrain" and a railing. The construction of the panorama – which presented the landscape surrounding the observer as untouched because it was untouchable – represented the act of enclosure and idealised it at the same time.[48]

Representing a landscape lost to history, the painting itself also remains impenetrable. Mars is not lost to history, but is absent in its physical distance from Earth. The *Panorama Mesdag* in The Hague is a depiction of a landscape lost, a landscape which lives on only through its simulation, yet the panorama itself is not so 'untouchable' as it was for the visitors in the late 1800s.

Figures 3.9 a-f. Photographs showing the outlook from the viewing platform. Henrik Willem Mesdag, *Panorama Mesdag,* 1881, The Hague. Photographs taken on 8 May 2014 by author, courtesy of Panorama Mesdag Museum.

[46] Shortly after its completion, the dune was levelled off to build a restaurant, and later an apartment building. Ernst Storm, "What makes the Mesdag Panorama Special?" in *Art Vision: museumMAGAZINE* 01 (2003): 15.

[47] Comment, 8.

[48] Oettermann, 45.


GEEN UITGANG
KEIN AUSGANG
SORTIE INTERDITE
NO EXIT

Upon visiting in 2014 my experience of Panorama Mesdag was remarkably similar to that of FFC. On my arrival, I approached the panorama through a series of galleries, past a television monitor showing the panorama's ten year restoration (already I had caught a glimpse of its construction) and up a short flight of spiral stairs to the viewing platform. As I emerged from the darkness below, I found myself standing on wooden decking, typically found on beach promenades, and looking out across sand dunes littered with disgarded chairs, baskets and old boots, to the painting beyond. The 14.5 x 114.5 metre painting and surrounding faux terrain were bathed in a milky warm glow, the source of which was obscured by a canvas canopy overhead; the light felt neither artificial, nor natural, and it was a little disorienting. Somehow the scene did not feel so vast as the dimensions suggested and perhaps this was due to the enclosed nature of the viewing platform. The sound of pre-recorded seagulls, waves and music filled my ears, and a narrator described the illusion from the speakers above my head, taking me on a 'tour' of the panorama. This tour however was not one of Scheveningen, but more a discussion of the panoramic painting's construction and the artist himself. Although this provision of information was logical (this was a museum piece visited for its historical reverence and not a 'game of deception' for the 'oblivious' observer) it prevented me from becoming totally 'entrapped' in the spectacle; my immersion in it was fractured from the beginning by its museum context. The discussions were dominated by how the illusion was constructed but undoubtedly these were not the discussions had in front of the Mars panorama, as deception was secondary to the landscape depicted.

After seeing the painted space from the viewing platform, I was taken 'behind the scenes' to view the construction of its illusion. I was warned by Marije Beckers, Assistant Manager for the museum, that the illusory experience upstairs on the platform was about to be broken by stepping into its construction, into the very 'belly of the image'. Entering through a doorway located beneath the viewing platform and into the panorama's hidden depths, the notion of it as a borderless image collapsed.

Figures 3.10 a-b. Photographs showing behind the scenes of the panorama. Henrik Willem Mesdag, *Panorama Mesdag,* 1881, The Hague. Photographs taken on 8 May 2014 by author, courtesy of Panorama Mesdag Museum.

Figure 3.11. Photograph showing the distortion of the representation when seen from below the viewing platform. Henrik Willem Mesdag, *Panorama Mesdag,* 1881, The Hague. Photograph taken on 8 May 2014 by author, courtesy of Panorama Mesdag Museum.

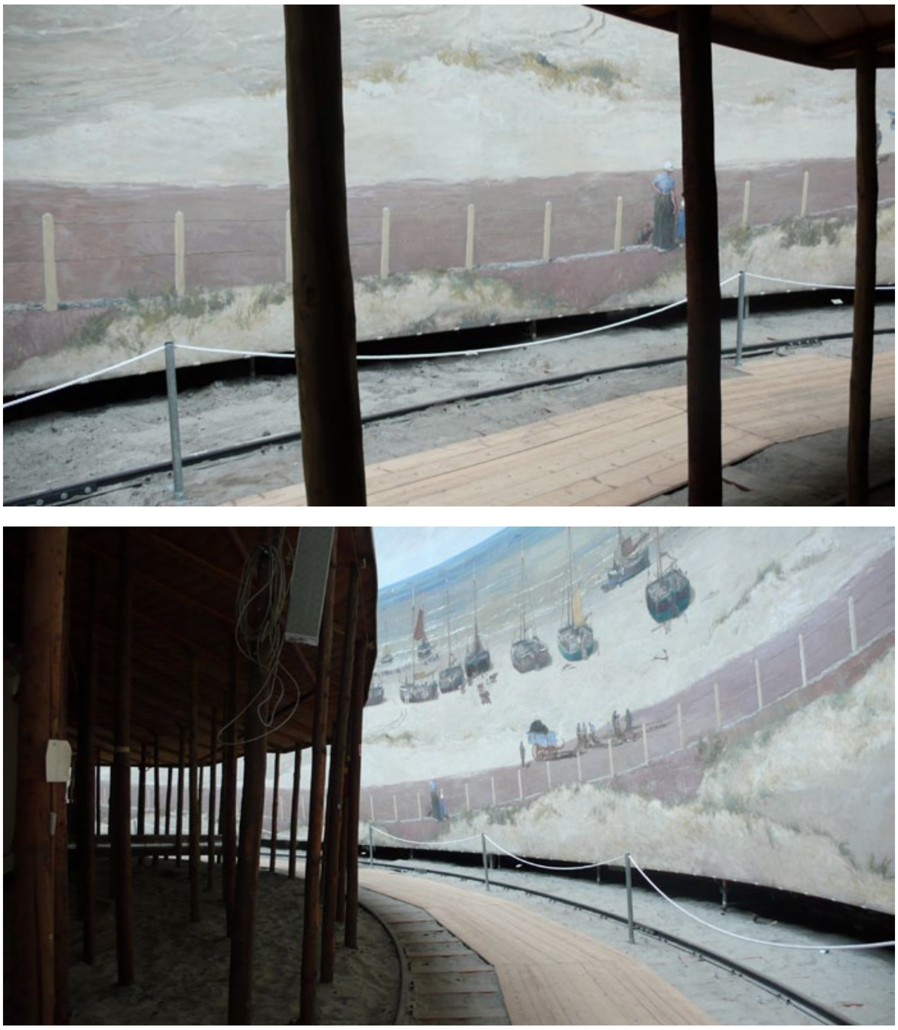

Figure 3.12 a-b. Photographs showing the point at which we had to walk underneath the viewing platform, so as not to disrupt the illusion. *Panorama Mesdag,* 1881, The Hague. Photographs taken on 8 May 2014 by author, courtesy of Panorama Mesdag Museum.

Figure 3.13. Photograph taken from the viewing platform showing the point at which we would have been visible if we had continued to walk around the outside of the rotunda. *Panorama Mesdag,* 1881, The Hague. Photograph taken on 8 May 2014 by author, courtesy of Panorama Mesdag Museum.

The bottom of the faux terrain support was held up by wooden posts that ended several metres away from the painted surface so that there was a gap that revealed the source of lighting above, a large glass roof from which light flooded down upon the painting. Walking around on the wooden decking and gazing upwards at the painting, I became acutely aware of the looseness of brushwork and the distortion of objects due to the perspective being dictated from a central outlook of the viewing platform above. About halfway around, I was directed underneath the canopy and told that the faux terrain came so low at this point that if we continued our journey around the outside of the rotunda, we would, quite literally, walk into the painting above and disturb the illusion for the visitors on the platform (fig. 3.12 a-b).

Once upstairs again (fig. 3.13), I considered how odd this would have appeared, as from the viewing platform there did not seem to be any gap between the painting and faux terrain. The presence of my body, downstairs behind the scenes, would have jolted the unwitting visitor out of their reverie; I would have become a glitch in the image space – a mobile, three-dimensional body against a flat backdrop – resulting in their disillusionment.

Back on the viewing platform my eyes became more accustomed to the glitches I had noticed below; I could see the joins in the picture, and the sections of unpainted canvas not obscured by the faux terrain. I also noticed the different painting styles, different portrayals of the same landscape joined together; as in the construction of the Martian image, these fragments joined in a mismatch of information, forming a reconstructed whole.

Viewing the *Panorama Mesdag* from behind the scenes revealed many glitches that might otherwise have remained unnoticed. Perhaps most compellingly, collapsing the frame and stepping out underneath the viewing platform revealed the constricting nature of the frame for the viewer on the platform. The frame in this case enabled the viewer to remain 'entrapped' within the spectacle and it is here that the concept of Derrida's *parergon* (as detailed in Chapter 2) has great significance. As with the clothing on stone statues in Derrida's example, the faux terrain in the *Panorama Mesdag* is both integral to and separate from the representation. There is a distinction; the faux terrain is made of a different material to the painting it frames, it is three-dimensional. Nevertheless it is a necessary form of ornamentation which orders the illusion and veils the edges of the picture like the draping fabrics veil nudity. The frame is invisible, or at least it is part of the illusion in the same sense that Derrida's *parergon* is integral to the illusion. But as Derrida notes, a frame is 'constructed and therefore fragile, this is the essence or truth of the frame'.[49] By stepping into the panorama's hidden depths the fragility of the frame truly reveals itself and we get a real sense of its importance as a necessary border between what is seen and what should remain unseen.

The faux terrain at the *Panorama Mesdag* acted as a boundary, an interface which made the image impenetrable for the visitor on the viewing platform. The workstations and panels of glass in FutureFlight Central reenacted this physical frame. Mars beamed down, projected within a limited space which deliniated between what is known and unknown, between what is visible and invisible. The restraints enforced by the staging of the image work to reinforce the knowledge of the physical impossibility of stepping into Mars itself. I could not reach out and touch the image of Mars, it was a spectacle to be looked upon, being forever trapped within an impenetrable screen.

Furthermore, my experience of Mars in FFC and the *Panorama Mesdag* was dictated by the frame provided by my own two eyes; 'entrapped' in my own body I became aware of my own subjectivity as a viewer. I could not experience the 360° image at once. As Brian Massumi observes:

> The painted panorama liberated the horizon line. Representation was now allowed latitude […] Formally, the scene was a composite of a number of segments, each ordered according to the conventions of perspective, with its own vanishing point […] The vanishing points of the joined segments stood out as privileged viewpoints, structuring the composition. The panoramic image did not in fact break with traditional perspective, but multiplied it. [50]

In this sense my experience of the images in FFC and in the *Panorama Mesdag* was fractured, but my perception of the panoramic installation as a whole, was very real. As in real life I had to negotiate different viewpoints, and other visitors who had come to view this landscape from the same spot as I. Perhaps then, this is one reason why *Curiosity's Billion-Pixel View* or the *Mars Window* at *Visions of the Universe*, cannot and do not propose to deliver fully immersive panoramic visualisations as they *are* able to be seen from one viewpoint: both have a central focus, and their horizon lines have not been liberated from their framing devices.

We might also take into consideration a more literal interpretation of Massumi's statement; the Mars panorama is made from hundreds of high resolution pictures each with their own perspectives and vanishing points. In some places, where there has been a

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[49] Jacques Derrida, "The Parergon," trans. Craig Owens, *October* 9 (Summer 1979): 33, accessed 7 January 2015, http://dx.doi.org/10.2307/778319.

[50] Brian Massumi, "PANOSCOPIA, The Panoramic Photography of Luc Courchesne," *Panoscopic Journal* (2003): 2, accessed 8 July 2014, http://www.brianmassumi.com/textes/Panoscopia.%20The%20Panoramic%20Photography%20of%20Luc%20Courchesne.pdf.

mismatch in tonal range, we can see the composition and on occasion these separate vistas break forth and confront the viewer as ‘privileged viewpoints’ in their own right. This can be seen in *Curiosity’s* black and white *Panorama with Sandstone Outcrop Near 'The Kimberley' Waypoint* (fig. 3.14, pg. 156).[51] The vanishing point disappears when we view Mars panoramas in FFC and the penetrating aspect of a single image is lost in the collage.

NASA’s FutureFlight Central and the *Panorama Mesdag* hold certain similarities; individual vistas spring forth; physical space presents a barrier preventing the viewer from touching the image; light and the continued process of looking emphasise the flatness of the painted surface or screen. Yet there is one fundamental difference between these two types of panoramic visualisation. We are able to drive up to the spot in Scheveningen from where this painting was based and see for ourselves exactly how this particular landscape has changed over the years. Both are images without a referent; the painted panorama represents a landscape lost to history, the Martian panorama represents a landscape we have never been able to witness; a landscape alien to this world. It is through the presence of the frame, the screen, and the state of the image in a process of transformation that this alien terrain collapses into illusion and we become aware of seeing the Martian terrain through the technological eye. ‘Looking out’ through the windows of a virtual spacecraft, this private facility enables a form of travel, albeit virtual, that the *Mars Window* at *Visions of the Universe* played upon at a public exhibition. For the viewer of the Martian panorama it is both Mars and its image that remain intangible, as the next section of this chapter shows.

[51] This effect is often highlighted in painted panoramas, as sections can be painted by different artists.

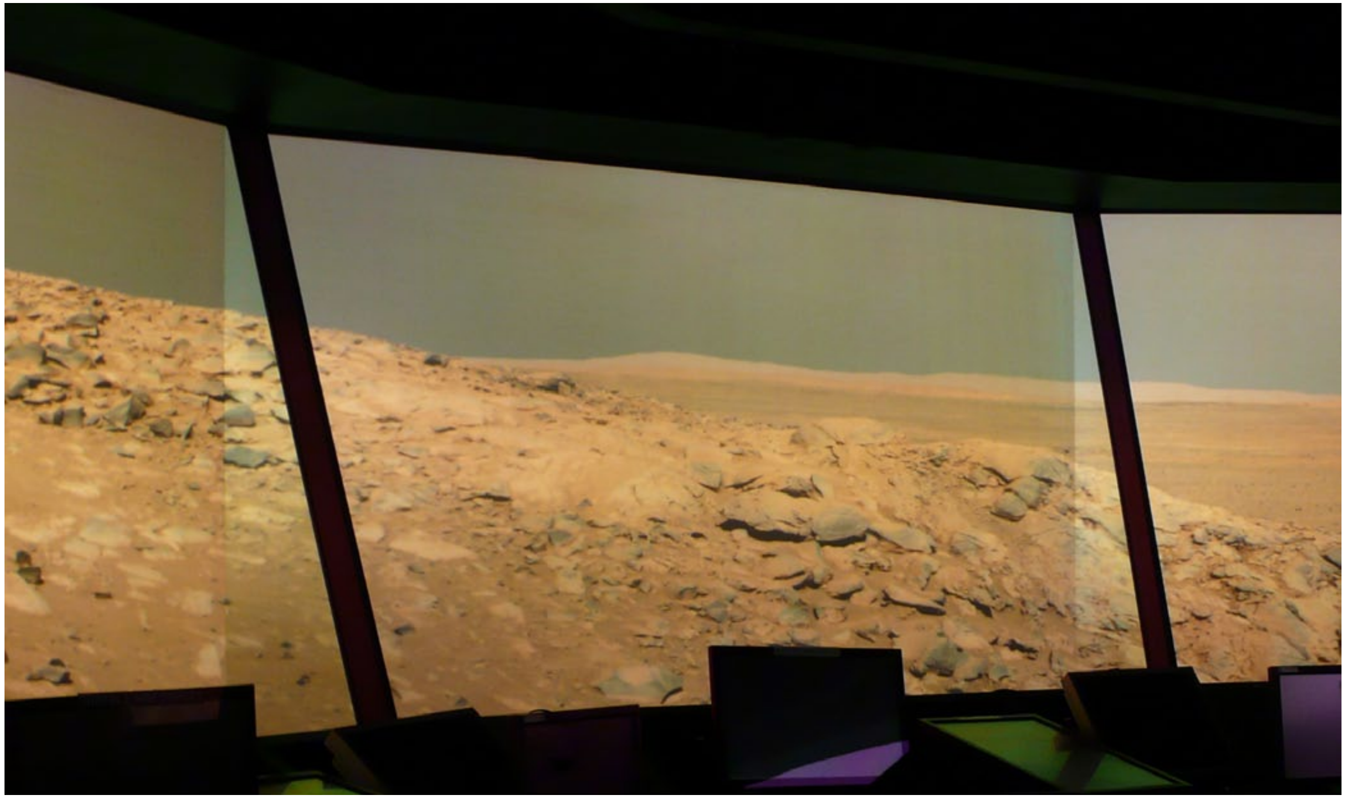

Figure 3.14. *Panorama with Sandstone Outcrop Near 'The Kimberley' Waypoint,* captured by the NavCam on 18 March 2014. Photojournal image addition date: 24 March 2014. Credit: NASA/JPL-Caltech.

Figure 3.15. *Cahokia Panorama,* captured by NASA's Mars rover *Spirit* in 2004 and displayed in NASA Ames Research Centre's FutureFlight Central on 9 November 2015. Photograph by author, courtesy of NASA Ames Research Centre.

Figure 3.16. *'McMurdo' Panorama from Spirit's 'Winter Haven'* displayed on the *Mars Window* at *Visions of the Universe,* 2013. Credit: National Maritime Museum.

Figure 3.17. *Curiosity's Mount Sharp Panorama in Raw Colours,* displayed on the *Mars Window* at *Visions of the Universe,* 2013. Credit: National Maritime Museum.

A Window on Mars: Travelling to Distant Lands through the Image

'A child just stepped onto the Red Planet.'[52] This was the opening sentence of a newspaper reporting on *Visions of the Universe*, an exhibition held at the National Maritime Museum, Greenwich in 2013, featuring a vast panoramic visualisation of the Martian terrain. The exhibition took the visitor on a journey of scientific discovery and technical evolution; beginning with Galileo's drawings of our closest satellite, the imagery moved methodically out to the nearby planets, our solar system, distant galaxies and the far reaches of the visible universe, imaged through the most technically advanced devices. The show felt something like an art exhibition, merging gallery display methods with scientific images, which were – as curator Dr Marek Kukula and writer Elizabeth Kessler have argued – works of art due to their associations with the sublime.[53] The images were backlit and hung against black walls, drawing the visitor in to examine each luminous depiction for moments of contemplation. In the 16th century Nicolaus Copernicus proposed in *De Revolutionibus Orbium Coelestium* (*Of Celestial Orbital Revolutions*) that the Earth was not the centre of the universe and since this time man has fixed its gaze outwards.[54] *Visions of the Universe* mapped this journey of discovery.

At the centre of the exhibition, visitors found themselves looking out across a Martian landscape. This *Mars Window* – as Kukula has termed it – was projected onto a 16 metre curved wall, which had the effect of embracing the visitor, surrounding them in image space.[55] The projection cycled between three different panoramic mosaics taken by NASA's rovers, *Spirit, Opportunity* and *Curiosity* (the latter mosaic was created especially for the exhibition by the *Curiosity* team). It was the first time these images had been seen on such a scale by public viewers. To quote Kukula;

> As part of the gallery design we knew we wanted to have a 'wow' moment that would immerse people and make them stop and contemplate the ideas that they'd been absorbing throughout the exhibition. My direct inspiration for this was Olafur Eliasson's *Weather Project* in the

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[52] Jonathan Jones, "Visions of the Universe Exhibition Reveals Full Wonder of Space Images." *Guardian,* 11 June, 2011, accessed 5 January 2014, www.theguardian.com/artanddesign/2013/jun/11/visions-of-the-universe-greenwich-space-photography.

[53] Kukula states:

> As curator for *Visions of the Universe*, right from the start I wanted the exhibition to address the aesthetic and philosophical dimensions of the images as well as their scientific, technological and historical aspects. We determined that the exhibition should feel something like an art installation despite its science theme and we were influenced by the idea of astronomical images being part of the artistic tradition of the sublime, as discussed in Elizabeth Kessler's book *Picturing the Cosmos*. This also influenced the inclusion of the Wolfgang Tillmans prints in the show.

Kukula, email message.

[54] Xavier Barral, *This is Mars* (New York: Aperture, 2013), 234.

[55] Kukula, email message.

> Turbine Hall of Tate Modern in 2003. We were inheriting a gallery layout from the previous Ansel Adams exhibition so I knew that we would have a long curving wall, and the preliminary planning period for *Visions* coincided with the build-up to the landing of the *Curiosity* Rover on Mars in August 2012. The rover was being hailed as the first mission to take HD cameras to another planet and this is what made me think about the idea of projecting 'life-sized' panoramas onto the wall. The intention was very much to try to give visitors a sense of actually 'being there' but also to play with the cognitive dissonance of experiencing an ostensibly familiar, graspable landscape which is also on an alien world millions of kilometres away.[56]

The image was projected with three ceiling-mounted digital projectors using edge-blending to 'create a seamless image'.[57] Similarly with FutureFlight Central, the software enabled the images to pan slowly across the landscape and allowed viewers to interact with it; as visitors stood on points on the floor in front of the *Mars Window*, certain surface features were highlighted with information pertaining to a specific place. The scientists, visual imagers, curators and teams that made *Visions of the Universe* possible reconstructed for the viewer the illusion that they were looking out across the Martian terrain. A 'life-sized' reconstructed landscape.

Although the *Mars Window* was not all encompassing like the panorama in FFC, it nevertheless used a panoramic image and displaying the image on a long curving wall attempted to reduce the presence of the frame and 'entrap' the viewer in a more immersive image space. This need to visualise places physically unavailable to us was one of the key themes of *Visions of the Universe* and the *Mars Window* went beyond the conventional wall hung image in its attempt to take audiences on a tour of Mars. NASA's rovers contribute to the telerobotic exploration of the solar system; sending back digital postcards of new lands they enable us to travel virtually across millions of miles. It is in this respect that the *Mars Window* may be likened to painted panoramas; it too was a virtual reconstruction of time and place, allowing public visitors to travel to distant lands through the image.

This subchapter considers the *Mars Window* in relation to the virtual tourism enabled by the painted panorama; as a way of acquiring knowledge without having to travel, the rover is arguably the contemporary artist, reconstructing a vision that remains impossible for the Earthbound spectator.

The painted panorama was linked to the new era of tourism in the 19th century and according to Charlotte Bigg, 'historians have linked the invention of the panorama to the late eighteenth century's first hot air balloon rides and a new fashion for travelling'.[58] Panoramas became an 'economical surrogate for travel', announcing and preparing in 'virtual form the

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[56] Ibid.
[57] Ibid.
[58] Bigg, 74.

mass tourism that developed with railways and steamships from the 1850s'.[59] The painted panorama was praised for its ability to transport the viewer, and for naturalist Alexander von Humboldt the panorama could

> almost substitute for travelling through different climes. The paintings on all sides evoke more than theatrical scenery is capable of because the spectator, captivated and transfixed as in a magic circle and removed from distancing reality, believes himself to be really surrounded by foreign nature.[60]

This echoes cultural theorist Paul Virilio's position on telecommunication today. In *Polar Inertia*, Virilio argues that physical travel has been usurped by virtual travel; as a 'high-performance vehicle', the image enables 'travelling on the spot'.[61] Presenting a 'crisis of the household car' '*now everything leaves without any need to depart'.*[62] He continues:

> The special arrival of dynamic vehicles, moving and then self-moving, has suddenly been replaced by the general arrival of images and sounds in the static vehicles of the audiovisual. Polar inertia is setting in. The instant interface is being substituted for the longest journey times.[63]

To enable virtual travel to Mars, immersive image forms are being employed in the hope of giving the most life-sized and life-like experiences possible in an attempt to leave flatness behind. The *Mars Window* and Mars panorama in FFC certainly make for a more 'life-like' and immersive experience in comparison to *Curiosity's Billion-Pixel View*. Arguably these image forms contribute to a greater understanding of Mars because of their scale, allowing us to be transported imaginatively, however momentarily, to a distant land. The *Mars Window* today becomes a substitute for real experience because the real Mars is out of reach, the image is without a referent.

The painted panorama made claim to be an 'absolutely faithful reproduction of an actual landscape' in order to replace a real experience for the virtual tourist.[64] Much in the same way as the Mars panorama enables us to acquire a greater situational understanding of what we see in the image, the painted panorama contributed to the acquisition of knowledge.[65] To achieve this, the panorama's aim was to create a faithful representation of reality. For example, Robert Barker, on exhibiting his first panorama of Edinburgh in 1789 is said to have asked the Provost of Edinburgh for a statement certifying that the work was a 'perfectly fair and accurate representation of the city and its surrounding as far as the horizon

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[59] Oskar Bätschmann (1989) quoted in Grau, *Virtual Art,* 69; Bigg, 75.
[60] Alexander von Humbolt (1993) quoted in Grau, *Virtual Art,* 69.
[61] Paul Virilio, *Polar Inertia,* trans. Patrick Camiller (London: SAGE Publications, 2000), 14 & 18.
[62] Ibid., 14 & 20.
[63] Ibid., 20-21.
[64] Bigg, 75.
[65] Comment, 130.

and in all directions' as 'wishing to replace reality, it had to be able to guarantee that it conformed to its model'.[66] Advertisements emphasised the fact that all sketches and observations were made from the viewpoint itself and that artists spent great amounts of time studying their chosen location.

Almost a century later the panorama still laid claim to such veracity. In Germany in 1883, the panorama artist Anton von Werner presented *The Battle of Sedan*, a 1725 square metre panorama to honour the anniversary of the battle.[67] Reconstructing for the viewer a historical moment in time, it

> shows that moment in the Battle of Sedan during the afternoon of September 1, 1870, between 1:30 and 2:00, when the French Army […] enveloped by the left flank of the German army and pushed back to the Plateau of Floing-Illy, is making its last desperate attempt to smash through the Prussian lines and gain an avenue of retreat.[68]

According to philosopher Dolf Sternberger, this description 'focuses the expectant viewer's attention on a highly specific historic situation' so that they are 'carried away […] to a time thirteen years ago'.[69] The historic battle has been reconstructed as a moment in time in a similar manner to how the *Mars Window* reconstructed a scene in recent history that the viewer cannot physically encounter. In the *Battle of Sedan* we experience the distance of time, whereas in the *Mars Window* we experience the distance of place; both are scenes requiring virtual reconstruction in order to be 'seen'.

One newspaper reporting on the *Battle of Sedan* claimed that 'the visitor is gripped immediately; he is taken completely by surprise and instinctively holds back. One is afraid of being trampled by the horses' hooves.'[70] Reactions such as these were not rare, and serve to validate the panorama as a 'second world' in relation to which the visitor felt immediately in danger.[71] Von Werner was obliged to emphasise the documentary nature of his panorama, claiming it as a second reality rather than an illusion so that it did not appear to be deceiving the public. 'Entrapping' them in the 'real', the *Battle of Sedan* enabled the viewer to imagine travelling back in time to the moment of battle.[72] Interestingly, von Werner, who, responsible

[66] Ibid., 129.

[67] Benefitting from a grand opening ceremony at which the Kaiser praised von Werner for making the battle 'a living memory for the people' demonstrates the use of panoramas for political support. In this example, the French were portrayed as faceless attackers, whereas the Prussians were individualised and portrayed as superior and as the defenders, when in reality this was not the case. Grau, *Virtual Art,* 91-94.

[68] Sternberger, 3.

[69] Ibid.

[70] Grau, *Virtual Art,* 98.

[71] Viewers of the Lumière Brother's *Arrival of a Train* (1895) experienced a similar phenomenon; not having seen a moving image they feared the train was real and would inevitably crash through the screen into the theatre. Many ran screaming from the cinema.

[72] Grau, *Virtual Art,* 98 & 70.

for the composition, viewpoint and the panorama's authentic 'look', had not spent a single day in battle and consulted many sources in order to reconstruct a 'life-like' representation.[73] The artist was assisted by general officers and soldiers, and studied strategic maps to measure distances of fighting areas.[74] Unlike Thomas Hornor's panorama of London, or Henrik Willem Mesdag's panorama of Scheveningen – which were copied directly from the scene – *The Battle of Sedan* reconstructed a moment with no direct empirical experience of the battle. In some ways then, the *Mars Window* and the Mars panorama in FutureFlight Central hold strong ties to *The Battle of Sedan.* The rover, positioned on the surface of Mars, is the soldier, recounting information to the visual imagers at NASA who construct the final image from hundreds of snapshots of non-empirical information, pre-recorded by a machine that is millions of miles away. The panorama in its historical context was seen as a 'source of truth, a guarantee of reality', however as Bernard Comment writes in *The Panorama*, it did not merely repeat 'an experience that had already taken place', but rather replaced it.[75] The visions of Mars cannot replace a moment that has not occurred for the visual imager at NASA, there is no first-hand experience to draw upon in order to represent Mars. As discussed in Chapter 1, the rovers, and in turn the visual imagers, reconstruct a vision from digital interpolation and rover automation, allowing us to travel *virtually* to this distant land through the image.

As means of travel became more advanced in the 1850s and these distant worlds were in turn depicted in image representations at the time, the technologies for exploration being developed today are similarly evoked in our contemporary visualisations of unknown realms. While *Mars-as-image* remains an impenetrable place for the body, plans to send humans to Mars are already in the making.[76] We are not satisfied by the image of a distant land as a flat, intangible entity, we must go there, grasp it with our senses and allow our body to be enveloped by its atmosphere. It is this very insatiable desire to step out and onto Mars that works to jolt the spectator of the *Mars Window* from their reverie, bringing them back to Earth and revealing again the *image-as-image.*

[73] Comment, 129.
[74] Sternberger, 4.
[75] Comment, 130.
[76] NASA aims to send manned missions to Mars in the 2030s.

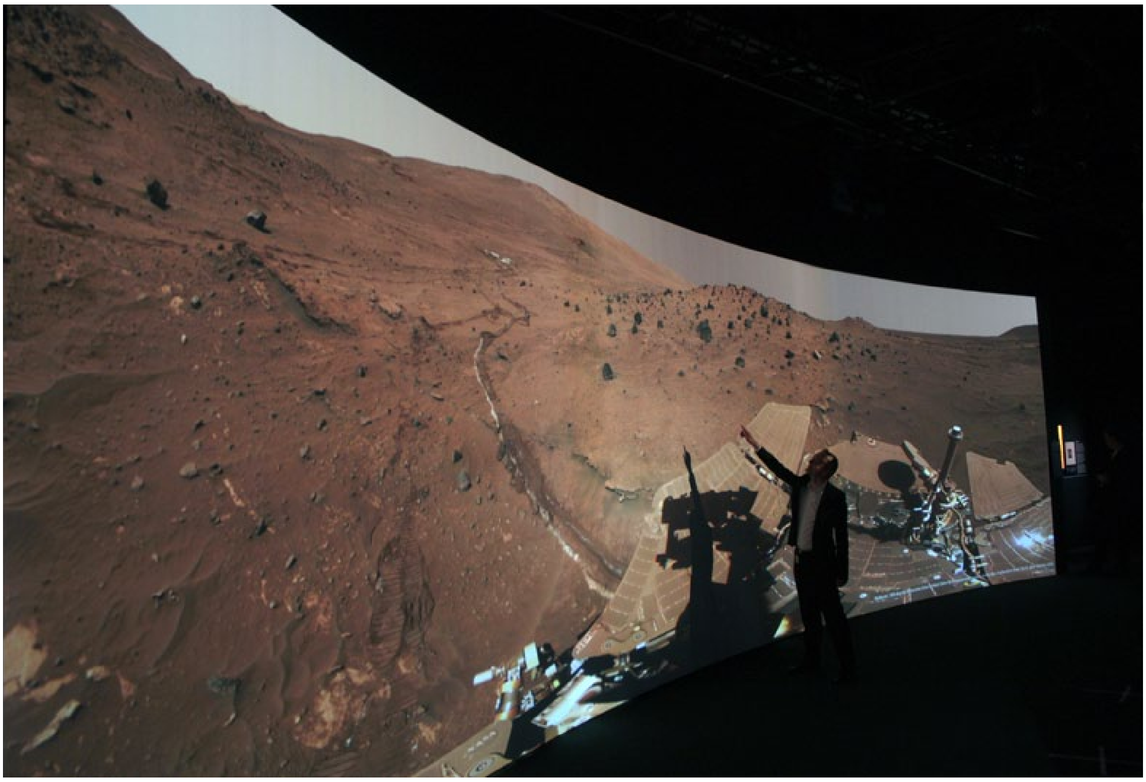

Figure 3.18. Photographer unknown. *The impressive 'Window on Mars' at the Visions of the Universe exhibition.* Image shown in "Visions of the Universe Preview," in *Sky at Night Magazine*, 5 June 2013.

The *Mars Window:* The Body as Chiasm or Chasm?

The spectator of the *Mars Window* was presented with an image they could observe from one viewpoint, more in tune with the traditional Albertian concept of a window upon a world. Despite its intention of reconstructing a view for the visitor, to use Anne Friedberg's words,

> the condition of the window implies a boundary between the perceiver and the perceived […] Enclosed behind the window the self becomes an observing subject, a spectator, as against a world which becomes a spectacle, an object of vision.[77]

A window is a separating interface, and not a portal that may lead us to the place beyond. Thus it makes the thing it represents untouchable; to view only through a window means to experience from beyond and not within. In the case of the *Mars Window*, we cannot step through the divide onto the surface of Mars, rather we are trapped somewhere in between the physical environment of the exhibition space, and the imaginary two-dimensional space of the image.

Unlike the viewer of Charles Langlois' panorama who, surrounded by props, is 'entrapped' in illusion, on viewing the *Mars Window* our feet remain firmly fixed upon the carpet and we become a part of the illusion in an entirely different sense. A desire to move

[77] Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge, MA: The MIT Press, 2006), 16.

closer to the landscape reveals, through the presence of the body, the construction of illusion. Dolf Sternberger has described the painted panorama as ‘an enclosing artificial Nature, whose relentless illusionistic unity forbade even the faintest hint of a frame’.[78] In the *Mars Window*, it is not the frame that collapses to draw us into illusion, rather the framed illusion is the thing collapsed as we become the glitch. In order to become fully immersed in the illusion one imagines an all-encompassing experience whereby our visible field is enveloped by image. But the *Mars Window* does not give us this option; we cannot examine this terrain up close, as any attempt to do so is rendered useless by the body’s presence within the beam of digitally projected light. Here the *Mars Window* is a transitory space of immersion, an ‘illusionary address to the senses’ that collapses as the spectator advances forth.[79] As discussed in Chapter 2, Slavoj Žižek suggests that glitches or ‘digital breaks’ are necessary in revealing the presence of the image.[80] In the case of the *Mars Window* it is not a glitch within the image that forces an awareness of its materiality, rather the body produces a break in the digital; as the viewer becomes aware of their presence within the space of the image, so too do they recognise the very act of looking.

In Maurice Merleau-Ponty’s *The Visible and the Invisible,* written in French in 1945, Merleau-Ponty discusses the idea that the invisible – which, he argues, is not opposed to the visible – is the ‘invisible *of* the visible’.[81] The book moves from a discussion about perception (the visible) to a discussion about language and truth (the invisible) and is a phenomenological enquiry drawing on the works of Kant, Husserl, Bergson and Sartre. The fourth chapter titled “The Intertwining – The Chiasm” explores the production of visibility and ‘the metaphysical structure of our flesh’.[82] Merleau-Ponty passed away whilst writing it so the text is incomplete, but it nevertheless breaks new ground, building upon a phenomenon discussed in his earlier book *The Phenomenology of Perception;* that of the body as both subject and object, but that which is never both simultaneously. To exemplify this phenomenon, Merleau-Ponty uses the example of touching one hand with the other and vice versa, claiming that this act reveals two dimensions of our flesh: [83]

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[78] Sternberger, 5.

[79] The description of the panorama as an ‘illusionary address to the senses’ comes from Grau, *Virtual Art,* 15.

[80] Slavoj Žižek, *The Plague of Fantasies* (London: Verso, 1997), 151.

[81] Stanford Encyclopedia of Philosophy, “Maurice Merleau-Ponty,” 14 September 2016, accessed 20 June 2014, http://plato.stanford.edu/entries/merleau-ponty/.

[82] Translator’s preface, Maurice Merleau-Ponty, *The Visible and the Invisible, followed by Working Notes,* trans. Alfonso Lingis, ed. Claude Lefort (Evanston: Northwestern University Press, 1968), xi.

[83] Merleau-Ponty defines flesh as follows:

> the flesh we are speaking of is not matter. It is the coiling over of the visible upon the seeing body, of the tangible upon the touching body, which is attested in particular when the body sees itself, touches itself seeing and touching the things, such that, simultaneously, *as* tangible

> my hand, while it is felt from within, is also accessible from without, itself tangible, for my other hand, for example, if it takes its place among the things it touches, is in a sense one of them, opens finally upon a tangible being of which it is also a part. Through this crisscrossing within it of the touching and the tangible, its own movements incorporate themselves into the universe they interrogate.[84]

The subjective hand touches and examines the other hand as object. The phenomenon of the body as both object and subject is what creates the 'chiasm', a gap between ourselves as touching and ourselves as touched, a crossing over or fold between our mind and the world. Yet this 'chiasm' is an ambiguous one as the body switches between subject and object, between perceiver and perceived. As with Lacan, we are both seer and seen. Furthermore, Merleau-Ponty's argument is that the body is intrinsic to perception, being a subject of perception but also an object seen within the fabric of the world.

Introducing *The Visible and the Invisible,* Alfonso Lingis makes an interesting observation pertinent to the *Mars Window* spectator:

> The seer is not a gap, a clearing, in the fabric of the visible; there is no hole in the weave of the visible where I am; the visible is one continuous fabric, since inside of me there are only "shadows stuffed with organs – more of the visible". The manifest visibility of the world closes in over itself across the zone of latent visibility of my flesh.[85]

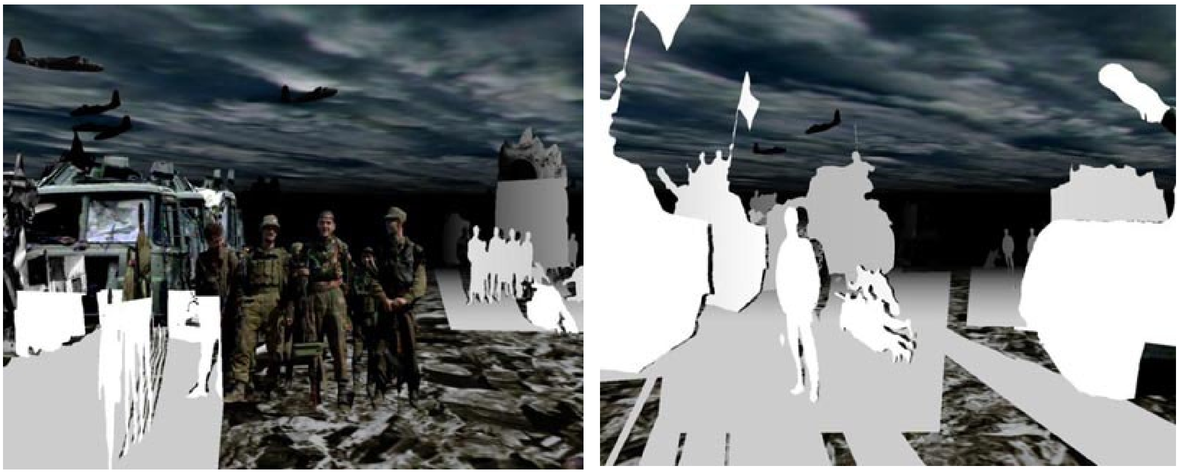
Approaching the *Mars Window*, our body is not a *chiasm*, a link or fold intertwining us with the visible world, rather it becomes a *chasm* because the 'fabric of the visible' is projected light and not material reality. The body here becomes a gap, a fissure in the digital landscape. Our illusory experience of the *Mars Window* becomes fractured through an attempt to move closer to the land and thereby we become the glitch; our physical presence dissolving the landscape into blacked out silhouettes of ourselves, disrupting the projection, creating an impenetrable chasm in the landscape we strive to reach. In so doing we become part of the image through its absence; our presence translates into an absence of image, we are *apart* from the image yet integral to its disillusion. We are reminded of the flatness of the wall, the substrate upon which the image of Mars remains a ghostly semblance.

> descends among them, *as* touching it dominates them all and draws this relationship even this double relationship from itself, by dehiscence or fission of its own mass […].

Merleau-Ponty, *The Visible and the Invisible,* 146.

[84] Ibid., 133.

[85] Translator's preface, ibid., vi.



Figures 3.19 a-b. Maurice Benayoun, *World Skin: A Photo Safari in the Land of War,* Virtual Reality, CAVE, cameras, printer, Internet, 1997.

It is in a similar manner that media artist Maurice Benayoun points to the fragility of the digital projection. His 1997 installation piece at Ars Electronica titled *World Skin: A Photo Safari in the Land of War* used CAVE technology with Liquid Crystal glasses to create a feeling of immersion within a videogame aesthetic war zone environment. In this installation, images were back projected onto the semi-translucent walls and the ceiling to give the participant the feeling that they were 'physically present in the images'.[86] Like the gigantic panoramas of historic battles, the subject of Benayoun's piece was warfare, the images of which were collaged in computer graphics to create a panoramic visualisation that moved the visitors through the landscape virtually. However, unlike the *Mars Window* where the destruction of information is unintended and comes as a disruptive break for the viewer, the visitors of *World Skin* were actively encouraged to participate in the disintegration of image space. Entering the virtual environment equipped with a camera, they were invited to take pictures; but these pictures did not simply manifest themselves within the device, instead the cameras were used as weapons of annihilation, as whatever the visitor chose to frame within the photograph was withdrawn immediately from the virtual landscape: 'the fragment photographed disappears from the image space, leaving a monochrome area with black silhouettes'.[87] The captured picture was then printed off for the visitor upon leaving the installation, thus they became actively involved in both changing the appearance of the installation, and becoming immersed through the physical removal (manifest in the paper

[86] Grau, *Virtual Art,* 238.
[87] Ibid., 239.

printout) of their fragment.[88] Here photography was used at the visitor's discretion as a 'weapon of erasure', negating the image it cast an eerie shadow according to the visitors' perspective at the moment of capture.[89] The photographs detached only the surface of the visible at the time when the shutter was released, and as the virtual space unfolded revealing more of the landscape, visitors were able to see which points had been left untouched by the camera's gaze. It was not simply the visitor's presence that affected how the image space was perceived, it was their active participation with it. The further back the visitor to the *Mars Window* stands, the more realistic the illusion remains. But approaching the image, we are Maurice Benayoun's camera, erasing – albeit momentarily – the projection of Mars. This attempted physical engagement with Mars results in a withdrawal of it; the closer we get, the further we are pushed back into our own reality, reminding us of the impossibility of ever stepping out onto this alien terrain.

For Merleau-Ponty, the body unites us with the world, it is only through the body that we may perceive and to quote Brian O'Doherty in *Inside the White Cube*, 'the Eye urges the body around to provide it with information – the body becomes a data-gatherer'.[90] Perception is therefore defined by the body, the body dictates what one perceives and our bodily and tactile experiences of the world play important factors in our perception of it: 'All knowledge takes its place within the horizons opened up by perception.'[91] Yet our experiences of Mars are dictated entirely by the rover; the rover becomes the body, and we perceive Mars through it. It is thus a mediated perception, one relying solely on our visual experience and our imaginative ability to place ourselves on the dusty red terrain.

[88] A photograph, no matter how large or detailed, is always a fragment of a greater picture as the photographer generates what Christian Metz termed in his 1985 essay *Photography and Fetish* as 'a cut inside the referent', an 'instantaneous abduction of the object out of the world into another'. Thus the moment it captures is removed and re-contextualised within the confines of the picture frame. Christian Metz, "Photography and Fetish," *October* 34 (Autumn 1985): 84, accessed 20 October 2013, http://www.jstor.org/stable/778490.

[89] Maurice Benayoun, "World Skin: A Photo Safari in the Land of War," Maurice Benayoun 1998, accessed 20 August 2014, http://www.benayoun.com/projet.php?id=16.

[90] Brian O'Doherty, *Inside the White Cube: The Ideology of the Gallery Space* (Berkeley: The Lapis Press, 1976), 52.

[91] Maurice Merleau-Ponty, *The Phenomenology of Perception,* trans. Colin Smith (London: Routledge & Kegan Paul, 1962), 207.

Figure 3.20. *Greeley Panorama* captured by NASA's Mars rover *Opportunity* in 2011. This panorama is comprised of 827 image tiles and was taken on 21 December 2011 (sol 2,811). Panorama as displayed in NASA Ames Research Centre's FutureFlight Central on 9 November 2015. Photograph by author, courtesy of NASA Ames Research Centre.

It is in the Mars panorama in FFC that the presence of the rover's body, the object through which we see, betrays the illusion. Unlike the painted panorama in which the presence of the artist and the painted surface should not be felt, we are aware of the 'creator' in FFC. Scrolling down the panoramic image in FFC in an attempt to view the rocky terrain closest to us, the rover appears gigantic and warped. Kenji Kato explains this distortion:

> The image is not enlarged, but because these are wide field cameras, it distorts the image a little. When we drop down to view the terrain closer to the rover, and parts of the rover, we're actually giving it a magnification.[92]

The footprint of the room also accounts for this distortion; this is supposed to be a single point (the camera's lens), which has been expanded to a radius of 7.3 metres.[93] In the *Mars Window* we also look past oversized representations of the rovers; imposing and larger than life, we look both through and at the rover simultaneously. In this instance the rover is the glitch, a reminder that this image is impenetrable, that we see the Martian terrain through its eyes and not our own. Dictating our position within a panoramic landscape, it is both subject and object simultaneously.

In the distortion of the rover we are aware of its body and in turn our own. But our body is not part of the landscape we look upon, we are not the locus of perception in this visible world.[94] The presence of the rover is a reminder that the visible is alien to us, and so we cannot grasp it in its entirety. To this end, Merleau-Ponty discusses the idea of the seer and the visible:

> Hence, without even entering into the implications proper to the seer and the visible, we know that, since vision is a palpation with the look, it must also be inscribed in the order of being that it discloses to us; *he who looks must not himself be foreign to the world that he looks at.* As soon as I see, it is necessary that the vision (as is so well indicated by the double meaning of the word) be doubled with a complementary vision or with another vision: myself seen from without, such as another would see me, installed in the midst of the visible, occupied in considering it from a certain point […] *he who sees cannot possess the visible unless he is possessed by it, unless he is of it.*[95]

Is this why our body must disrupt the illusion of the *Mars Window*? We are not a tangible part of the thing perceived, and it is through the emergence of a glitch – created by our presence – that we become aware of the landscape as reconstructed image. For Merleau-Ponty the 'body as a visible thing is contained within the full spectacle', yet in the *Mars Window* the body becomes visible as a shadow, a reverse of the visible, and part of the spectacle in a

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[92] Kato, interview.

[93] Rabin, interview.

[94] The idea of the body as a 'locus of perception' was set out in Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 178.

[95] Merleau-Ponty, *The Visible and the Invisible,* 135.

different manner.[96] One must dance back and forth to obtain the desired visual information. Brian O'Doherty makes a similar observation describing the spectator of an Impressionist painting:

> Impressionism's first spectators must have had a lot of trouble seeing the pictures. When an attempt was made to verify the subject by going up close, it disappeared. The Spectator was forced to run back and forth to trap bits of content before they evaporated. The picture, no longer a passive object, was issuing instructions.[97]

The *Mars Window's* spectator is subjected to an equivalent challenge; on their approach the illusion of reality breaks down into its materiality, not daubs of paint on canvas, but digital points of projected image.

Both the panorama in FutureFlight Central and the *Mars Window* are volatile projections of an intangible alien landscape. Each image form holds at its core the desire for larger and more expansive ways of seeing, to travel to distant lands through a borderless image. For the Mars panorama in FFC the framing device is concealed, masked as a window and we step up through the hatch of a spacecraft to look out upon the Martian landscape. The thick glass between us and the screens reinforces the feeling we are looking out from a central, elevated position, which affords us views in all directions. But we cannot look over the sides and down at the ground beneath, and an attempt to do so by shifting the focus of the image reveals the rover's body as distorted and alien to the landscape it inhabits. The rover dictates our position within the *landscape-as-image*.

It is also through the image's ability to revolve in FFC that we become aware of our fragile position as a viewer; this is a temporal, ethereal space, bound by the rigidity of the frame. The frame collapses as the *Mars Window* spectator advances forth, the edges of the wall retreating into peripheral vision. But it is our longing to step ever closer and onto the terrain that causes the image to withdraw, causing the glitch. The blacked-out space of our silhouette recalls Slavoj Žižek's 'elusive point from which the object returns the gaze'.[98] The image is impenetrable because the landscape of Mars is always beyond our grasp.

[96] Ibid., 138.
[97] O'Doherty, 55.
[98] As discussed in Chapter 2. Žižek, *Plague of Fantasies,* 133.

Chapter 4
A Glimpse of Mars through Fragmented Illusion: The Materiality of the 3D Image

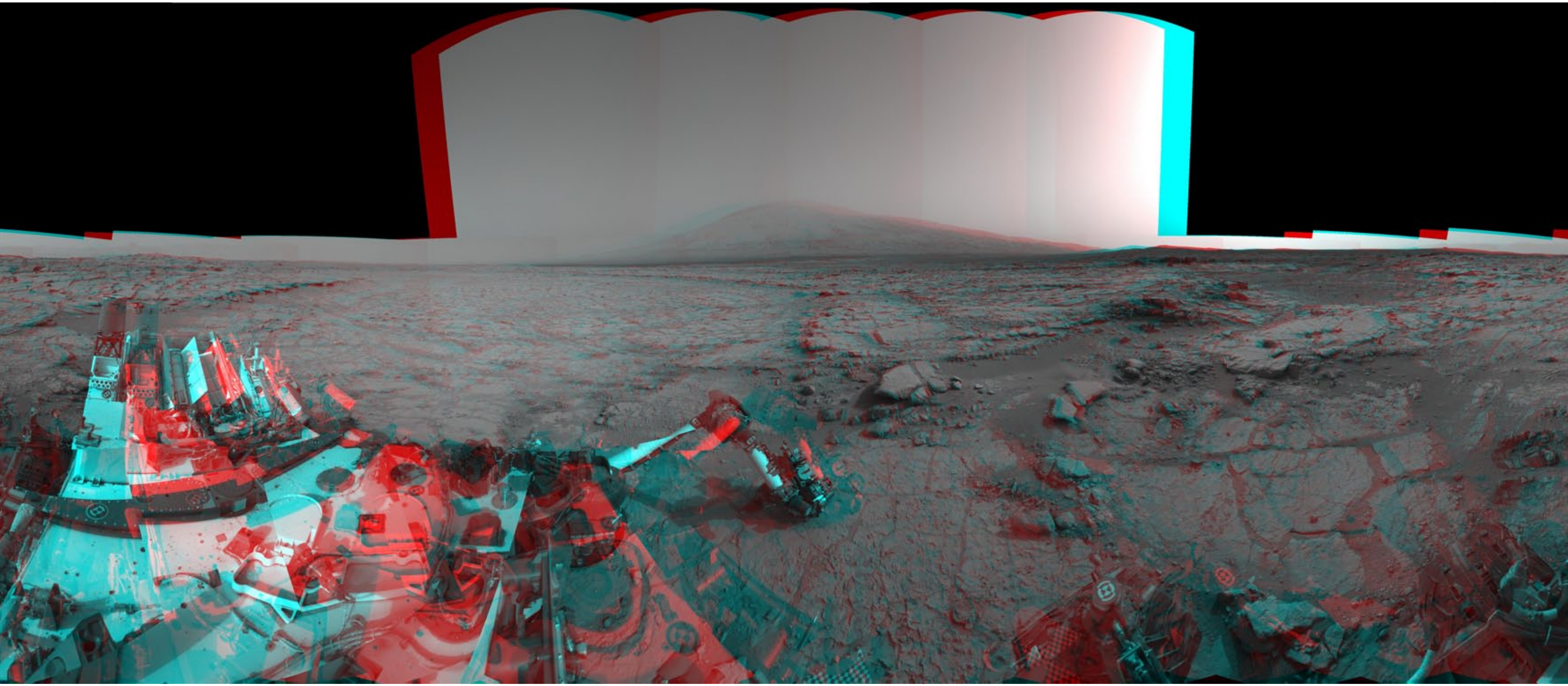

Figure 4.1. *Mars Stereo View from 'John Klein' to Mount Sharp, Raw.* This 360° anaglyph combines dozens of images taken by *Curiosity's* right and left Navigation Cameras on 23, 25 and 26 January 2013 (sols 166, 168 and 169). Photojournal image addition date: 23 April 2013. Credit: NASA/JPL-Caltech.
3D glasses enclosed inside back cover.

As I don the red/blue glasses and gaze deep into the image, Mount Sharp emerges as a smudged horizon, a veil of dust with sharp interruptions of red and blue. Jagged borders.

There are three horizon lines to this image; the first being where land meets sky and the second where the sky meets a void of imageless space. The third is more subtle, it is the space in between the land and the sky, the faint tinge hovering above the dusty horizon, pixelated and shimmering in red and blue. Curiosity's *goal has been saved from the void of disillusion. Upturned waves mark the top of this murky clearing, the sky juts upwards to reveal Mount Sharp, swimming in the pale grey. But the sky is cracked in too many places and glitches in image data become faint streaks of colour in the grey atmosphere. Dust seems to build up in these crevices and the seams become heavy, threatening to split apart and reveal the black vacuum beyond.*

This nothingness draws me in and pushes me back, representing the intangible and becoming a space for imagination. The landscape wraps around my body in a 360° panorama, the shroud of invisibility envelops all senses. Stepping through the dark archway onto the grey Martian dirt, the scene glides towards me like an apparition as its translucency merges my body – my virtual presence in the image – with the glimmering landscape. There seems to be a path laid out ahead between the shattered flat rocks and splicing primary colours, but distances along this path are unidentifiable, objects are of no fixed size. Boulders float through image space towards me, distorted, creating the sensation of time and space spinning out of control.

Putting on the 3D glasses causes the landscape to emerge from the image as a three-dimensional reconstruction. During this process I become trapped somewhere between the space of the screen and the space where the virtual representation of landscape exists; beyond the flatness of the screen, within the imaginary space of a three-dimensional illusion. Reaching out to touch part of the landscape my hand sinks below the surface; the luminous terrain in the digital space reveals itself as transitory, immaterial.

Turning around I see the warped body of Curiosity*, merged with the silver screen, distorted through its own flattening of a three-dimensional rendition on a two-dimensional plane.*

A simulated illusion of space, the greyscale landscape has been made three-dimensional through the imposition of red and blue, these vibrant colours interlaced into the landscape's skin like veins.

The sun glows from behind panels of dust. The blue is blinding. The sky pearlescent. The flickering translucency of the screen above and beneath the landscape.

> We must repeatedly be reminded what a great device the human eye is. Our two eyes not only make us aware of our surroundings, but also enable us to interpret them three-dimensionally.[1]
>
> Hans Harbele.

It is vision that is reconstructed in the anaglyph image of Mount Sharp; composed of a pair of images overlaid, the 'anaglyph' filters the left and right image through red and blue so when viewed with appropriately coloured glasses, the subject of the image appears in '3D'.[2] The anaglyph was invented in 1891 using knowledge about stereoscopic vision as set out by Charles Wheatstone and Sir David Brewster. In his 1838 paper "Contributions to the Physiology of Vision", Wheatstone claims that there is a vital difference between observing an object and observing a painting of that object. On observing the object in reality, the eyes see two dissimilar pictures, but upon viewing the painting, two similar pictures are projected onto the retinae. Consequently, writes Wheatstone, 'the painting cannot be confounded with the solid object'.[3] For Leonardo da Vinci, a painting is only a reflection of what is seen by one eye.[4] Representing the vision of a *singular* technological eye, the images I have examined thus far – *Curiosity's New Home,* the mosaics and the panoramas – do not enable a three-dimensional understanding of the terrain in accordance with human vision. These images,

[1] Hans Harbele, 1987 quoted in Dieter Lorenz, ed., *The Stereo Image in Science and Technology* (Braunschweig: KeddigDruck, 1987), 3.

[2] I shall return to this image and the anaglyph's use in Mars exploration later in the chapter.

[3] Charles Wheatstone, "Contributions to the Physiology of Vision Part One: On Some Remarkable, and hitherto Unobserved, Phenomena of Binocular Vision," Stereoscopy.com, 21 June 1838, accessed 23 December 2013, www.stereoscopy.com/library/wheatstone-paper1838.html, 2.

[4] Francoise Reynauld, Catherine Tambrun and Kim Timby, eds., *Paris in 3D: From Stereoscopy to Virtual Reality 1850-2000* (Paris: Paris Musees; Booth-Clibborn Editions, 2000), 17.

as I have demonstrated, must not be read as unmediated vision, but as two-dimensional interpretations of vision, as flat re-presentations. Realising the importance of gaining stereo views of Mars, scientists and engineers have equipped the rovers with stereo cameras. Seeing the terrain 'three-dimensionally' enables greater levels of perceptual understanding; the different types of 3D imaging used in Mars exploration are the focus of this chapter.

For historian Martin Jay the two-dimensional image is 'conceived in a manner of a lone eye looking through a peephole' at a scene; 'following the logic of the Gaze', the two-dimensional image is taken from a fixed perspective and offers a 'window' upon a world.[5] Embodied perception (three-dimensional experience) takes on a different form of seeing, which Norman Bryson describes as the 'Glance'. Our eyes flit between objects near and far; focusing upon one thing at a time the rest of the scene fades away into the periphery. This chapter looks at forms of 3D imaging that attempt to recapitulate vision in image form, to render the 'Gaze' as a 'Glance'. However, as we cannot experience an embodied relationship with the thing depicted I would like to propose another term that may be useful in describing how we 'see' Mars through such immersive devices; *to glimpse. To glimpse* implies a momentary or partial view, one bound by the materiality of the frame and the glitch. It is in this fragmentary fashion that we experience Mars through 3D imaging.

Mimicking human vision, 3D imaging supposedly gives scientists a view that is closer to true perception. This chapter argues that whilst such image forms enable us to glimpse Mars, reconstructing an illusion of 'being there' is inevitably an impossible feat; stereo data is obtained from a fixed position in the landscape, giving us a perspective that is framed by the limitations of technology. It is a partial reconstruction that relies as much on the participation of the viewer as it does on the image itself.

[5] Martin Jay, "Scopic Regimes of Modernity," in *Vision and Visuality,* ed. Hal Foster (Seattle: Bay Press, 1988), 7.

Figure 4.2. Photographer unknown, *Photograph of the surface of Mars*, 2 August 1976. Image shown in Ernst H. Gombrich, "Standards of Truth: The Arrested Image and the Moving Eye," in *The Language of Images*, ed. William J.T Mitchell, 181-217, 4th ed. (Chicago: University of Chicago Press, 1980), 184.

In "Standards of Truth", Ernst H. Gombrich comments on the problems arising from scientific images, arguing that they should be seen 'not as visual truth[s] but as 'objective records'.[6] As I explored in Chapter 1, Lorraine Daston and Peter Galison's view is that objectivity should be 'seeing without interference'.[7] In a different take on 'objectivity' to Daston and Galison, Gombrich positions an 'objective record' as information obtained from scientific images (such as x-rays) that is *independent* of human vision. For Gombrich, such images present scientific 'truth' as seen and mediated by the machine, allowing access to data that might not necessarily be witnessed through vision alone. In his analysis Gombrich comments on a photograph of Mars (fig. 4.2) sent back to Earth for examination in 1976. The correlation between this image and *Curiosity's New Home* is striking*;* the images are not dramatically different, despite the years between their making, and Gombrich's commentary is equally relevant today. Both his example and *Curiosity's New Home* have been sent a distance of 212 million miles, through many electronic devices and satellites, taking in all twenty minutes to reach Earth. Reinforcing many of the ideas laid out in Chapter 1,

[6] Ernst H. Gombrich, "Standards of Truth: The Arrested Image and the Moving Eye," in *The Language of Images*, ed. William J.T Mitchell, 4th ed. (Chicago: University of Chicago Press, 1980), 182.

[7] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 17.

Gombrich's argument is that in this case the level of machine-mediation prevents us from gaining valuable knowledge about the true size and scale of the landscape depicted from the one photograph.[8] Unlike the x-ray image – which offers a precise reading of the invisible structures of our bodies – we do not gain a full understanding of Mars from this image; thus it cannot be an 'objective record' in Gombrich's sense. But neither can it be equal to human vision, or Daston and Galison's 'seeing without interference'; it is merely a flat rendition of the light-reflective surfaces apparent to the photographic lens at the moment of capture.

Three-dimensional imaging techniques attempt to surpass flat two-dimensional renditions like *Curiosity's New Home* and Gombrich's Mars example in order for us to get a better sense of the terrain. Incorporating within them fundamental attributes of seeing stereoscopically, 3D images reconstruct both vision and landscape in order to help scientists and engineers get closer to a feeling of 'being there' on Mars. Roland Barthes' wrote on photography's relationship with death; re-presenting an 'intractable' moment the photograph encompasses the 'that-has-been'.[9] For Barthes, 'the Photograph mechanically repeats what could never be repeated existentially', possessing an 'evidential force' that bears testament to time. For him, 'the power of authentication exceeds the power of representation'.[10] *Curiosity's New Home* represents the 'that-has-been'; *Curiosity* was standing at that spot during the first few days of the mission and its Navigation Cameras' captured the two-part black and white image as 'evidence' of this past moment. Re-capitulating such images in 3D functions in a slightly different manner; instead of standing as testament to the past, they conjure up a new – albeit impossible – experience that is key to driving rovers on Mars to repeat 'what could never be repeated'. This conjuration enables us to project ourselves imaginatively into the landscape and 'be there' virtually through the eyes of the rover. In this way, perhaps the 3D image revisits the 'that-has-been' in an attempt to solidify and make present and palpable a landscape that is beyond our reach.

The importance of being able to re-present (and reconstruct) images of Mars in three-dimensions has been outlined by Janet Vertesi. Her PhD thesis, "'Seeing Like a Rover': Images in Interaction on the Mars Exploration Rover Mission" focuses on NASA's twin rovers *Spirit* and *Opportunity.*[11] Vertesi examines the role of visual representation and

[8] Gombrich, 184-5. As we cannot gain empirical knowledge about the scene, we cannot fully know the distance travelled by light from the depicted boulders to the camera lens, therefore making it difficult to determine scale. Ibid., 185.

[9] Roland Barthes, *Camera Lucida: Reflections on Photography,* trans. Richard Howard (1981; repr., London: Vintage, 2000), 77.

[10] Ibid., 4, 89.

[11] In 2015 Vertesi's thesis was published by University of Chicago Press as *Seeing Like a Rover: How Robots, Teams, and Images Craft Knowledge of Mars.*

embodiment practices in helping scientists and engineers make daily decisions on where to drive the rover, what experiments to undertake, and what to image, based on the rover's accomplishments the day before. Vertesi explains that stereo-pairs can be 'mined for topographical data' which includes producing anaglyph images and 3D models of the landscape.[12] As Vertesi observes, anaglyph images like *Curiosity's Mars Stereo View from 'John Klein' to Mount Sharp* are essential to the rover missions and are employed for different reasons, be it to 'get a sense of the texture or the morphology of a rock or surface feature' or to get an overall 'kinaesthetic sense for the terrain'.[13]

But unlike the panorama in FutureFlight Central, most 3D images of Mars are viewed on two-dimensional, small-scale computer screens; the sense of immersion then relies not on an all-encompassing image but on the trained viewer's ability to project themselves *imaginatively* into the space of the image. It is in this respect that 3D imaging enables a very particular kind of encounter with Mars, one that hovers on the border between two- and three-dimensions, between image, landscape and the space of the glitch.

The virtual exploration of Mars is achieved by NASA scientists and engineers in a number of ways; through 3D monitors, terrain mapping and 3D visualisation, and through red and blue anaglyphs. Serving as quick and convenient modes of experiencing Mars in 3D, anaglyphs can be viewed on conventional computer screens and in printed form. They are used by scientific and engineering teams to gain a feeling for the rover's environment, but can also be enjoyed by the public on NASA's Photojournal image archive. In these primarily black and white images that are made 3D through representing the left and right image in red and blue, it is both colour and frame that dictate illusion; through the donning of red/blue glasses the landscape simultaneously recedes into and spills out of the frame.

3D visualisation tools are used by Mars rover drivers at the Jet Propulsion Laboratory to assess the traversability of the rover's surroundings from stereoscopic data captured by the Navigation Cameras, the Hazard Avoidance Cameras, and the Mast Cameras. These image pairs are uploaded into computer programmes that automatically produce terrain models, allowing rover drivers to plan traverses and see the rover's positioning in relation to potential obstacles. Both anaglyphs and 3D monitors are employed in this context to 'glimpse' Mars in 3D, helping gain a better sense of elevations and ridges in the terrain, and holes in image data.

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[12] Janet Vertesi, "'Seeing Like a Rover': Images in Interaction on the Mars Exploration Rover Mission" (PhD diss., Cornell University, 2009), 259, accessed 15 March 2014, http://hdl.handle.net/1813/13524.

[13] Ibid., 266.

The stereoscope is a further device by which Mars might be glimpsed in 3D. With the development of 3D displays and monitors, the stereoscope is now an outmoded device for Mars exploration. However, the instrument, invented in the mid 19th century, undoubtedly led to the development of stereoscopic image forms currently in use. It sought to re-present the world in greater realism and for this reason it will function in this chapter as an important historical model that can, if so desired, still be used today.

Three-dimensional imaging techniques raise questions about spectatorship that have been present throughout this thesis but that really come to the fore in this chapter. In *The Society of the Spectacle* theorist Guy Debord argues that the spectator of cinema and of theatre is an ignorant one; immobile they live through representation rather than living themselves. In such arenas,

> images detached from every aspect of life merge into a common stream, and the former unity of life is lost forever. Apprehended in a *partial* way, reality unfolds in a new generality as a pseudo-world apart, solely as an object of contemplation. The tendency toward specialisation of images-of-the-world finds its highest expression in the world of the autonomous image, where deceit deceives itself. The spectacle in its generality is a concrete inversion of life, and, as such, the autonomous movement of non-life.[14]

Contrary to this view, philosopher Jacques Rancière argues that the spectator (he uses the theatre-goer as an example) is not passive but instead enters into a space whereby their subjectivity affects the reading of the image; in this case that of the performed image. Rancière is critical of Debord's opinion that 'viewing is the opposite of knowing' and argues that 'ignorance is not a lesser form of knowledge, but the opposite of knowledge; that knowledge is not a collection of knowledge, but a position'.[15] The spectator is instead active in their interpretation of the image; thus viewing is a subjective experience, or 'a position'. The 3D image requires the viewer to actively engage with the image on a fundamental level; we must put on the glasses and allow our eyes to relax in order to witness the illusion.[16] Furthermore, it is through a certain training that scientists and engineers are able to make sense of Mars through such images. As this is a landscape without referent, spectatorship is the only means by which we might experience Mars. In order to make the informed transition from seeing to understanding, objective and subjective levels of engagement with images must be carried out in order to obtain knowledge.

In Chapter 2 I touched upon the notion of Roland Barthes' *punctum* and its similarity (and difference) with the glitch. For Slavoj Žižek the glitch might function to push us *out* of

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[14] Guy Debord, *Society of the Spectacle* (Detroit: Black and Red, 1983), 12.

[15] Jacques Rancière, *The Emancipated Spectator,* trans. Gregory Elliott (London: Verso, 2011), 2-3, 9.

[16] In addition, some people are actually unable to see 3D illusions.

the image, into our own physicality. For Barthes' the *punctum* functions to draw us *in* to the image. In the case of the glitch it makes us aware of our own subjectivity as a viewer. With the *punctum* it is our subjective reading of the image that highlights a particular feature that touches or 'pricks' us.[17] The *punctum* touches our heart, the glitch pricks our eye. But what constitutes the *punctum* for Barthes might be different for each person who views that same image. Likewise, the experience of a 3D image can differ for each individual viewer and because it is such a personal encounter (the image fuses into 3D in our minds), the glitch depends very much upon our subjectivity. The glitch – as I have defined it thus far – is a break in the illusion's transparency, often manifesting itself as an absence in information or a visual anomaly; the black surround of *Curiosity's New Home,* the void of the image as the *Mars Window* spectator advances towards the projected image. The *punctum,* on the other hand, retains a certain presence; for Barthes, it is the presence of a woman's lace-up pumps, a child's teeth or a necklace that 'pierces' him.[18] Perhaps it is in the subjective nature of how and when these glitches reveal themselves, in addition to the presence they retain within the image once they have been observed, that glitches in the 3D image hold ties to Barthes' notion of the *punctum*.

In the search for a palpable image of Mars and through my own subjective readings of images I shall argue that the glitch gains its own kind of materiality in the 3D image, one that holds greater presence within the overall experience. Through this process I have become somewhat enamoured by the glitch; perhaps it features as my *punctum,* pushing me out of the landscape but pulling me into the space of the image. As Barthes states: 'the Photograph belongs to that class of laminated objects whose two leaves cannot be separated without destroying them both: the windowpane and the landscape'.[19] It is through the use of thick description that the notion of stepping imaginatively into the image comes into play; in an attempt to pry open the space in between the two leaves – the landscape and the window – I become immersed in another space, one which hovers between flatness and three-dimensionality: it is the space of the glitch.

Within the stereoscope the glitch manifests itself as fracture, dust, void and veil; in the digital terrain model it is the limit of the rover's visibility; and in the anaglyph it is the frame and colour. In each the glitch is intrinsic to the image from the outset, serving to reveal the image as a space of intangible dissolution.

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[17] Barthes, 26-7.
[18] Ibid., 26-27 & 45.
[19] Ibid., 6.

<u>Seeing through a Veil: Reconstructing Vision in the Stereoscope</u>

Pictures can never be wholly realistic because they do not present us with a vision that mimics binary optics, being ‘defined to a significant degree by the rules and ideology of monocular perspective’.[20] As Dieter Lorenz observes, our eyes ‘are at a distance of about 2 ½ inches from one another. Thus two somewhat different images are formed.’[21] This is particularly evident when looking at something up close, and is described in great depth by Sir David Brewster in *The Stereoscope* (1856). Brewster exemplifies how each eye sees a different image: ‘if we hold up a thin book perpendicularly, and midway between both eyes, we see distinctly the back of it and both sides with the eyes open’, on closing each eye however we see different sides:

> the picture of the book, therefore, which we see with both eyes, consists of *two* dissimilar pictures united […] we not only see *different pictures* of the same object, but we see *different things* with each eye.[22]

Similarly, if we were to hold our thumb out in front of us and alternatively close our left and right eyes, our thumb would appear to ‘jump’ from left to right.[23] Brewster goes on to demonstrate how the brain unites these two dissimilar pictures into a reconstruction of the object in reality, drawing on the work of Charles Wheatstone, who argued that it is the projection of these two *dissimilar* pictures onto either eye that creates the ‘relievo’ effect.[24] In “Contributions to the Physiology of Vision”, Wheatstone proposed a device that uses the two dissimilar images and combines them in the mind to recreate the appearance of solidity. He asks: ‘what would be the visual effect of simultaneously presenting to each eye, instead of the object itself, its projection onto a plane surface as it appears to the eye?’[25] In August 1838 Wheatstone presented the British Association with the first ever Stereoscope.[26]

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[20] Kaja Silverman, *The Threshold of the Visible World* (London: Routledge, 1996), 125.
[21] Lorenz, 9.
[22] Sir David Brewster, *The Stereoscope: Its History, Theory and Construction* (1856; repr., London: The Fountain Press, 1971), 5.
[23] Lorenz, p.9
[24] This was outlined more than 2,000 years ago in Euclid’s *Treatise on Optics,* but Euclid’s use of a sphere to explain the theory has been criticised by Wheatstone; a sphere looks the same from any angle and would therefore present itself with the same view to each eye. Wheatstone, 3.
[25] Ibid., 3.
[26] Ibid., 5. We cannot know what the stereoscopic image looked like for the 19th century viewer, as Jonathan Crary examines:

> Pronounced stereoscopic effects depend on the presence of objects or obtrusive forms in the near or middle ground; that is, there must be enough points in the image that require significant changes in the angle of convergence of the optical axes. Thus the most intense experience of the stereoscopic image coincides with an object-filled space, with a material plentitude that bespeaks to the nineteenth-century bourgeois horror of the void; and there are endless quantities of stereo cards showing interiors crammed with bric-a-brac, densely filled museum sculpture galleries, and congested city views.

Jonathan Crary, *Techniques of the Observer* (Cambridge, MA: The MIT Press, 1990), 125.

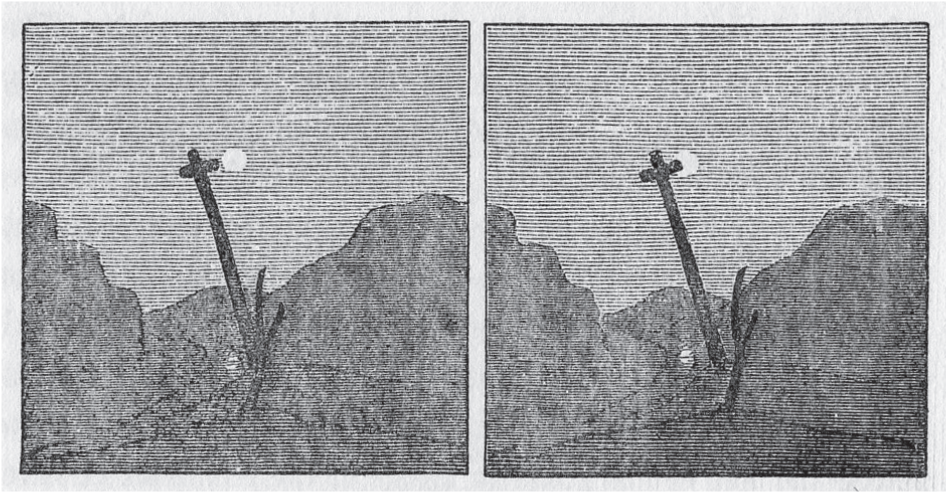

Figure 4.3. Stereoscopic drawing showing the difference between the right and left eye views: the dissimilarity between each image is particularly evident in the way the cross partially covers the moon and the shifting of the branch in the foreground. Image shown in Sir David Brewster, *The Stereoscope: Its History, Theory and Construction* (1856; repr., London: The Fountain Press, 1971), 56.

Some of Wheatstone's first observations were based on the difference between the perception of close and distant objects; at distances, both eyes see the same picture, but up close, the two pictures are dissimilar and need to converge to be seen as a whole.[27] The stereoscope uses two pictures as if taken from either eye, the difference in these images lying in the slight displacement of a vanishing point and the shifting of objects in the foreground horizontally (fig. 4.3). Prior to photography, images for the stereoscope had to be constructed by hand, and it was almost impossible to represent the object or scene in an identical manner as if seen by the two eyes, 2 ½ inches apart. Although basic concepts of stereoscopic vision stem from Euclid's *Treatise on Optics,* written more than 2,000 years ago, it wasn't until 1839 that the stereoscope's illusion gained greater levels of reality. With the invention of photography two images could successfully be produced by lenses positioned a few centimetres apart; these images would satisfactorily fuse together in the brain of the observer.[28]

There were numerous versions of the stereoscope with later devices placing stereoscopic photographs side by side either in a box (usually glass slides were backlit) or in an open contraption.[29] The pair of photographs was viewed through an eye piece with a middle bar to keep both images separate to either eye, the purpose of which was to place the right eye and left eye images *on top* of one another with the use of lenses, which also

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[27] Dennis Pellerin, "The Origins and Development of Stereoscopy," in Reynauld, Tambrun, and Timby, 43.

[28] Brewster, 1.

[29] See Brewster for further examples.

effectively magnified the illusion. Brewster's stereoscopic instrument consisted of a pyramidal box, blackened inside with two tubes at the top containing the lenses. He wrote on his invention that 'no portrait ever painted and no statue ever carved, approximate in the slightest degree to the living reality now before us'.[30] But how alive is the reality held within the stereoscopic device? The photographic archive at the Victoria and Albert Museum has a collection of 19th century stereoscopic pairs together with the appropriate viewing devices. Visiting the archive one can experience this reconstruction of solidity from two dimensional images; what is discovered seems imperative to the powerful presence of the glitch.

Image unavailable due to copyright restrictions.

Figure 4.4. Handheld stereoscopic viewer. Photograph by author, courtesy of Victoria and Albert Museum, London.

[30] Ibid., 64-67.

Image unavailable due to copyright restrictions.

Figure 4.5. Photographer unknown, *Unidentified Terrace Steps in a (French?) Garden.* Photograph by author, courtesy of Victoria and Albert Museum, London.

Image unavailable due to copyright restrictions.

Figure 4.6. Photographer unknown, *Passage de la Gemmi, Lonéche-les-Bains.* Photograph by author, courtesy of Victoria and Albert Museum, London.

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Image unavailable due to copyright restrictions.

Figure 4.7. Photographer unknown, unnamed photograph (museum number 3968-1953). Photograph by author, courtesy of Victoria and Albert Museum, London.
Figure 4.8. Detail of figure 4.7. Photograph by author, courtesy of Victoria and Albert Museum, London.

Image unavailable due to copyright restrictions.

Figure 4.9. Photographer unknown, unnamed photograph (museum number 155-1961). Photograph by author, courtesy of Victoria and Albert Museum, London.

Inserting the double image into the frame of the handheld stereoscopic device, I slid the image back and forth along the runner, waiting for the illusion of 3D to click into place. Peering through the mask-like device, my peripheral vision was curtained off and I looked directly at the bright image space before me. The first image I placed into the viewer was titled *Unidentified Terrace Steps in a [French?] Garden* which showed a view of a statue and steps in sepia tone. Perhaps due to ageing, or the way this photograph had been stored, the left-hand image of the two was imbued with pink and this seemed enough to allure me. Upon looking through the viewer at the merging of the two images, the coloured hue gave the image space a hazy quality, as if I was viewing the scene through an undulating mist of sepias and pinks.

As was the case with many of the stereo photographs I viewed, age and incessant handling had produced upon their surfaces scratches, scuffs and blotches, as if reality had been brutally ripped from the image in detached fragments. What I found most curious about this was not the effect it had on the photographic surface itself (when viewed without the device), but the effect it had when the two images (each having acquired different levels of damage) came together to form an illusion of space. Instead of seeming integral to the paper or glass surface, these blotches seemed to float above the image space closer to my eyes, as if I were looking through a time-worn window frame onto the world outside. Instead of the holes in the photographs being what they were, erased fragments, negative spaces, they became positive and physical, like particles of dirt, or remnants of unwanted posters refusing to be fully extricated, clinging on as sticky residue.

In *Passage de la Gemmi, Lonéche-les-Bains*, the hummock in the foreground jumped forward towards my eyes but this sense of reality was almost immediately betrayed by the scratch on the right eye view, drifting above the image space towards me. In another glance these residual specks seemed to merge with illusion, becoming holes in the reality represented in the photograph. In an unnamed photograph (museum number 3968-1953) a section of the right image had been clumsily painted out creating a rupture in the illusion of dancing three-dimensional space. The singed spot past the trees in 155-1961 seemed to become a part of the small world; the winding road curiously drawing my eyes to the only coloured blemish in the scene, like an explosion in the sky which existed both within representation and outside of it on the surface of the paper.

The white splotches of *Unidentified Terrace Steps* flickered before my eyes, and although the image was black and white, my eyes forged colour where there was none, creating the blurred appearance caused by print mis-registration that shimmered on the edges of these white voids. But it was not in the make-up of the image, it was my eyes creating a glimmering screen. Reflections of light upon the glass slide altered and shifted with the tilting motion of my head and handheld viewer, ruination of the photographic surface swimming atop the image space, like particles of dust on a computer screen, debris on a murky lake, magnified by the lens.

These reconstructions had depth, the illusion of space in these miniature worlds seemed almost real, but the damage upon their surfaces betrayed them, creating a space that revelled in the glitch. This space swam across the top of the image and held greater presence than what lay beneath; the glitch here contained more depth than the image it was contorting.

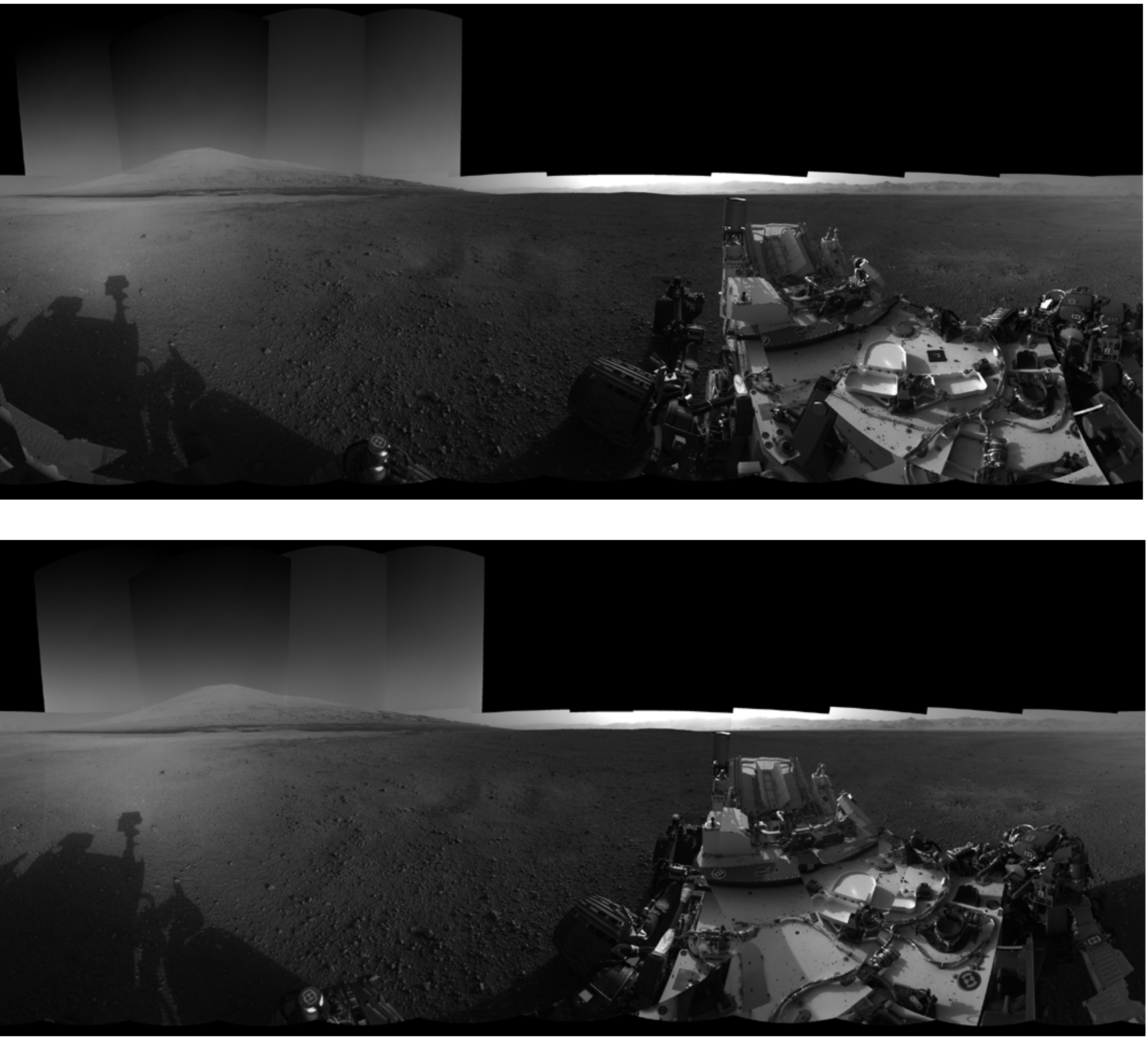
I was also acutely aware of another space, the physical one in which I held the stereoscope carefully in both hands. The instrument had a very strong presence in the viewing of the image, creating a perplexing interplay between the visual illusion and the physical framing device used to order that illusion; the central bar keeping each image separate to either eye became a blurred border in addition to the mount of the stereo photograph and the moveable frame it rested in. Due to the magnifying lenses highlighting photographic detail, the framing device itself was also accentuated and the grain of the wooden surround closed in on these small worlds. The tactility of the stereoscope was blown out of proportion, it became too close for comfort, overpowering the miniature photographic interior.

The stereoscopic device enabled me to take a glimpse into historical moments; like the panorama it was a means to travel virtually back in time, this time through the veil of photographic materiality. Seeking to travel virtually to a distant land and experience Mars through a stereoscope, I visited the Regional Planetary Imaging Facility at University College London. Their stereoscope (fig 4.10) was more complex than the device in the V&A archive; it used mirrors and lenses to reflect the stereo-pairs into the eyes. Although stereoscopes are no longer used for space exploration, placed under this one's lens was a pair of radar images of the planet Venus, captured by NASA's *Magellan* spacecraft in the early 1990s. At that time NASA distributed hardcopies to imaging facilities, but due to the sheer quantity of images and technical innovations, planetary data is now transmitted digitally. It is very unusual for hardcopies to be made so this device is no longer used for current missions.

Figure 4.10. Stereoscopic device at the Regional Planetary Imaging Facility, University College London. Photograph taken on 7 August 2014 by author, courtesy of the UK-NASA RPIF, part of the Geology Collections at UCL.

Determined to see how the image of Mars translated into 3D via this viewer, I returned with some stereo pairs of Mars, obtained from NASA's digital archives.[31] I discovered that these stereoscopic images offered an experience of reconstructed illusion not dissimilar to that encountered in the V&A archive; during both viewings the illusion of three-dimensions appeared trapped behind a kind of veil. Nevertheless, one difference in *how* this space emerged was eminently clear; my freshly printed pairs had not had the time to obtain any level of surface damage which may have resulted in a fragmentary experience similar to the one just described. Rather the rupturing of illusion in these reconstructed spaces materialised from within the very images themselves. The glitch here was not commanded by a tangible surface, but was instead intrinsic to these images from the outset; their mosaicked nature sprung forth, and the seams joining data fragments were accentuated by the transformation into three-dimensions.

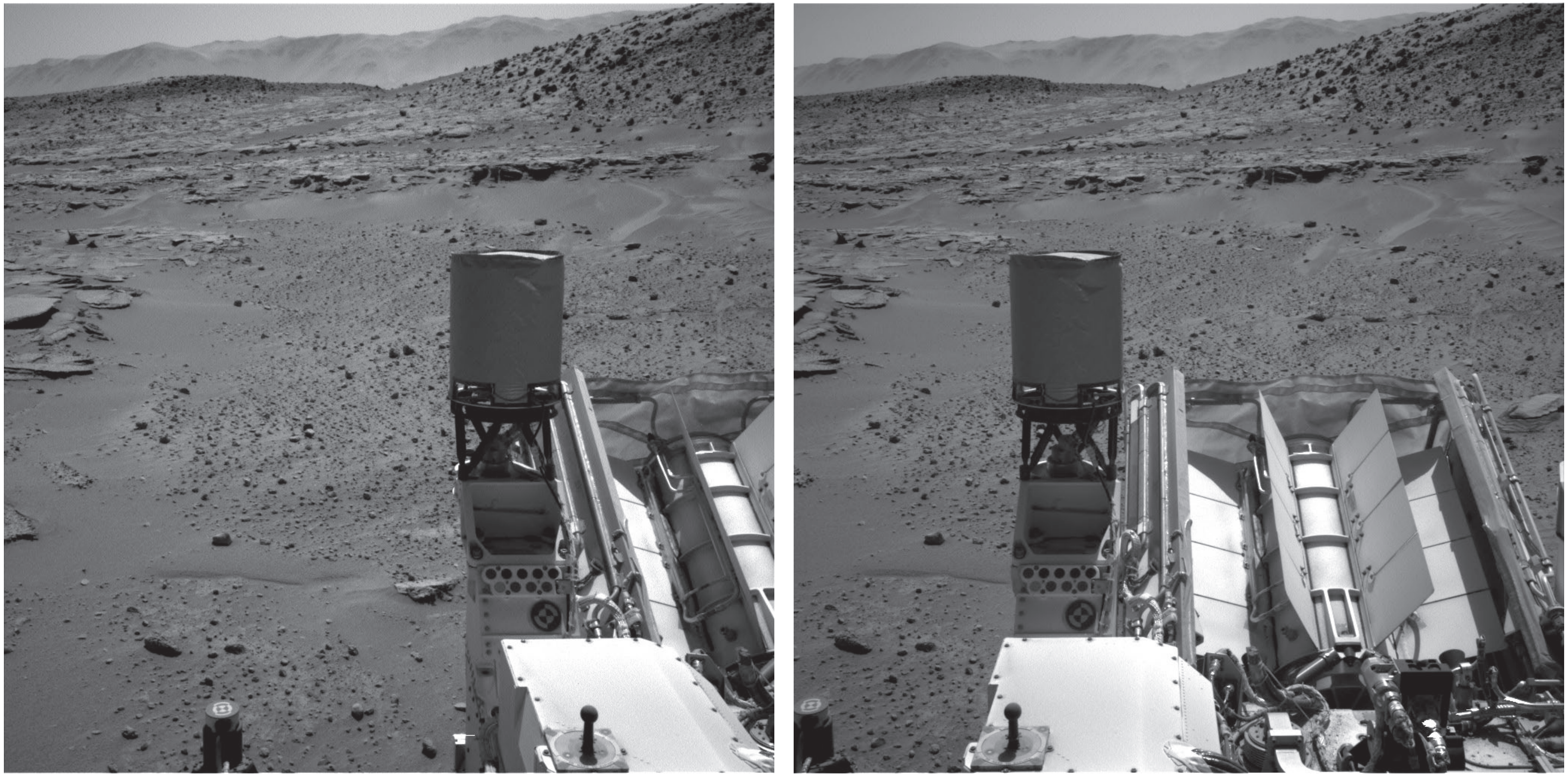
[31] It is possible to print out the stereo-pairs provided on NASA's *Photojournal* and place them into devices like these with relatively good results. In this case it took a bit of time to get each image in the correct position so as to see them both simultaneously in 3D.



Figures 4.11 a-b. Left (above) and right (below) eye views of *3-D View from Bradbury Landing Site.* This 360° image pair is a mosaic captured by *Curiosity's* right and left Navigation Cameras on 8 and 18 August 2012 (sols 2 and 12). Photojournal image addition date: 4 September 2012. Credit: NASA/JPL-Caltech.

The first stereoscopic pair of images I placed under the device was taken by *Curiosity* and showed a 360° panorama of the Bradbury Landing site, captured in the first few days of the mission. Due to the limited scope of the stereoscope's lens, I was forced to shift the images around on the base, in order to experience the whole scene in fragmented three-dimensions. I began first by peering through the two lenses and at the body of *Curiosity,* who, distorted and made larger than life due to the panoramic visualisation, was the nearest plane in this three-dimensional image world. But looking past *Curiosity*, my eyes were drawn to the illuminated sky beyond, hazy due to the dust, and emanating the milky glow of overexposure. It was as if an attempt had been made to grasp the land and sky simultaneously, a compromise of exposure levels that resulted in a blanched horizon rushing forth out of blackness. This luminous fragment of the image commanded my attention and held a peculiar, contradictory position within my visual field; it was the furthermost point of the scene, yet it seemed to hover above and in front, closer to my eyes than the body of the rover, oscillating between flatness and three-dimensionality. Perhaps this was due in part to the jutting nature of its upmost edge, and the sudden shift from black to white. But I also assumed it had something to do with how the two-dimensional pictures had been put together, as each join in image data held greater resonance in three-dimensions, giving an incongruous sensation that the landscape had been assembled behind a hovering screen of pale translucent greys.

The perception of this reconstructed three-dimensional space differed to my perception of it as a two-dimensional picture; instead of the individual image fragments entering my perception as constituent parts of the same landscape, all on the same level, in three-dimensions the composite nature gained its own kind of three-dimensionality. The terrain remained at one level, and above it there seemed to float, shimmering in the Martian haze, veils of grey at different opacities, a collage of translucency closer to my eyes, obscuring the landscape beyond. This effect was all the more pervasive as I shifted the images to the right, bringing Mount Sharp into view. The mountain appeared trapped, stifled beneath panels of thick shrouds, concealed in shadow. The overall appearance was that this landscape had not been constructed from pieces, but that it was a whole, obscured and segmented by a translucent patchwork quilt. A virtual space of illusion, trapped beneath a veil.



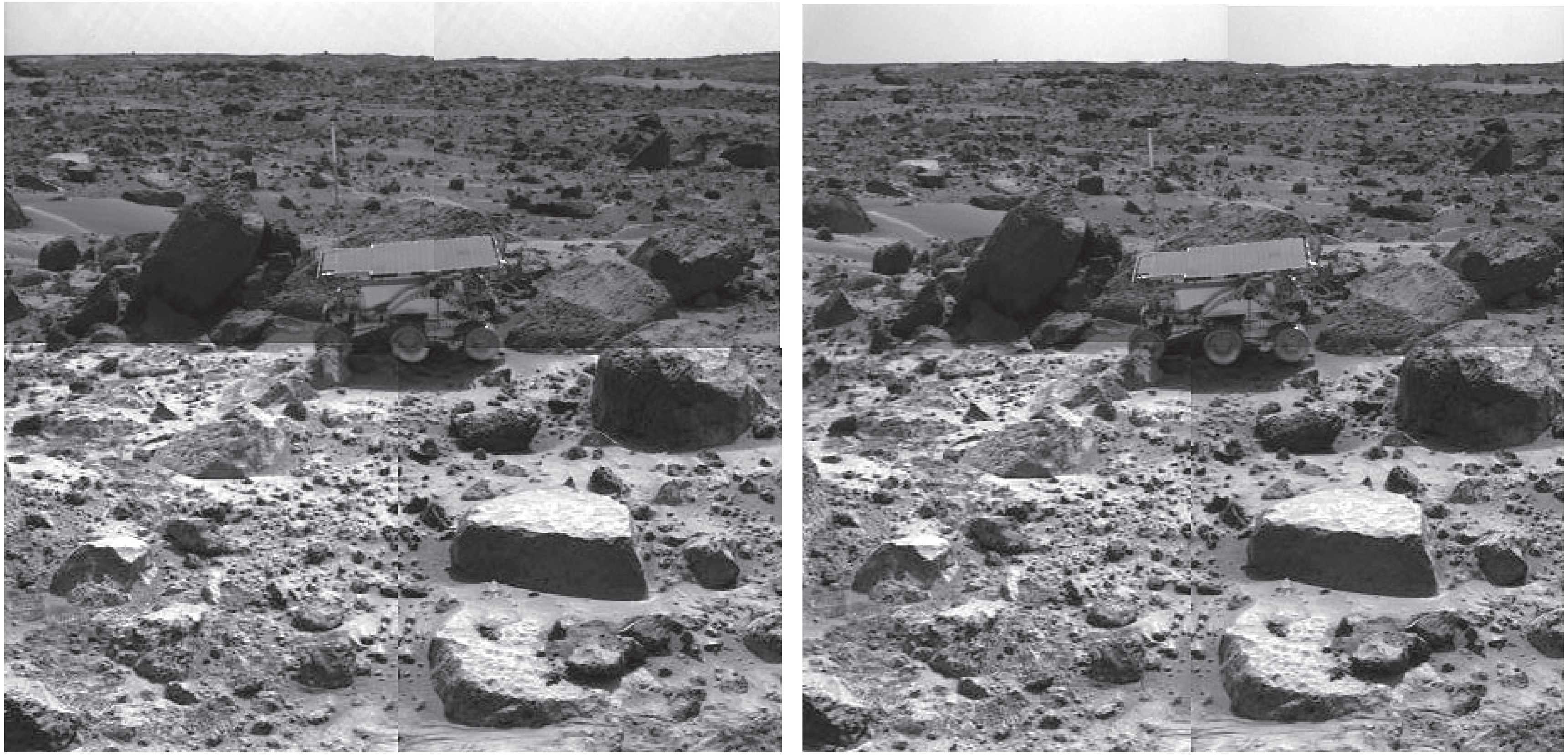
Figures 4.12 a-b. This image pair was captured by *Curiosity's* right and left Navigation Cameras on 15 May 2014 (sol 630). Credit: NASA/JPL-Caltech.

The second pair of images I placed beneath the lens was taken by *Curiosity's* Navigation Camera on the 630th Martian sol. With this stereoscopic pair, my gaze shifted focus between the foreground, the body of the rover, and the background, the sloping hills of Martian terrain. Considering it was a flat image, I found it perplexing that I was having to shift my focus in order to obtain three-dimensional information from foreground and background individually. It dawned on me however, after spending a little longer attempting to get my eyes to see both simultaneously, this alternation was in fact a viable part of vision, and thus testimony to the stereoscope's veracity in its reconstruction of a scene. Yet it still felt rather strange applying the same perceptual shift to a relatively small paper printout and the necessity to alter my eyes' depth of field enhanced the stepped effect of the image. Observing for longer periods of time, I became aware that the image appeared as a construction in the form of stage scenery, with flat cardboard cut-outs arranged as if in a pantomime.

Where the landscape sloped upwards away from the rover, there was a smooth patch of sand, seemingly inverted and appearing as a gully in the terrain, another point at which the landscape had been chopped up and reassembled for this 3D stage set. I imagined stepping forth into this image, past the body of *Curiosity* and out onto the grey slopes; I considered what it would be like to look over the crest of the shallow v-shaped terrain and into the chasm beyond. Perhaps this illusion may be constructed in a similar manner to the *Panorama Mesdag*, with its faux terrain on a separate plane to the painted picture beyond; a sharp drop past the hills, the distant mountains simply painted onto a flat framework.

Curiosity stood out in sharp relief, but when I attempted to focus on a specific feature of its body, I struggled to construct any form of solidity; the forms flickered before my eyes, oscillating between what felt like tangible object and intangible projection. Looking out to the background I could sense the body of the rover, the visioning machine that made this experience possible. I was examining the scene through its eyes and not my own. I experienced this image space through the body of the rover as subject, but I was also very aware of its presence as an object, to be looked upon as part of the scene itself.[32]

[32] *Curiosity* here became Merleau-Ponty's 'chiasm' (as explored in Chapter 3), the body as both object and subject – but never both simultaneously – connecting me with the Martian world.



Figures 4.13 a-b. This stereo pair was captured by NASA's Mars *Pathfinder* Mission on 9 September 1997 (sol 68). The image pair shows the *Sojourner* rover at the *Carl Sagan Memorial Station*. Credit: NASA/JPL-Caltech.

This stereo pair of images was captured in September 1997 by NASA's *Pathfinder* mission. I had selected it for its basic construction; made from four image fragments, I was intrigued by how this simplicity would translate into three-dimensions. Of all the images I placed into the device, this was certainly the most alarming. Although the collaged nature of the individual images is in a sense fairly subtle, it wasn't until they came together in the illusion of three-dimensionality that this notion of a patchwork veil, obscuring the depths of a virtual image space, really came into play. A dark shroud enveloped the upper half of the image; due to underexposure these two fragments created a horizontal divide. But once again, this did not highlight the image as construction, but gave the impression that a translucent blind had been pulled down across a window, faintly obscuring the upper limits of the scene.

Perhaps due to the jagged nature of the topography, the ground receded in a stepped fashion; beyond the body of the rover the terrain appeared to be made up of four distinct fragments, and I encountered the image as a stage set. The closest parts of the terrain appeared to recede in a fairly natural manner, yet this naturalism was rather painfully disturbed by the seam running through the vertical axis of the image, and it was clear from looking at a single two-dimensional image why this was the case. The two images had not been spliced together correctly (most likely by the computer programme constructing the image composites), and there was a repetition of information that caused the seam to judder uncontrollably in three-dimensional reconstruction. But the pieces themselves did not seem to each be fighting to come to the fore, rather the seam felt very much as though it were its own entity, suspended above the space of the image and not integral to its make-up. The tonal range of either image was consistent, but it was the alignment of them that caused this rupture, a dynamic ridge suspended above the virtual space of the image, it seemed to invade my personal space. A jolting, disruptive glitch in the composite image.

These images with no referent can only be seen through the rover's technological eye. Glimpsing Mars through a patchwork veil it was the presence of the glitch – which surfaced during long periods of looking – that jolted me out of my reverie. This manifested itself most predominantly in the seams joining image segments together; appearing as suspended above the three-dimensional landscape the space of the glitch acted as a reminder of the impossibility of stepping out onto this alien terrain, gaining its own kind of materiality and presence atop an impenetrable image of an absent and alien landscape. Three-dimensionality was glimpsed, but the Martian landscape remained unobtainable.

Looking for prolonged periods at Mars through the stereoscope I became acutely aware of the glitches brought about by this form of illusion. I was not looking at a flat image, nor was I encountering a 3D scene. Rather it was as if I was caught in between the two, and the space inside the stereoscope gained its own kind of physicality. Theorists Michel Frizot and Jonathan Crary have both written critically on this phenomenon. Frizot writes that the space inside the stereoscope is

> merely an illusion, an approximation which satisfies the mind; it is an exaggeration of space, an optical space devoid of reality and atmosphere, a uniform swollen image […] Imposing, certainly, but still artificial: it is a space that exists via a device, not a natural space.[33]

Similarly, in *Techniques of the Observer,* Crary highlights the 'cardboard' effect created by stereoscopic images; describing the image space as a 'sequence of receding planes', he states that 'we perceive individual elements as flat, cut-out forms'. This, he observes, gives a 'strange insubstantiality' to the different elements in the image and draws 'superficial similarities' with classical stage design.[34] Our eyes 'traverse the image' 'in terms of a localised experience of separate areas' which results in a

> perceptual effect of a patchwork of different intensities of relief within a single image. Our eyes follow a choppy and erratic path into its depth: it is an assemblage of local zones of three-dimensionality, zones imbued with a hallucinatory clarity, but which when taken together never coalesce into a homogenous field.[35]

The stereoscopic image is thus a 'conjuration' of an image that never really exists and can never be experienced in its entirety.[36] For the 3D image of Mars this holds particular significance; this is not an image or landscape we can currently hope of traversing in person.

The 'cardboarding' effect conjured in the space of the stereoscope gives us the sense objects are both present and absent simultaneously; a solidity that is at once two- and three-dimensional. We feel we should be able to reach out and touch the flattened objects in the scene; it is not the Martian landscape that feels tangible but its image. In *The Primacy of Perception,* Maurice Merleau-Ponty asks how we should experience the existence of absent objects, and how we should experience the nonvisible parts of present objects. 'Should we say' he asks 'that I *represent* to myself the sides of this lamp which are not seen?'

> If I say these sides are representations, I imply that they are not grasped as actually existing; because what is represented is not here before us, I do not actually perceive it. It is only a

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[33] Michel Frizot, "Surface Space and Instrumental Depth," in Reynauld, Tambrun and Timby, 32.

[34] Crary, 125-6. *Techniques of the Observer* places the viewer at the centre of vision and its historical construction. Alongside the camera obscura, the zoetrope and phenakistoscope, Crary considers the stereoscope 'as a means of detailing the observer's transformed status' to argue that such forms were 'in fact based on a radical abstraction and reconstruction of optical experience, thus demanding a reconsideration of what "realism" means in the nineteenth century'. Ibid., 8 & 9.

[35] Ibid.

[36] Ibid.,122.

> possible. But since the unseen sides of this lamp are not imaginary, but only hidden from view (to see them it suffices to move the lamp a little bit), I cannot say they are representations.[37]

The unseen sides are in fact anticipated, according to Merleau-Ponty, 'as perceptions which would be produced necessarily' upon movement. He goes on to examine:

> It is *true* that the lamp has a back, that the cube has another side. But this formula, "It is true," does not correspond to what is given to me in perception. Perception does not give me truths like geometry but presence.
>
> I grasp the unseen side as present, and I do not affirm that the back of the lamp exists in the same sense that I say the solution of a problem exists. The hidden side is present in its own way. It is in my vicinity.[38]

Yet when a single photograph is taken, those sides of the object not apparent to the camera's lens remain in the shadows; although we *know* the back of Mount Sharp exists, it is the inability to walk into the Martian landscape and prove this that evokes Roland Barthes' line:

> When we define the Photograph as a motionless image, this does not mean only that the figures it represents do not move; it means that they do not *emerge,* do not *leave:* they are anesthetised and fastened down, like butterflies.[39]

The photographic image then inevitably flattens the landscape and its image within the pictorial frame. The stereoscope is an attempt to regain solidity, to regain the appearance that the object or landscape has sides, has distance, has a reverse. In light of Merleau-Ponty's statement, it is interesting to consider *how* the stereoscopic device fails; unlike Merleau-Ponty's lamp, there is no solidity to the tiers of landscape in the Martian stereoscopic image, one cannot shift one's gaze and reach out and around to touch what is unseen. The stereoscopic device here accentuates flatness, but flatness with depth, two dimensional images layered in a three-dimensional stage set.

As Crary writes, 'the stereoscope was not simply likeness, but immediate, apparent *tangibility*. But it is a tangibility that has been transformed into a purely visual experience.'[40] This tangibility manifests itself in the glitch; as fracture and as veil it highlights the reconstructed nature of both landscape and vision in the stereo-image of Mars. Through the fusing of the two images, the fabricated nature of the landscape-as-image pushes to the fore; it is the materiality of the image that is the thing *almost* palpable.[41]

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[37] Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 13-14.

[38] Ibid., 13-14.

[39] Barthes, 57.

[40] Crary, 122-4.

[41] I presented this research to some scientists and engineers at NASA Ames Research Centre in 2015. One participant said that he fused the two images captured by *Pathfinder* (which were displayed in my presentation) and was happily viewing the representation of landscape. As soon as I mentioned the seam however, it was the only thing he could see; as it did with me, it became an overpowering rupture in the space of illusion.

These experiences allow us to glimpse Mars at very particular points in time and each pair of images presents a fragment, a framed view of a landscape. The rover is the body through which Mars is imaged, yet we have little awareness of its surroundings and context on Mars. Subsequently, our wider picture is fragmented, experienced as a series of 'snapshots' of an otherworldly terrain.

At the Centre of the Image: Terrain Models and Rover Driving

Using the stereoscope today provides a glimpse of the terrain as seen from the rover's point of view. Although the ability to look at fragments of the landscape in this way is useful for observing snapshots of Mars, it is vital that scientists and engineers at JPL have an overall account of the terrain surrounding the rover. This predominantly features as 'interactable' terrain models which display the rover in the context of its 'seeable' surroundings. These models are used alongside the raw images to provide the rover's up to date location, allowing engineers to plan traverses depending on the wishes of the science team. Such modes of visualisation generate what Janet Vertesi terms as an 'immersive view of the Rover's environment', '*draw[ing]* Mars *as* [a] tangible, interactable terrain', and allowing engineers to conjure up the sense of 'being there' virtually.[42] But this, as Vertesi examines, requires knowing how the rover moves, its possibilities and its limitations, thus 'Mars is drawn as tangible and interactable *for the Rover*'.[43]

Seeing Mars from the rovers' point of view is the job of rover drivers like John R. Wright. Using software that constructs polygon meshes of the terrain, engineers are able to figure out the best route for the rover; as such they are innately aware of the rover's capabilities and the holes in image data which are seen as possible obstacles. The terrain models are created automatically through a pipeline that is triggered as soon as the data starts coming down and there are certain steps in the pipeline that work on stereo pairs. The software works out correlation, range maps and height maps and these are incorporated for the planning stages of the mission. The rover drivers study images and analyse the three-dimensional terrain models, simulate drives over them, and when they feel comfortable with the planned traverse, upload the command sequence to the rover along with instructions from the science team.

[42] Vertesi, 260 & 262.
[43] Ibid.

I met rover driver John R. Wright at the visitor reception desk at JPL. After signing for my visitors badge I followed him through the security gates and out into an open plaza-like space. The site felt very much like a university campus, with buildings constructed over the years in different styles, raised beds with plants and trees, and a collection of outside eating spaces. I followed Wright across this space and into one of the tall buildings to his office. After switching on the computer and the pair of screens (one standard, the other 3D enabled) he typed some unintelligible code into a pop-up window; a non-visual beginning to how rovers are driven on Mars.

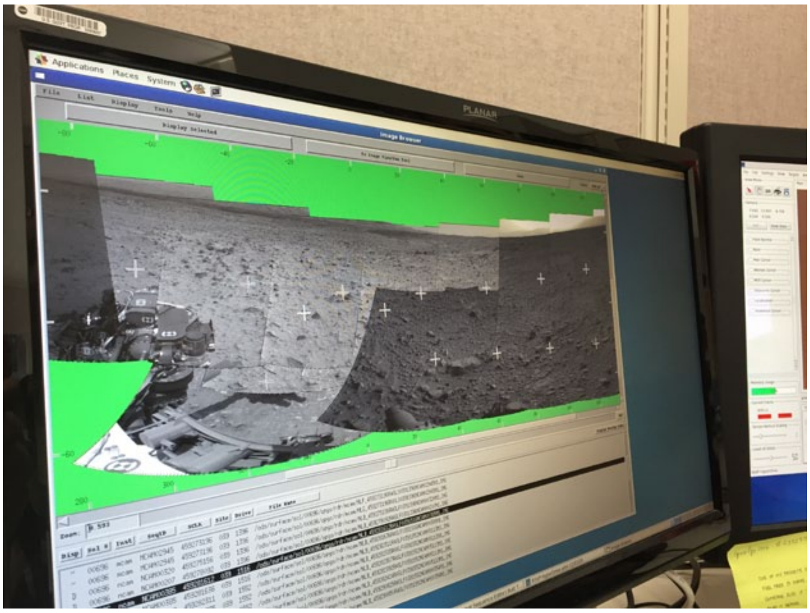
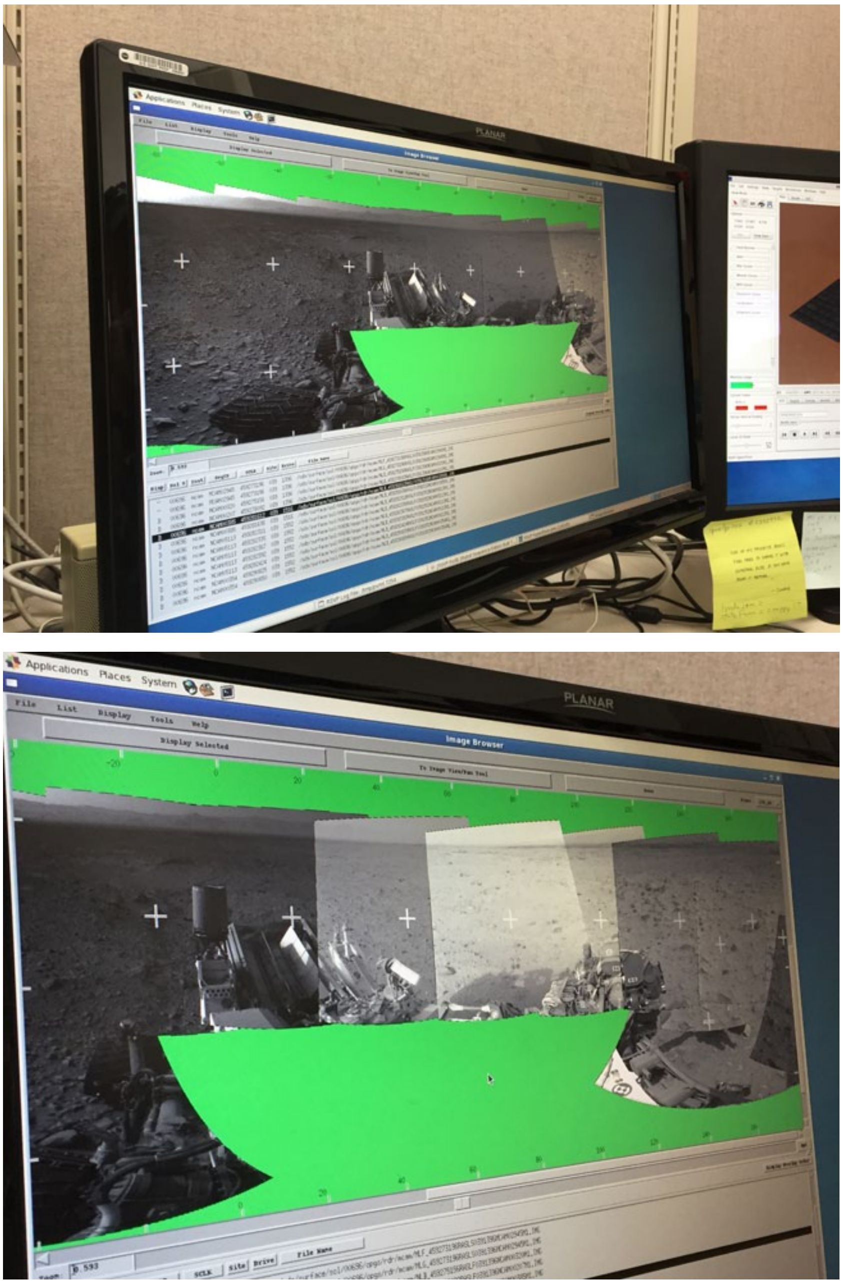


Figure 4.14. Photograph of *Curiosity* image mosaic shown on-screen in RSVP. Photograph taken on 3 November 2015 by author, courtesy of JPL-Caltech.

The multiple programmes used to drive *Curiosity* are part of a suite of applications called the Rover Sequencing Visualisation Programme, or RSVP.[44] To begin with, Wright checks to see if there are any failures with the previous day's traverse and then looks to see what kind of data has been captured. We focused on sol 696 and clicking on the data from the Navigation Cameras the programme quickly reads all the image headers to see what direction the camera was pointing in, constructing a mosaic as seen in figure 4.14. The images are projected as a cylinder (which accounts for the keystoning effect), and the programme allows you to pan around the image to see the landscape in different directions.[45]

[44] The acronym RSVP in its more day-to-day usage of 'please respond' is also suggestive of some kind of invitation to Mars to reveal itself and this programme certainly employs the notion of images *at work* (a concept explored in Chapter 1) in order to reveal Mars as a drivable terrain.

[45] John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2015.

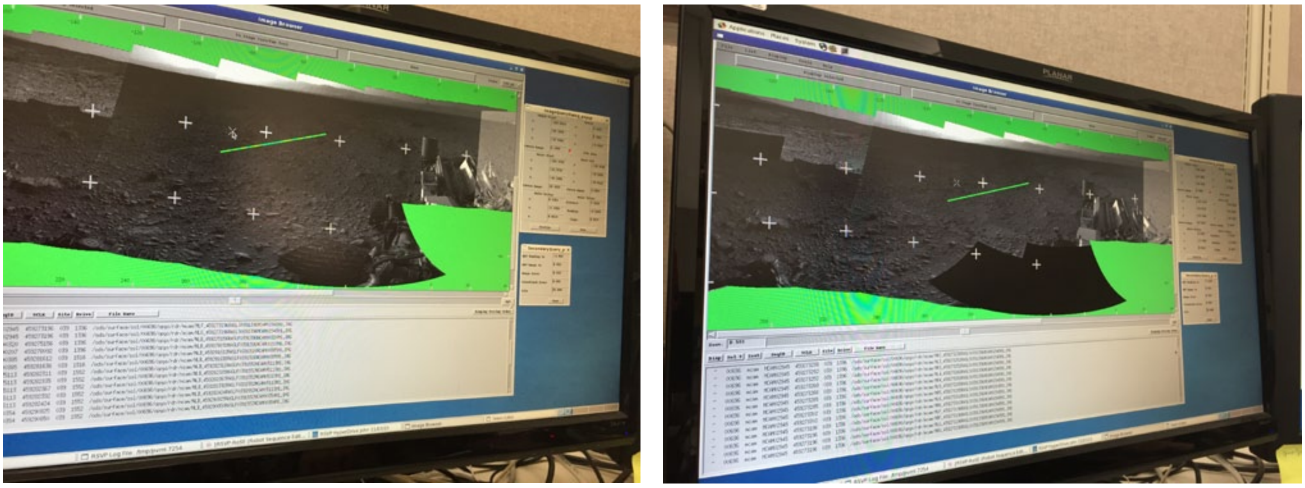


Figures 4.15 a-b. Photograph of *Curiosity* image mosaic shown on-screen in RSVP. Second image shows result of tone mapping. Photographs taken on 3 November 2015 by author, courtesy of JPL-Caltech.

All the images displayed are stereo-pairs, and the ones in these particular examples are what is referred to as RDRs or Reduced Data Records. As opposed to the raw EDRs (Engineering Data Records), RDRs have been linearised, and had various processes applied to them such as balance correction.[46] Individual frames may then be made brighter through

[46] This is done automatically by software created by Bob Deen and his team. Linearisation is applied to stereo-pairs, as Wright explains:

a process called tone mapping; revealing what is in the shadow, Wright is able to see if there are any obstacles that may otherwise remain unseen (fig 4.15 a-b).[47]



Figures 4.16 a-b. Photograph of *Curiosity* image mosaic pairs shown on-screen in RSVP. Image a (left) is left eye view, image b (right) is right eye view. Photographs taken on 3 November 2015 by author, courtesy of JPL-Caltech.

At this point the images are not three-dimensional but are seen as a black and white composite: the difference between the right and left eye images can be seen in figures 4.16 a-b. The programme loads both the right and left eye image, the XYZ image, the range image, and the surface normal image.[48] As a set of variants on the landscape these images are essentially layered behind the one on show. The user can bring forward individual images

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> In general, lenses of cameras have some distortion. In addition, no matter how you build and mount the cameras, it is impossible to get the boresights [the direction the camera is pointing in] pointed exactly parallel to each other for a stereo pair. What you do is create a mathematical model of the cameras (a camera model) from taking images of calibration targets. The linearisation process then warps the images according to their camera models so that the boresights are parallel and that any real-world object visible in a particular pixel in one image must be in the same row of pixels in the other eye image. Thus, matching a feature from one image in the other image requires only a one-dimensional search/matching process.

John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), email message to author, 14 June 2016.

[47] Wright, interview.

[48] An XYZ image, a range image and a surface normal image are data structures that hold the results of the stereo image computation carried out after the linearisation process; these images are not generally looked at, but their data is used to assist with the construction of the digital terrain model. An XYZ image is made by 'computing the 3D coordinates of every pixel you can match in the left and right images' and this data is used to construct the range image. The range image holds information about the distance of surface features from the camera. The surface normal image uses data from the XYZ image to determine the ground level, slope and roughness of the terrain. Wright, email message.

by clicking on the files in the drop-down list in the window below the black and white image to flip between seeing the same portion of the landscape from the right or left NavCam, for instance. Although the user cannot see all the different variations at once, they come together in his/her mind to help form a deeper understanding of the terrain. The metadata is coded in the header of each image showing the state of the rover, the focal point of the camera, the direction it was pointing in, where the mast was pointing and the state of the arm; this is held as both ones and zeroes within the image, but is also accessible in a readable format via a pop-up window. For Barthes a photograph 'is never anything but an antiphon of "Look," "See," "Here it is"; it points a finger at certain *vis-à-vis,* and cannot escape this pure deictic language.'[49] Arguably these black and white images in RSVP go beyond this definition of a snapshot photograph; the images tell more than what they show, but this requires knowing exactly how to look at them. To return to Rancière:

> Emancipation begins when we challenge the opposition between viewing and acting; when we understand that the self-evident facts that structure the relations between saying, seeing and doing themselves belong to the structure of domination and subjection. The spectator also acts, like the pupil or scholar. She observes, selects, compares, interprets. She links what she sees to a host of other things that she has seen on other stages, in other kinds of place.[50]

In a sense, engineers like Wright are trained as professional 'lookers'. They have an educated understanding about how these images should be read and how to reveal more information to help them with the task at hand; essentially how the images can relay driving limitations for the rover. Here it is not just a question of what the image does (what we see at face value) but what the viewer brings to the viewing experience.

This cylindrical view of the landscape is seen through the eyes of the rover as subject, whom we experience as Merleau-Ponty's chiasm; both a subject we 'see' through, and an object as part of the scene itself (as discussed in the previous chapter). As Merleau-Ponty states:

> For if it is true that I am conscious of my body *via* the world, that it is the unperceived term in the centre of the world towards which all objects turn their face, it is true for the same reason that my body is the pivot of the world: I know that objects have several facets because I could make a tour of inspection of them, and in that sense I am conscious of the world through the medium of my body.[51]

In this part of the RSVP programme we, via the body of the rover, are at the central viewpoint and we may only experience the surfaces of Mars apparent to the NavCam's lens at the moment of capture. It is through the second part of the RSVP programme that we can 'tour'

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[49] Barthes, 5.
[50] Rancière, 13.
[51] Maurice Merleau-Ponty, *The Phenomenology of Perception,* trans. Colin Smith (London: Routledge & Kegan Paul, 1962), 82.

the other facets of the scene. Using terrain models constructed by RSVP, we can move away from existing as an 'unperceived term in the centre of the world' and experience the rover as an object within its wider context. Reminiscent of the first aerial photographs of the Earth, RSVP enables a different perspective 'beyond the frontier of natural sight' afforded to us by the rover.[52] It is through this process that we gain a greater understanding of the landscape but simultaneously become alien to it, as seen in figures 4.17 and 4.18.

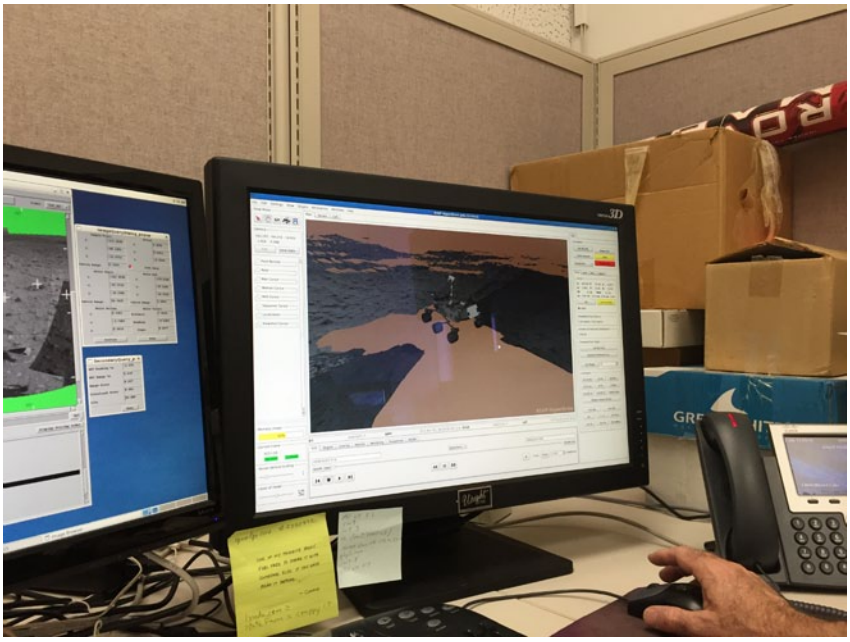

Figure 4.17. Terrain model of *Curiosity's* surroundings shown in RSVP. Photograph taken on 3 November 2015 by author, courtesy of JPL-Caltech.

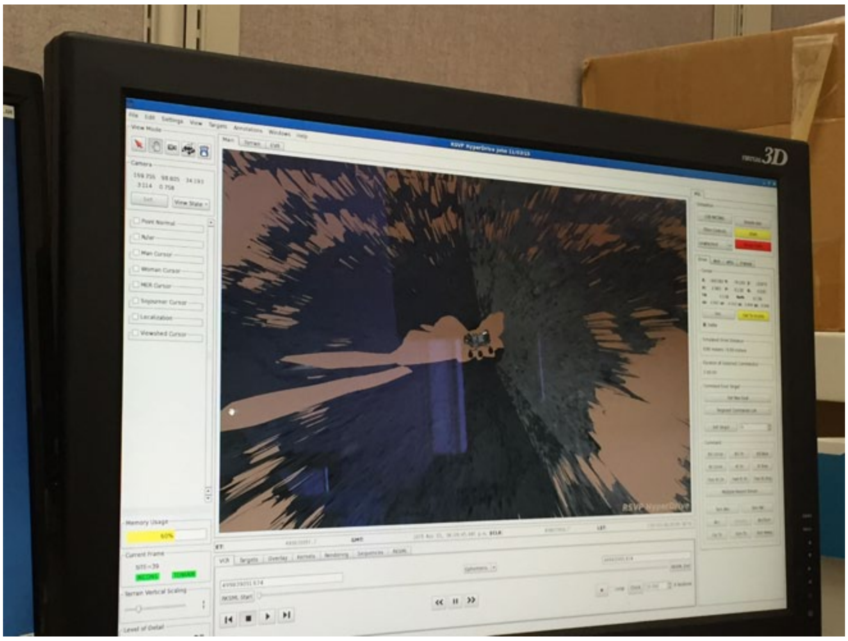

Figure 4.18. Elevated terrain model of *Curiosity's* surroundings shown in RSVP. Photograph taken on 3 November 2015 by author, courtesy of JPL-Caltech.

[52] Kitty Hauser, *Bloody Old Britain: O. G. S. Crawford and the Archaeology of Modern Life* (London: Granta Publications, 2008), 34.

Merleau-Ponty states that 'all knowledge takes its place within the horizons opened up by perception'.[53] As users of RSVP we may – superficially at least – detach ourselves from the viewpoint given to us by *Curiosity* and look down upon the body of our surrogate explorer as an object within its wider context on the surface. Through this process we can glimpse Mars from above, a view inconceivable for the rover. Nowadays we are visually acquainted with the landscape as seen from above; through plane journeys and satellite imagery of the Earth and other planets we have learnt how to understand such images and what they represent. The first aerial photographs captured during World War 1 provided a view never seen before, one which was very different from a person's view on the ground. Kitty Hauser writes on the landscape as seen from above through images:

> Aeroplanes were still a recent invention in 1914, and the photographs they brought back from the field must have constituted a kind of visual shock, showing the landscape in a way often imagined but never before seen with anything like such clarity. This was how the earth and its contents might appear to a disembodied, astral eye. The most familiar of things seen from a human perspective – trees, fields, church towers, towns; the receding orders of earth and sky, foreground, middle ground and misty distance – were all made unfamiliar from the air, all turned inside out.[54]

These images were used as maps, often to work out how 'far away the enemy was' and just how 'complex its earthworks were', thus giving wider context to the soldiers' surroundings and enabling troops to plan attacks.[55] To exemplify the different perspectives, archaeologist O.G.S. Crawford uses the analogy of the difference between a cat's and a human's perspective of a patterned carpet: 'The man, standing over there, can see quite clearly the pattern on the carpet. The cat, however, has only a blurred awareness of the pattern, being so close to it.'[56] He argues that:

> we earthbound humans are like the cat on the carpet, with only a partial perception of the earth we tread upon, and live in. It takes another kind of eye, another viewpoint to reveal to us the truth about the world.[57]

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[53] Merleau-Ponty, *The Phenomenology of Perception,* 207.

[54] Hauser, 34.

[55] Hauser, 34.

[56] Hauser, 87. Crawford was describing the difference between *perspectives,* but it is worth noting that a cat's *vision* also differs from a human's. A cat has better vision at night (due to a high concentration of rod receptors in the retina) but their colour perception is not as good as a human's (having a lower concentration of cone receptors in the retina). Cats also have a slightly wider field of view than humans, but seem to be 'near-sighted', that is they are able to register only close-up surroundings. To engage with Crawford's example then, perhaps we have to imagine that the vision of the human and the cat are the same and that in this instance it is just the perspective that alters. Dina Spector, "How Cats see the World Compared to Humans," Business Insider, 16 October 2013, accessed 9 November 2016, http://www.businessinsider.com/pictures-of-how-cats-see-the-world-2013-10?IR=T.

[57] Hauser, 88.

Revealing such truths about the Martian surface in this way is made possible by satellite imagery from orbiters and by the polygon models constructed by RSVP. In a sense, we lose an immersive encounter with the landscape as we no longer observe the scene from human eye level. However, what we do gain is a different level of situational awareness. Implying some kind of omnipotent overview, we gain a wider understanding that is impossible to obtain through the eyes of the rover due its sheer proximity with the nearby terrain it traverses.

Created using data gained from stereo-imagery these models are representative of the terrain, and grey-scale NavCam image data is draped over the models to increase pictorial illusion. In this process the NavCam image gets stretched out across the three-dimensional landscape. Filling in only what can be seen from the rover's central viewpoint, the image's grey-scale features are strewn along a perceivable path. Such models are, to quote Wright, 'two and a half D' and show the exact position of the rover and any holes in the terrain mesh created by a ridge line, rocks, or the rover itself.[58] The underside of the polygon model is a digital elevation model or DEM that approximates the height of the terrain, essentially meaning the rover doesn't fall through the holes in the mesh, virtually that is.[59] Essentially these pieces (represented by the Martian brown flat colour) are what the rover cannot see at that given moment in time. Rovers are never driven into these spaces because they are unknowns, and so these models make the holes – information that cannot be seen within the two-dimensional image or the fused stereo-pair – physical and palpable. The DEM underneath pushes upwards; seeping up and out onto the grey-scale image we are distinctly aware of what is missing. Absence here becomes present, and this attempt at solidifying the landscape serves to highlight the limits of the rover's technology in a constructive way that can be used by rover drivers. In effect we navigate the visible and invisible as represented in two material forms; the grey-scale terrain is patchy, in flux, whereas the flat DEM is overwhelming. Here the invisible becomes a blotch on the landscape through which the real Mars can only be glimpsed.

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[58] Wright, interview.

[59] Elevation is not usually exaggerated, however a slider in the programme does enable users to do this. Wright explains:

> We do this occasionally on really long drives, because sometimes we want to follow the contours of things, don't want to go up the steepest part of the hill, so this enables us to visually see the terrain. Even though it may look pretty flat, doing this helps us.

Data from Mars orbiters can be used to approximate the terrain and satellite images taken by the Mars Reconnaissance Orbiter (MRO) can be draped over the DEMs. However, these images are nowhere near as high resolution as those provided by *Curiosity* on the ground and so satellite data is not very helpful for rover drivers who need to see the landscape within very close range. Wright, interview.

Figure 4.19. Marcel Odenbach, *Die Distanz zwischen mir und meinen Verlusten (The Distance Between Myself and My Losses),* video, duration: 10 minutes 11 seconds, 1983. Screenshot of video.

The 1983 video piece by Marcel Odenbach titled *The Distance Between Myself and My Losses* collages imagery of medieval paintings, gay pornography, war films and ambiguous objects to construct a story about identity and memory.[60] The images are accompanied by the Romantic opera of Schubert's *Der Erlkönig* and Burundian funeral songs. In response to this work, Paul Virilio writes on the notion of *catching a glimpse.* The piece restricts the viewer's vision by 'masking all but the barest slit of the visual field' so that the subject matter (in this case that of a human figure) is 'not seen all at once but is successively revealed'.[61] Virilio continues:

> The search for the minimum that one can perceive thus appears to be a paradoxical objective: how can you see *without* seeing, perceive without knowing what you really perceive? The final question is, how far can you take blindness and still maintain form recognition?[62]

For rover driver Wright, the blind spots are as important as those areas of the terrain that can be seen. Unlike Merleau-Ponty's lamp, these are spaces we cannot reach into or around to touch: we cannot physically move through the landscape to reveal the invisible. Virilio goes on to examine: 'it is not enough to know one is looking through a slit; the slit must be seen […] The shape of the aperture has an important influence on what is perceived'.[63] It is the

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[60] Sofia Reina, "Die Distanz zwischen mir und meinen Verlusten (The Distance Between Myself and My Losses), Marcel Odenbach," Museo Nacional Centro De Arte, accessed 14 June 2016, http://www.museoreinasofia.es/en/collection/artwork/die-distanz-zwischen-mir-und-meinen-verlusten-distance-between-myself-and-my.

[61] Paul Virilio, *A Landscape of Events,* trans. Julie Rose (Cambridge, MA: The MIT Press, 2000), 38.

[62] Ibid.

[63] Ibid., 38-9.

frame, this time represented by the flat colour of the DEM, that becomes the 'limit of visibility'.[64] Ordering the illusion it stands in the way of this illusion becoming a reality.

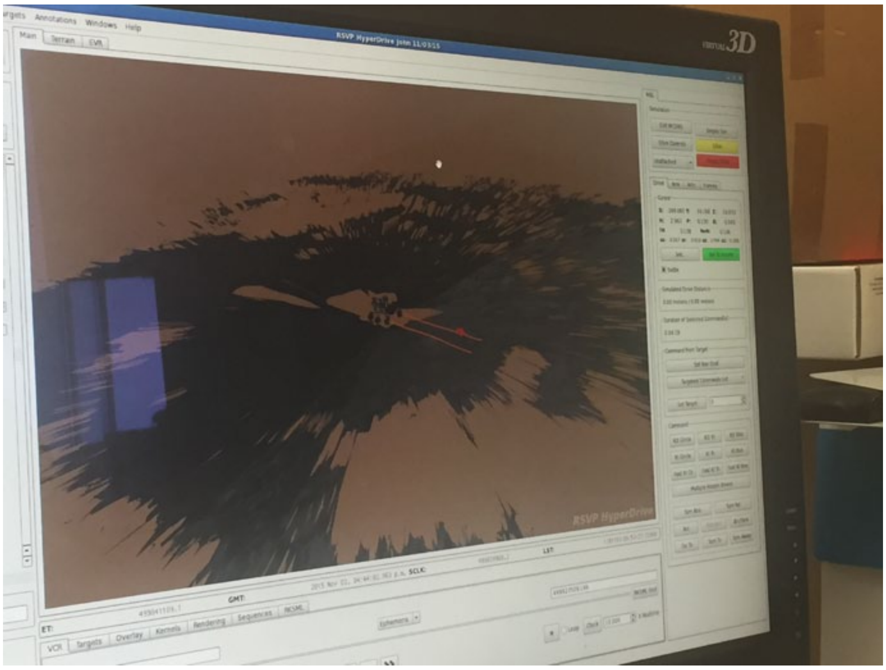

Figure 4.20. Elevated terrain model of *Curiosity's* surroundings and the rover's direction shown in RSVP. Photograph taken on 3 November 2015 by author, courtesy of JPL-Caltech.

In order to demonstrate how we can imagine different perspectives because of embodied perception, Merleau-Ponty uses the example of trying to draw his home from a bird's eye view:

> the fact that I am able to draw together in it all habitual perspectives is dependent on my knowing that one and the same embodied subject can view successively *from* various positions.[65]

It is this form of embodied engagement that is lacking in our experience of Mars. *Curiosity* is not able to shift its position as easily as the human subject, and although our perspective is dictated by the position of the rover, Merleau-Ponty's 'birds-eye view' is artificially enabled via stereoscopic image data. In a sense, the pictorial frame collapses in the RSVP terrain model; zooming out to look at the model from an elevated position and rotating so we can see the front of *Curiosity,* we are no longer restricted to the two-dimensional cylindrical perspective. Wright explains the importance of these models for driving (see fig. 4.20):

> If you were planning a drive and you wanted to go that way *[points to bottom right]* you would have to navigate around these holes because you can see what's ahead, so you know it's safe.

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[64] Ibid., 38.
[65] Merleau-Ponty, *The Phenomenology of Perception,* 203.

> It's also possible that you might see some rocks, and know you don't want to go in that direction.[66]

Commands can be written and drives simulated in this programme, enabling engineers to present possible traverses to the science team. But these types of visualisation also allow us to glimpse a different kind of image of Mars, one that places the viewer above the scene; in this case we do not perceive Mars as the rover, but perceive the rover as part of the Martian terrain. Subject and object become detached in RSVP as we shift our viewpoint upwards and outwards for a wider contextual view. Simulating drives in this way presents an alternative to Barthes' 'that-has-been'; the programme enables a certain level of immersion with the landscape that allows engineers to imagine 'being there', but these simulations are also possible projections into the future. They cannot predict for certain what the rover will encounter, so in a sense they provide a 'this-could-be' for engineers and scientists.

Unlike the two-dimensional window upon a world, RSVP allows engineers to see what is on the periphery of vision, to rotate, zoom in and out, and generally gain a more encompassing understanding of the terrain they have to navigate. The terrain model then may be seen as a form of focused vision, bringing the periphery into view and allowing us to grasp it all at once. As architect Juhani Pallasmaa states: 'focused vision confronts us with the world whereas peripheral vision envelops us in the flesh of the world', providing context for our embodied perception.[67] For the terrain model, peripheral vision does not exist as we know it; we cannot be enveloped in the flesh of Mars and it is our physical periphery, beyond the window of our computer screen, that brings us back to Earth.

Paul Virilio makes a further observation on shifting one's gaze, one's vision, and one's blindness, which can be seen in the context of Maurice Merleau-Ponty's theorising on the body and vision: 'Shifting your gaze, whether thanks to the mobility of your head or the mobility of your eyeball, also means effectively shifting your blindness, your own relative blindness.'[68] In figures 4.17 and 4.18 we see according to blindness, distinctly aware of what is missing. Blindness pushes up from underneath the terrain model in the form of the DEM, giving material form to that which remains invisible. We cannot fully perceive the surrounding landscape, not through *Curiosity's* eyes or our own. Merleau-Ponty maintains that the body is 'an intertwining of vision and movement': the body is 'steer[ed] through the visible'. 'We see only what we look at' he states, thus vision is attached to movement.[69]

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[66] Wright, interview.

[67] Juhani Pallasmaa, *The Eyes of the Skin, Architecture and the Senses,* 3rd ed. (Chichester: Wiley, 2012), 14.

[68] Virilio, 39.

[69] Merleau-Ponty, *The Primacy of Perception,* 162.

Wright can simulate the rover's traverses through the virtual model, but by doing so he cannot reveal any more than what is already there. *Curiosity* is at the centre of the image. The 'window' view through its eyes may be collapsed, offering us an overall view of the terrain, but we still glimpse Mars in fragments, our vision fully dictated by the rover's capabilities, the limits of its vision, in a visualisation that is only 'two and a half D'.

Figure 4.21. Photographer unknown. Scientists observing anaglyph images of Mars through 3D glasses. Image shown in William R. Newcott, "Return to Mars," *National Geographic* 194, no. 2 (1998): 3.

<u>A Glimpse of Mars in Black, White, Red and Blue: The Anaglyph</u>

In comparison to the 'two and a half D' of the terrain models, John R. Wright explains the benefits of being able to see the terrain three-dimensionally through 3D enabled glasses:

> Once I put 3D glasses on [to look at images taken by the Navigation Cameras] I said Oh! there's the hill that I can't go over, it's right there […] 3D gives you a really good idea of where the breaks in the terrain are, where you know you cannot see something. You get that from here *[signals terrain model]* but this actually could be really low features like sand, and you can tell in 3D right away what it is. My eyes, with millions of years of evolution, enable me to do that.[70]

The stereo image reveals the incoherence of the camera's monocular vision, replacing the eyes with two cameras. Following the stereoscope came the red/blue anaglyph, which is still in use today in the Mars rover missions and is used as part of the RSVP programme.[71]

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[70] Wright, interview.

[71] Although when possible preference is often given to quad buffering with liquid crystal shutter glasses. Wright explains that this technology 'draws two copies of the left and right image in separate memory planes and then it swaps them in and out'. Wright, interview.

In 1891 the French inventor Louis Ducos du Hauron submitted a patent for 'prints, photographs and stereoscopic images that produce their effect in daylight without the use of the stereoscope'.[72] He named his invention the anaglyph: comprising a stereoscopic pair of images superimposed with a slight offset – being represented by red and blue – so when viewed through the appropriately coloured 3D glasses, each eye sees a slightly different picture that combines in the brain to form an illusion of three-dimensionality. The left eye always sees through the red filter; anything represented as red in the image this eye sees as 'white', whilst anything represented in the image as blue it sees as 'black'. The same works for the right eye viewing through the blue filter, but the other way around. Anything that is black and white in the image is perceived the same by both eyes.[73]

For Hauron, the anaglyph posed a more attractive model as it could easily be distributed inside publications and enlarged. It also, he believed, had scientific merit, and he was willing to give up the rights of his patent for any attempt 'which aimed to print and publish an anaglyphic image of the moon suspended in space'.[74] In 1923 Hauron's request was answered by Leon Gimpel and Emile Touchet, who was secretary of the French Astronomy Society. In the archives of the society, the pair found two prints of the moon taken at the Paris Observatory in 1902 and 1904 and when viewed stereoscopically, these images created a three-dimensional effect. After some difficulty Gimpel managed to convert the images into an anaglyph and when shown in the French weekly *L'Illustration,* the anaglyph aroused great enthusiasm; newsagents were reported to have been so overwhelmed by the demand from the public that police had to be called to control the crowds.[75] This level of public enthusiasm demonstrates the commanding nature of experiencing the unknown in three-dimensions.

Participating Scientist and Long Term Science Planner on the *Curiosity* mission Sanjeev Gupta elaborates on the anaglyph's value for science exploration:

> We all look at NavCam anaglyph images for depth of field – you really need that; they make an enormous difference. Without them you can make a lot of mistakes about the geometry, shape of the landscape and rocks. You can see these properly through anaglyphs.[76]

JPL produces anaglyphs for their Photojournal image archive, and anaglyphs for the cylindrical views are constructed automatically in the RSVP programme. In RSVP the

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[72] Louis Ducos du Hauron quoted in Pellerin, 121.

[73] Rio Kevin, "How it Works: The Evolution of 3D Glasses and 3D Technology," *Journal of Young Investigators* (April 2007), accessed 15 June 2016, http://www.jyi.org/issue/how-it-works-the-evolution-of-3d-glasses-and-3d-technology/.

[74] Hauron quoted in Pellerin, 121.

[75] Pellerin, 122.

[76] Sanjeev Gupta (Professor of Earth Science, Imperial College London and Participating Scientist on the Mars Science Laboratory Mission), interview by author, London, 2 July 2015.

simulated drives can also be viewed in 3D with either polarised glasses and 3D enabled screens or anaglyphs (fig. 4.22). However, as Wright explains, anaglyphs and other types of 3D are generally only used for taking a quick look at, rather than studying due to the disconcerting effect when viewed for long periods of time. They are used to get a sense of the terrain, to 'glimpse' Mars, rather than being a real means through which to plan traverses.

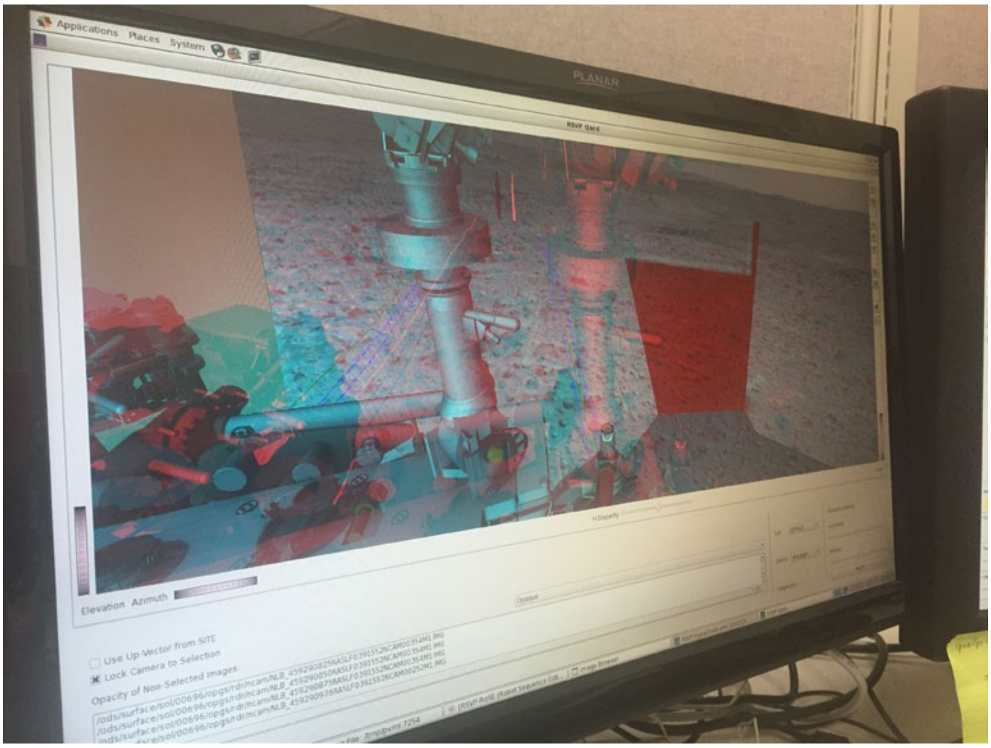

Figure 4.22. Anaglyph view of rover's drive path in RSVP. Photograph taken on 3 November 2015 by author, courtesy of JPL-Caltech.

Dr Peter Grindrod, a Lecturer in Planetary Science working at UCL's Regional Planetary Imaging Facility, explains that anaglyphs of Mars are not often seen in print form; due to the size and volume of the files now produced, NASA no longer distributes hardcopies of its images to the RPIF and instead everything is done electronically through online databases and image archives.[77] Anaglyphs of Mars are therefore only ever seen on computer screens, and on relatively small scales. The images are held within the frame of the screen and colour is imposed onto the greyscale stereo-pair in order for it to be seen in 3D. Both the screen and the red/blue colours are fundamental to maintaining the illusion of the anaglyph,

[77] Peter Grindrod (UK Space Agency Research Fellow and Lecturer at Birkbeck University of London and Data Manager at UCL Regional Planetary Image Facility), interview by author, London, 7 August 2014.

but, as I shall demonstrate, can also be seen as glitches which dictate *how* we glimpse Mars and its image.

The image at the beginning of this chapter, *Mars Stereo View from 'John Klein' to Mount Sharp* (fig. 4.1, pg. 172) shows a greyscale Martian landscape emerging from behind a thick black background. This black void curtains off the Martian sky and in 3D it flickers between flat colour and cavernous abyss. The image of Mount Sharp is held in place by two forces; it wants to sink beneath and break through simultaneously. This frame cannot be collapsed, and it stands in stark contrast to the panorama and early forms of immersive art that use perspectival laws to increase a sense of realism upon viewing.

Andrea Pozzo's paintings in the Sant'Ignazio church in Rome are Baroque ceiling frescoes in which a 'fascination with spectacle' manifests itself in 'illusionism, and the Baroque formal principle of the collapse of the frame'.[78] A sense of depth is created within the fake cupola and the framing is not necessarily apparent on viewing as the painting is essentially an extension of the surroundings. Reality merged with illusionism, this participatory element within Baroque spaces stems from a 'spatially invasive nature' in which the sheer scale immerses the viewer in representation.[79] However, unlike the painted panorama which can be viewed from any point on the viewing platform, the illusion of Pozzo's fresco only comes together at one specific viewpoint. This is echoed in the anaglyph image which only produces three-dimensionality upon donning the red/blue glasses. The sense of illusion in Pozzo's ceiling fresco and the anaglyph image are similar in that 'his or her bipolar sensory apparatus conjures forth a fictive image […] with an apparent depth of field'.[80] It is our suspension of disbelief that helps order the illusion of both the anaglyph and Pozzo's fresco; we *want* to believe the vaulted ceiling really leads up to heaven in much the same way that we want to reach out and touch the Martian soil and satisfy our desire to 'be there'.[81]

Figures 4.23 a-c. Andrea Pozzo, paintings in Sant'Ignazio, Rome, 1685 – 97.
a – View of the nave, crossing, and choir, oil on canvas and fresco, 1685-97.
b – Simulated cupola, oil on canvas, 1685.
c – *Allegory of the Jesuits' Missionary Work* (detail), fresco, 1688-94.

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[78] Angela Ndalianis, "Architectures of Vision: Neo-Baroque Optical Regimes and Contemporary Entertainment Media," MIT Communications Forum, accessed 17 May 2016. http://web.mit.edu/comm-forum/papers/ndalianis.html, 1.

[79] Ibid.

[80] Silverman, 128.

[81] This suspension of disbelief within an experience of illusion draws similarities with theme park rides.

Juhani Pallasmaa writes on embodied perception, peripheral vision and the Baroque:

> Baroque paintings open up vision with hazy edges, soft focus and multiple perspectives, presenting a distant, tactile invitation and enticing the body to travel through the illusory space.[82]

Within Pozzo's fresco the frame collapses, drawing us into the image space; our peripheral vision is addressed by a continuation of the image. This is not the case in the anaglyph or stereo-image, as Jonathan Crary observes in his writing on the stereoscope: 'its decisive three-dimensional image' 'barely extended beyond the range of central foveal clarity', producing 'an image which, in its hypertangibility, was all figure with no ground, no periphery'.[83] Our peripheral vision is clouded by the computer screen, the keyboard, our desk and the wider room; we are not physically immersed in the image of Mars, but experience it from one perspective as a 'conjuration' we can inhabit imaginatively.

The sudden reversal of three-dimensional space into flat image is triggered upon moving from the ideal viewing position of Pozzo's fresco, and from removing the red/blue glasses. The anaglyph image offers the viewer both a visual and conceptual conundrum in which imagination and belief are key to immersion in the image. But unlike Pozzo's all-encompassing ceiling fresco, the potential to be *perceptually* immersed in the stereo image is slight and our experience of the image is still very much two-dimensional.[84] We do not experience the image as all-encompassing; we have to hold the paper 3D glasses to our face to prevent them from slipping off, keeping us firmly rooted within our physical reality. The fracture in illusion is caused by our own physicality as spectators and on viewing the *3-D View from Bradbury Landing Site* (fig. 4.24) the shiny screen of the computer interferes with our experience of the landscape; light bounces off its surface and we must fight with reflections of ourselves and our surroundings. The otherworldly landscape as spectacle is observed in representation, never to be visited and experienced and this is due in part to the presence of the screen which acts as a 'barrier'.[85] 'What does the silver screen screen?' asks philosopher Stanley Cavell, 'it screens that world from me – that is, screens its existence from

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[82] Pallasmaa, 38.

[83] Crary, 295.

[84] *Live Forever*, a work created by the artist Lee Bul in 2002, encapsulates the viewer physically within a soundproof karaoke pod in which they are able to perform for a non-existent audience. This work in particular is an example of how the viewer may be enveloped within an environment that excludes them from the outside world, therefore blurring the boundary between what is real and what is fantasy, whilst also increasing the virtuality of the experience. It is an example of how physical involvement by the viewer can enhance the immersion in a virtual reality. Absolutearts, "Lee Bull: Live Forever," 2002, accessed 26 June 2012, http://www.absolutearts.com/artsnews/2002/05/17/29925.html.

[85] Anne Friedberg, *The Virtual Window: From Alberti to Microsoft* (Cambridge, MA: The MIT Press, 2006), 17.

me'.[86] As spectators we are aware of this boundary, however the more constructed or abstracted an image appears, the greater awareness we as viewers have of the screen's flat plane, and Mars recedes further into a reconstruction.

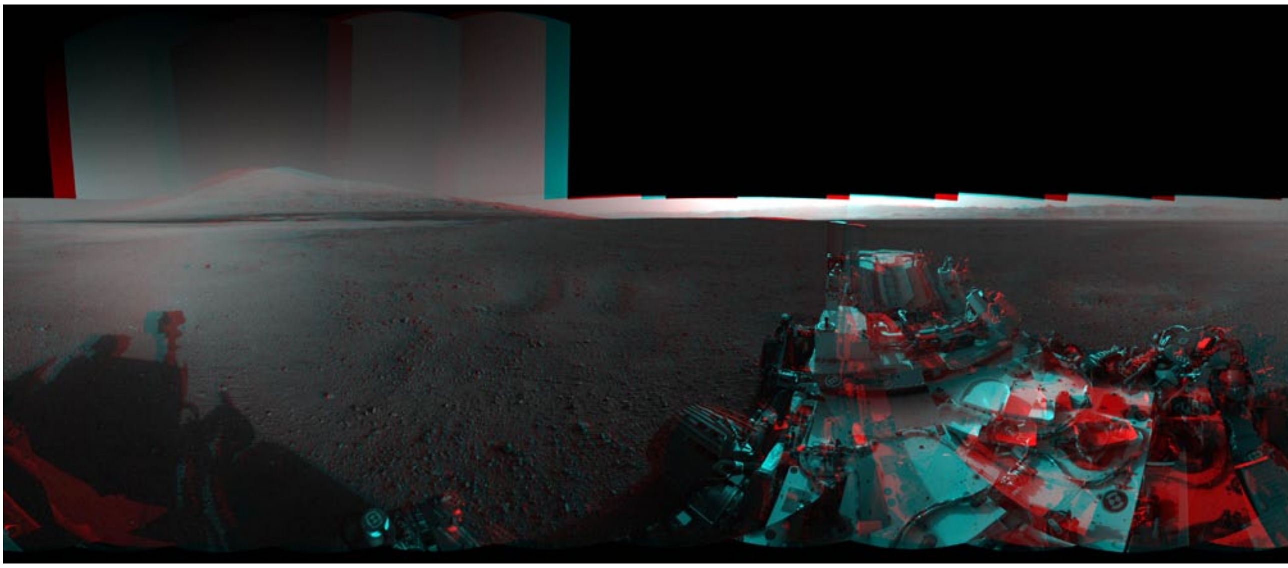

Figure 4.24. *3-D View from Bradbury Landing Site.* This anaglyph combines the left and right views of the pair seen in figure 4.11. Photojournal image addition date: 4 September 2012. Credit: NASA/JPL-Caltech.

Image unavailable due to copyright restrictions.

Figure 4.25. Photographer unknown, unnamed photograph (museum number 207-1945). Photograph by author, courtesy of Victoria and Albert Museum, London.

[86] Stanley Cavell, *The World Viewed* (New York: Harvard University Press, 1971), 24.

In the stereo pair 207-1945 (fig. 4.25) at the V&A archive a group of picnicking people have been frozen in time and this freezing becomes far more apparent in the 3D world; because the effect of three-dimensionality is so real in this particular image, there is a sense that the figures should in fact be in motion, but instead they each appear as miniature painted cut-outs in a false coloured world. The lurid green of the surrounding foliage, the bubble gum pink of the lady's dress; because colour is not integral to the image from its inception, it bursts forth, steeped in abnormality. Introducing colour where it does not belong heightens the freeze, the image's occupants appear to be surrounded by the scenery of a stage set. The materiality of the anaglyph image surfaces in the presence of alien colour upon the black and white landscape; it is colour more than anything that betrays the illusion here. *Mars Stereo View from 'John Klein' to Mount Sharp* (fig. 4.1, pg. 172) is a panorama made from multiple frames. The sharp interruptions of red and blue appear on the boundaries between the mosaic fragments; viewed through the appropriate glasses these patches of red and blue activate the landscape, causing it to shimmer behind a pale translucent screen. Drifting atop the space of the image, yet interlaced into its skin, these faint streaks of colour gain their own kind of three-dimensionality. Even in 3D, we are still aware of the landscape's reconstruction into image.

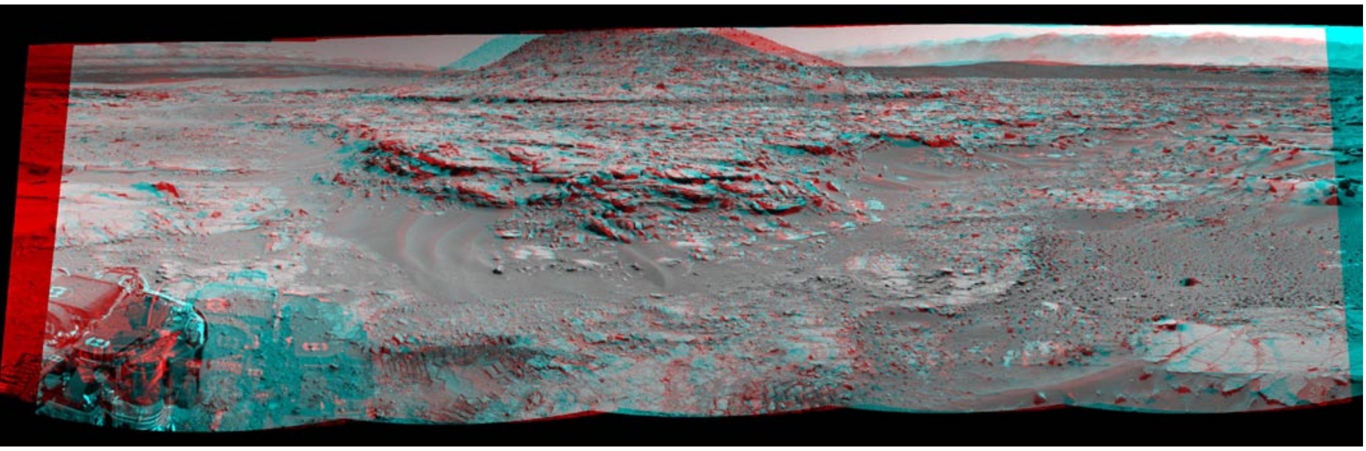

Figure 4.26. *Stereo View of 'Mount Remarkable' and Surrounding Outcrops at Mars Rover's Waypoint.* This mosaic anaglyph combines images taken by *Curiosity's* right and left Navigation Cameras on 11 April 2014 (sol 597). Photojournal image addition date: 16 April 2014. Credit: NASA/JPL-Caltech.

In *Stereo View of 'Mount Remarkable'* (fig. 4.26) the landscape appears to be split into very defined planes; the faint mountains in the background are comparable to the flat painted backdrop of a stage set and the foreground landscape appears as a series of black and white high resolution flat planes. Dr Peter Grindrod agrees with this observation, likening it to when contemporary films, not originally filmed with a stereo camera, are made '3D' afterwards. This is achieved by digitally moving every pixel over by one, yet this is often only done in close up shots, making objects closer to the camera 'jump out', whilst backdrops remain two dimensional. Grindrod explains that zooming into the image is often a way of eliminating this 'stepped' effect.[87]

Returning to *Mars Stereo View from 'John Klein' to Mount Sharp* I zoomed in to evade the space of the invisible void. Looking past the black frame and into the luminous image I traversed across the enlarged landscape on my screen; the landscape no longer appeared in separate planes and the rocks seemed somewhat tangible, albeit in black and white and not dusty reds. But still there was a perplexing quality to the viewing that I can't quite grasp in words. The black and white landscape seemed to emerge from behind a glimmering haze of red and now and again the boulders would quiver and become individually encircled with a blue glow. Scrolling too fast to the left I came upon *Curiosity,* and without warning, was blinded by the glaring mutation of the machine, ablaze with red where the two images did not align, oppressive in its vividness my eyes felt scorched by this sudden appearance of colour. A three-dimensional window set on a two-dimensional black void this landscape is dislocated by colour, it is unsettled, in motion. Virtual space is present, almost penetrable, but it is fragile, easily fractured by its very composition.

For Barthes colour could be 'like a pinprick in the corner of the eye' having the power to 'lacerate'.[88] *Curiosity* lacerates the black and white image of Mount Sharp; once again the presence of the rover acts as a reminder that this image of landscape is partial, immaterial, flattened and framed by technology.

Mars is a landscape we cannot grasp in its entirety, and the forms of 3D imaging available provide fragmentary glimpses of a terrain both alien and familiar. They attempt to

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[87] Grindrod, interview.

[88] Roland Barthes, *The Responsibility of Forms: Critical Essays on Music, Art, and Representation,* trans. Richard Howard (Oxford: Basil Blackwell, 1986), 166.

make present a sensation of 'being there' on Mars, yet we always see according to the limits of the rover; from its viewing position and by the frame of its technology. The image space of this other world exists via a device and for now, this reconstructed landscape *only* exists via a device, with no point of comparison to its referent.

The types of 3D imaging discussed in this chapter attempt to give material form to a landscape that remains impalpable. As French philosopher and literary theorist Maurice Blanchot writes:

> The image can, when it awakens or when we waken it, represent the object to us in a luminous *formal* aura; but it is nonetheless with *substance* that the image is allied – with the fundamental materiality, the still undetermined absence of form, the world oscillating between adjective and substantive before foundering in the formless prolixity of indetermination.[89]

The image highlights the ungraspable nature of the thing it represents as solidity and substance vanish in two-dimensions. Blanchot continues on the image: 'does the reflection not always appear more refined than the object reflected? Isn't the image the ideal expression of the object, its presence liberated from existence? Isn't the image form without matter?'[90] To this end Professor of Computer Science Edward R. Tufte describes the process by which a three-dimensional creature collapses into two-dimensions, likening it to the representation of something into an onscreen image: 'When the toad sheds its skin upon the occasion of a quarterly moulting, the suit leaves life's spaceland and collapses into flatland, not unlike our information displays.'[91] The 3D image endeavours to regain solidity from this flatland, to make matter *out of* form, attempting to make present that which we cannot physically experience. Yet the composition of the two-dimensional image always prevails; the glitch, be it in the presence of the device, the limit of the visible, the frailty of the mosaicked image or the colour which lacerates reveals the artifice, the reality of the *image* – and not the landscape – in an *illusion* of three-dimensional space. Because 3D is a solidity constructed from the outset in two dimensions – unlike Tufte's toad which was once filled with flesh and organs – Mars may only be glimpsed.

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[89] Maurice Blanchot, *The Space of Literature*, trans. Ann Smock (Lincoln: University of Nebraska Press, 1982), 255.
[90] Ibid., 256.
[91] Edward R. Tufte, *Envisioning Information* (Connecticut: Graphics Press, 1990), 14.

Chapter 5

Coloured Light upon the Surface: ‘Glitch-as-Method’

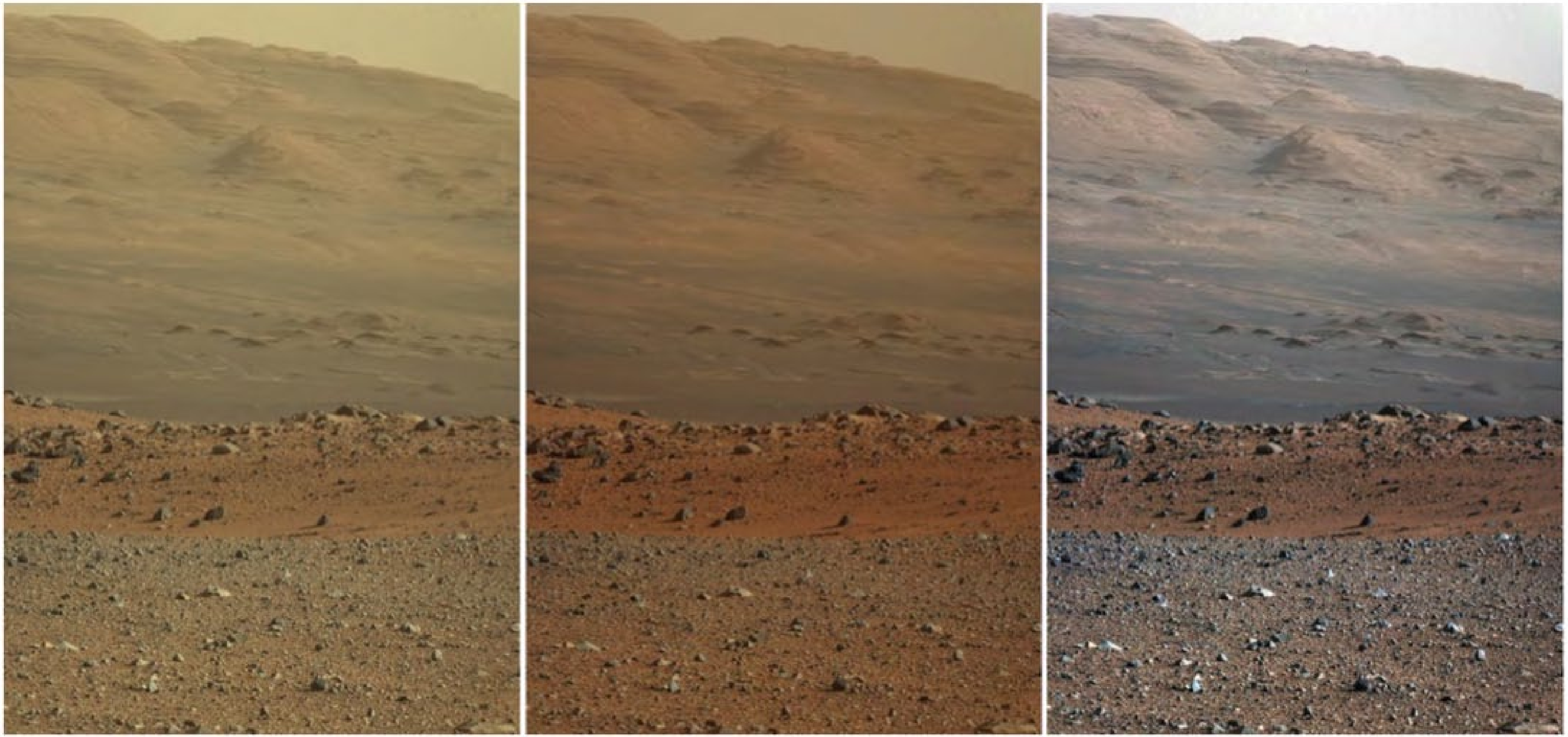

Figure 5.1. *'Raw,' 'Natural' and 'White-Balanced' Views of Martian Terrain.* This image was taken by *Curiosity* on 23 August 2012 (sol 19) looking south-west to Mount Sharp. Photojournal image addition date: 18 March 2013. Credit: NASA/JPL-Caltech/MSSS.

Digital dust veils the landscape with otherworldly debris, the sunlight is muffled through a thick atmosphere. Switching on the Earth-like filter in the third version balances out the image in white, artificially clearing the red haze from the sky, settling the dust. Features seem purer through Earth-light, vision is no longer blurred through the Martian haze; layers of sediment reveal themselves to us, we can see more than Curiosity. *The touch of the machine transforms the landscape into something other, alters it, pervades it with its vision. Earth-light estranges the landscape, repetition brings it closer to home, but further from its original. The split screen delays the white from seeping through and contaminating the raw, unprocessed landscape.*

Flicking between these worlds I become immersed in technological alterations; the forms remain but the interplay of light and colour constantly shift the landscape before my eyes. The filtered light comes from one direction, in line with my eyes just behind the luminescent screen, it veils the flattened landscape with a translucent film, painted only onto the surface of the visible. Stepping beyond the screen, past the barrier into the middle image, walking forwards into the landscape, those particles that were seen upon first entering stay the same and everything else flickers back to its original state of raw unprocessed colour.

Turning over a rock in 'white balanced' reveals the terrain as belonging to two worlds now: the filter over flat appearances is broken, it is not the light falling upon the landscape but a filter upon the window through which we look. No longer three versions of the same landscape*, but three versions of the same* image.

<u>Sweeping Away the Dust</u>

The single image from which the ‘three versions of the same image’ were reconstructed was captured by *Curiosity’s* MastCam on sol 19 looking south-west from the rover’s landing site towards Mount Sharp; the slope in the distance is the rover’s goal.[1] This triptych has been used in NASA press releases, and has subsequently been cited in newspaper and online articles to discuss the variability of colour perception in vision and photography and in articles discussing the ‘true’ colour of the Martian surface.

The unprocessed colour image on the left is what the MastCam captured; it is the raw, unfiltered photographic data recorded directly by the camera. For all intents and purposes this image is the most neutral: in ‘raw’ format it is a direct translation of the subject into image, of the light reflective surfaces apparent to the lens at the moment of capture. Raw images are often compared to photographic negatives and carry with them the implication that post-processing has yet to take place. But this is not to say they are totally unmediated and as we discovered in Chapter 1, no image can offer a totally objective depiction: the camera imposes its own constraints in terms of framing, the ability of the lens to render near and far, and imaging devices’ in-built colour calibration systems. The central image has been produced after ‘calibration’ on Earth to ‘show an estimate of “natural” colour, or approximately what the colours would look like if we were to view the scene ourselves on Mars’.[2] Although scientists rarely refer to these calibrated images as ‘true’ colour (recognising that they cannot be totally ‘realistic’ depictions) the ‘natural’ image aims to get closest to human vision. The calibration process is based on information acquired through imaging the calibration target on the body of the rover. This calibration target consists of variously coloured materials; as scientists already know what these colours should look like, the calibration target acts as a known quantity and point of comparison against which colours in the image may be measured.[3] In a sense the calibration target becomes a home referent on Mars.[4] The final ‘white-balanced’ image in this triptych shows an estimate of what the terrain would look like under ‘Earth-like, rather than Martian, lighting’.[5] Mars is further from the

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[1] The phrase ‘three versions of the same image comes from NASA / Jet Propulsion Laboratory, “'Raw,' 'Natural' and 'White-Balanced' Views of Martian Terrain,” Mars Science Laboratory Curiosity Rover, 18 March 2013, accessed 10 January 2015. http://mars.jpl.nasa.gov/msl/multimedia/images/?ImageID=5148.

[2] NASA / Jet Propulsion Laboratory, “'Raw,' 'Natural' and 'White-Balanced' Views of Martian Terrain.”

[3] *Curiosity* worked out its calibration when it landed, so unlike MER it does not have to image the calibration target so frequently.

[4] This will be discussed in more depth later in the chapter.

[5] NASA / Jet Propulsion Laboratory, “'Raw,' 'Natural' and 'White-Balanced' Views of Martian Terrain.”

sun so sunlight is weaker and the red dust in the atmosphere alters the colour of light reaching the ground; by 'white-balancing' the images, geologists are able to quickly and accurately identify rock types similar to those on Earth from their colours and textures, therefore enabling the *Curiosity* team to make decisions on potential points for investigation. White-balanced images assume something in the scene is white and the rest of the colours in the image are automatically adjusted accordingly. As there are no white objects on Mars (or at least the atmospheric dusts give sunlight a different hue to that on Earth), the colour-balancing process takes the lightest portion of the image to make the adjustment.[6] Looking at the 'natural' image of Mount Sharp we can see it is the sky and the highlights on the rocks in the foreground that are the lightest areas: in the 'white-balanced' version these portions of the image appear as white. As the intensity of the 'white' object can vary from image to image, the overall appearance of the 'white-balanced' image can differ: sometimes it is obvious that white-balancing has occurred (the sky is overtly white and sometimes blue as opposed to a dusty pink) but other times the colour adjustment can be fairly subtle.[7] As the 'white-balanced' image of Mount Sharp is displayed alongside its unprocessed and natural counterparts, the recalibration in this case is starkly evident.[8]

This chapter is a response to the three-part image (which I shall call the *Martian Triptych)* in relation to a comment *Visions of the Universe* curator Dr Marek Kukula made whilst we were discussing the *Mars Window*. When corresponding with NASA for use of images in the panorama, Kukula recalls scientists proudly sending him one of these carefully 'white-balanced' images, to which his reply was 'Er, that's lovely, but can you make it look like Mars again please?'[9] Although there is scientific purpose to these images, this use of imagery also highlights NASA's desire to image the (currently) impossible; i.e. 'this is what it would look like if you were stood there' or, in the most drastic case of the third image, 'this is what the landscape would look like if you brought it to Earth, or took Earth's atmosphere to Mars'. This desire to bring the vision of the Martian rover into our earthly grasp also refers to the decision to make the Mars panorama 'life-sized' and to experience the planet in 3D, thus enabling viewers to imagine themselves in the landscape, but all the while standing

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[6] This is done algorithmically and not on a scene by scene basis.

[7] Jerry Lodriguss, "Catching the Light: Using a Custom White Balance," Astrophotography Techniques, accessed 5 October 2016, http://www.astropix.com/HTML/I_ASTROP/CUSTOMWB.HTM.

[8] Often 'white-balanced' images are output in press releases as stand-alone images but NASA always makes a point of stating their recalibrated nature, often providing links to web addresses showing the raw or natural colour images.

[9] Dr Marek Kukula (Public Astronomer at Royal Observatory, Greenwich), email message to author, 21 January 2014.

firmly on Earth. The three-part image of Mount Sharp is a scientifically useful set of images for which the 'immersion' lies in the scientists' ability to distinguish different features under different lighting conditions.

This chapter examines the imposition of colour onto the surface of the visible in the image of the Martian landscape with particular reference to philosopher Ludwig Wittgenstein's ideas relating to perception and the effect of changing aspects in *Philosophical Investigations* (1953), Janet Vertesi's concept of 'drawing as', Maurice Merleau-Ponty's writings on perception, and artist and writer David Batchelor's remarks on colour in *Chromophobia* (2000) and *The Luminous and the Grey* (2014).[10] In the spirit of framing such immersive image forms against examples from art history, this chapter re-examines this three-part image of Mount Sharp within the context of the 19th century painted diorama, whose objective in immersion stemmed from the aforementioned panorama. Louis-Jacques-Mandé Daguerre's 1822 invention used lights and coloured filters to manipulate large painted pictures for theatrical effect; light was projected onto the back of the painting, hence its title, *dia* meaning through and *horama* view in Greek.[11] As with Daguerre's invention, the light in the *Martian Triptych* comes from behind the luminescent screen and we look upon three views of the same landscape, each manipulated in a different colour-way. The series of images act as fluctuating windows through which we view a shifting re-presentation of landscape.

This chapter argues that the glitch occurs in the fracture between vision and representation; as our eyes traverse the three images the glitch as a disruption manifests itself in the interchange. However, unlike in previous chapters where the glitch has occurred on the margin or fringe thus breaking the illusion, this chapter proposes the glitch as central to the mobilisation of the image and as a useful method in making the invisible visible: through manipulating the colour of images scientists are able to reveal features of the landscape that would otherwise remain unseen. The glitch then, whilst fracturing the relationship between what might be seen (on Mars) and what is represented (in the image before us) also functions

[10] *Chromophobia* is concerned with the forms of resistance to colour from the ancient Greeks to the present day. It addresses the chromophobic impulse in art, literature and popular culture in which colour has often been relegated to the superficial and cosmetic. David Batchelor, *Chromophobia* (London: Reaktion Books, 2000). *The Luminous and the Grey* is an enquiry into the beginning and end of colour, in the material world and in the imagination. Drawing on Wittgenstein's claim that 'whatever looks luminous does not look grey' Batchelor calls on artworks, the city and the cinema to highlight the difference between the luminosity of colour which represents chaos and movement, and the grey, which represents the static drab of inactivity. David Batchelor, *The Luminous and the Grey* (London: Reaktion Books, 2014).

[11] John Timbs, "Curiosities of London," Victorian London - Entertainment and Recreation - Theatre and Shows - Dioramas - in Regent's Park*,* 1987, accessed 18 February 2014, http://www.victorianlondon.org/entertainment/diorama.htm.

as a method towards another kind of visibility which is connected to knowledge and understanding in relation to what we know of Earth.

The cameras on *Curiosity's* mast are just above human eye-level and together with immersive technologies and techniques, they place humans at the centre of the visual experience. The *Martian Triptych* is a particularly anthropocentric image, displaying a certain tendency to succumb to an idea of scientific order. These attempts to re-present Mars in such a way could also be seen to go beyond the need for scientific discovery to deeper desires and fears regarding the level of human-centred environmental catastrophe we are now facing. In the age of the Anthropocene – a term proposed by Dutch chemist Paul Crutzen in 2000 ('from *anthropo*, man, and *cene*, new') – humans are looking beyond a life on Earth to new planets.[12] The effects of 'farming, deforestation, mining and urbanisation' have meant that 'humans have become the biggest threat to life on Earth'.[13] In the words of Professor of Computational Science Stephen Emmott: 'our cleverness, our inventiveness and our activities are now the drivers of every global problem we face'.[14] For Elon Musk, presenting his vision of getting humans to Mars at the International Astronautical Congress in Mexico in September 2016, humans can either stay on Earth to be met with an eventual extinction or become a 'space faring civilisation and a multi-planet species'.[15] The ability to familiarise

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[12] Joanna Zylinska, *Minimal Ethics for the Anthropocene* (Michigan: Open Humanities Press, 2014), 18.

[13] Ibid., 66 & 10.

[14] Stephen Emmott quoted in Zylinska, 10. Heather David and Etienne Turpin lay out the history of what is now known as the Anthropocene:

> In the estimation of paleoclimatologist William Ruddiman, the eight-thousand-year-old invention of agriculture and its attendant deforestation led to an increase in atmospheric carbon dioxide; this suggests that humans have been a primary geological force on the planet since nearly the beginning of the Holocene, making the Anthropocene nearly co-extensive with the last eleven and a half thousand years, since the most recent ice age. Crutzen has suggested his own date for the beginning of the epoch, putting the invention of the steam engine in the late-eighteenth century at the beginning of an uninterrupted rise in carbon dioxide emissions that can be read in ice-core samples. This date might be more precisely located in 1789, the year that witnessed the invention of the steam engine by James Watt – the technology that enabled human forces to exceed the modest limits of muscle- (whether human or animal), wind-, and water-power.

Heather Davis and Etienne Turpin eds., *Art in the Anthropocene: Encounters Among Aesthetics, Politics, Environments and Epistemologies* (London: Open Humanities Press, 2015), 5.

[15] Musk's SpaceX company is set on getting humans to Mars and Musk hopes that in 40-100 years, humans will be living on Mars in a self-sustaining civilisation of one million people. Musk envisions a 'colonial fleet' of 1000 spaceships (each carrying 100 passengers and their luggage) departing on mass from Earth. Testing has already begun for the rockets and the first spacecraft – *Red Dragon* – will be sent to Mars in 2020 as a test. This venture is being privately funded by campaigns, investors and the voyagers who will pay up to $200,000 for a ticket to Mars. Elon Musk, "Making Humans an Interplanetary Species" (paper presented at the International Astronautical Congress, Guadalajara, Mexico, 27 September 2016), accessed 28 September 2016, http://news.nationalgeographic.com/2016/09/livestream-spacex-elon-musk-plan-humans-mars-space/.

ourselves with Mars before future journeys then relies on images and data captured by the current rovers on Mars. This is arguably a planet that must be grasped by humans, for humans.

As discussed in Chapter 3, our immersion in the Martian panorama is ruptured by the frame, the body of the rover, and our own physical presence within the illusory space. We 'glimpse' Mars through a fractured illusion in the 3D image; we see according to the limits of the rover and the image, thus the landscape remains trapped behind a screen. The panorama encompasses the viewer in the image, the 3D image calls for the spectator to project themselves imaginatively into the scene. Yet the landscape represented in the *Martian Triptych* is not one we feel we can physically encounter, it is not an image that calls for the viewer to 'enter' it, in the words of Oliver Grau.[16] In presenting each iteration side by side with explanatory text below we are immediately made aware of the image's reconstructed nature. The *Martian Triptych* then presents a different kind of immersive encounter to that of the panorama and 3D image, which takes Roland Barthes' notion of 'that-has-been' (as outlined in the previous chapter) to a new level. Barthes' opinion that a photograph represents the 'that-has-been' is reconstructed in the 3D image to allow scientists a sense of 'being there' on Mars through the donning of 3D glasses. Through 3D visualisation tools rover drivers are able to propose drives, thus placing Barthes' notion into a probable future tense: 'this could be'. The *Martian Triptych* seems to illustrate each of these reiterations in one place. The first 'unprocessed colour' image is a direct photographic translation; Barthes' 'that-has-been'. The second 'natural' colour image is an approximation of the colours we would see if we stood there ourselves and conjures up the sense of 'being there'. The third 'white-balanced' image however goes beyond future paths simulated in the rover driver's 3D terrain mapping tool. As well as representing a landscape that remains (for now) only within the space of the image, this third iteration overtly recalibrates the scene through Earth-goggles; this is a vision of Mars that is required in order to 'see' and ascertain some kind of 'truth' from a geological standpoint. 'White-balancing' the image then reconstructs a vision of a landscape that does not and cannot exist, both for us as viewers of the image on Earth and for any future possible visitors to Mars. Nevertheless, at the heart of the third image lies the desire to place our human, earthbound vision at the forefront of seeing; this is a vision of a landscape that remains trapped within the space of the imaginary.

These technological alterations embody the subjectivity of the maker and the capacities of the imaging systems. Of course, the complications caused by the phenomenon of colour

[16] Oliver Grau, *Virtual Art: From Illusion to Immersion*, trans. Gloria Custance (Cambridge, MA: The MIT Press, 2003), 3.

in photography are not new, and anyone capturing a colour photograph on Earth will note the difference between how our eyes register colour and how the photograph renders the scene.[17] Our eyes are trained to adjust to so many variables affecting the change of colours (the position of the sun in the sky, whether or not it is behind a cloud or whether you are indeed indoors or outside) that the camera often struggles with; many digital cameras are equipped with automatic exposure levels for capturing scenes in different lights as a way to compensate for and get the best image possible under lighting conditions which are not deemed 'perfect'.[18] As Chapter 1 discussed, all decisions about framing, lenses and composition are coded by convention and intention, making the photograph a subjective image despite its early claims to mechanical objectivity. Allan Sekula writes in "On the Invention of Photographic Meaning":

> The most general terms of the discourse are a kind of disclaimer, an assertion of neutrality; in short, the overall function of photographic discourse is to render itself transparent. But however the discourse may deny and obscure its own terms, it cannot escape them.[19]

Similarly, for Umberto Eco, the photographic image as an 'iconic sign' '*reproduces* the conditions of perception, but only *some* of them'. Thus, we are 'faced with the problem of a new transcription and selection' for which '*every image is born of a series of successive transcriptions'.*[20] Colour adds another level of mediation; arbitrary and variable at every stage all decisions about colour are coded by the mechanism, convention and artistic intention. As the images of Mars represent an unseen referent, no human can verify the accuracy of the 'natural' colour image of Mount Sharp; these images are arguably imbued with a further level of subjectivity.

Sekula states that the message of a photograph is carried within it, but that its context also plays a large role in its 'readability': 'the meaning of any photographic message is necessarily context-determined'.[21] In the *Martian Triptych* the 'readability' of the three images comes about via repetition and difference, and by the explanatory text which is included as part of the image itself: the three images must be 'framed linguistically' in order to be understood.[22] Unlike, say, a colour photograph of a scene on Earth, the three-part image of

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[17] Just as no two people will perceive colour the same way, no two cameras will render colour the same.

[18] When capturing an image outside, the 'correct' image can be obtained on a sunny day when the sun is high in the sky. The 'scene' modes on digital cameras can include: Beach/Snow; Fireworks; Candlelight; Night Portrait; Party; Sports; Sunset; and Night Scene.

[19] Allan Sekula, "On the Invention of Photographic Meaning," in *Thinking Photography*, ed. Victor Burgin, 2nd ed. (London: Macmillan Press Ltd., 1982), 87.

[20] Umberto Eco, "Critique of the Image," in Burgin, 32-33.

[21] Sekula, 85.

[22] Ibid.

Mount Sharp is clearly influenced by the desire to see in different ways; the ability of the viewer to directly compare the three versions reminds us that there could be many more versions and that perhaps there is no 'pure' version to be had. Furthermore, the inclusion of explanatory text highlights the images' purpose within a scientific discourse and the subjective nature of the best way to 'see' Mars. In the *Martian Triptych* then, subjectivity is made explicit as we are aware from the beginning of our own, and others', acts of looking. Our act of looking is directed by our comparison between the three versions and the variations in colour can be seen as a form of Lacan's *tache*, a reminder that we view the Martian landscape through the mechanical gaze of the rover's lens and that of the imager who has manipulated it.

In the case of *Curiosity's New Home* (Chapter 2) the veil of black and white, the seam, and the body of the rover act as glitches to throw us back into the space of the image; to revisit astronaut John Glenn's definition of glitch, these features are 'unexpected occurrences', 'break[s] or disruption[s]'.[23] In the *Martian Triptych* superficial colours are imposed onto the surface of the visible and as our eyes traverse the three images we are reminded that no image is stable. The white-balanced filter creates a glitch between Mars and its image and the repetition of the framed view of landscape disturbs any sense of looking through a window. The glitch, as disruption, manifests in the interchange between each iteration and it is through the interchange that we become aware of the filters. As a result of colour balancing, Mount Sharp oscillates between 'raw', 'natural' and 'white-balanced' creating a flicker that does not occur within the image (as some kind of light display) but rather through the movement of our eyes as we scan the three images.[24] But whereas in previous examples the glitch often stands in the way of complete immersion – occurring involuntarily as some form of accident – in the *Martian Triptych* the glitch takes on special significance, acting as a way *into* the image: the glitch can be used as a method of becoming

[23] Rosa Menkman, *The Glitch Moment(um)* (Amsterdam: Institute of Network Cultures, 2011), 26.

[24] Perhaps Mars might be glimpsed somewhere in between the images in the same way that James Elkins describes death as coming somewhere in between a series of photographs of a Chinese execution by division into a thousand parts (1924). Referring to Georges Bataille (who 'said that there are three things that cannot be seen, even though they may be right in front of our eyes: the sun, genitals, and death'), Elkins writes on the series of 4 photographs:

> The eye begins, at the first frame, with a woman: she is whole […] The eye ends, at the last frame, with a piece of meat: it is blurred by photography, but certainly no longer living or human. In between comes pain and then death.

For Elkins, death is 'in the sequence, trapped between the frames'. Elkins searches for something beyond the image in the same sense we attempt to grasp Mars beyond what first appears. But perhaps Mars, like death, is never present within the three images and exists somewhere in between. In the flickering of the three images, in those blank white spaces in between, Mars exists as the ungraspable landscape it is. James Elkins, *The Object Stares Back: On the Nature of Seeing,* (San Diego: Harvest, 1996), 103, 110 & 115.

immersed. The glitch does not act to disrupt our immersion in the landscape, it *enables* our immersion in the landscape-as-image. The separate filters are fixed, and scanning from left to right we journey from the unknown to the nearly comprehensible, each repetition a variation on the last. The glitch in the *Martian Triptych* occurs through the scan of the eye and the understanding of difference which makes us question the purity of these images.[25] But it is in the difference, the flicker between raw, natural and white-balanced, that also enables a human-centred encounter with the Martian landscape. The glitch-as-method – evident most of all in the 'white-balanced' version – enables this kind of encounter. This will be the focus of the first part of the chapter with particular reference to Wittgenstein's changing aspects and the writing of Janet Vertesi.

The interchange between raw, natural and white-balanced reconstructs the image of Mount Sharp as something graspable through something known: repetition here is employed as a scientifically useful tool. Yet imposing superficial colours onto the surface of the image is what estranges it; the 'white-balanced' version does not retain the neutrality of the raw unprocessed image. In the third iteration of Mount Sharp Mars' atmospheric dust evaporates, the landscape-as-image becoming estranged from a referent we will never see or experience. We are not immersed here in a Martian landscape, but in an image that is unsettled in its flickering between raw, natural and white-balanced. Drawing similarities between Daguerre's painted diorama and the three-part image of Mount Sharp, the second half of this chapter considers colour as a superficial element; applied only to the surface of the visible in a futile attempt to grasp at order, 'white-balancing' the image erases all atmospheric characteristics of Mars from the image. Although the glitch is a method of becoming immersed in the geological features of Mars, it also fractures the relationship between vision and representation.

Revealing the Invisible: 'Glitch-as-Method'

Little has been written in a technical capacity about colour processing of images captured by the MastCam on *Curiosity* but the procedures share many similarities with the Panoramic

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[25] In *Difference and Repetition* (1968) Gilles Deleuze defines repetition in contrast to generality and resemblance, relating it to a unique series of events. For Deleuze, repetition is reliant on difference, it is 'difference without a concept':

> Repetition is truly that which disguises itself in constituting itself, that which constitutes itself only by disguising itself. It is not underneath the masks, but is formed from one mask to another, as though from one distinctive point to another, from one privileged instant to another, with and within the variations. The masks do not hide anything except other masks.

Gilles Deleuze, *Difference and Repetition,* trans. Paul Patton (1968; repr., London: Continuum, 2004), 19.

Cameras on the Mars Exploration Rovers (MER) *Spirit* and *Opportunity.* The predominant difference between the MastCam on *Curiosity* and the PanCam on MER is the ability to directly record colour images. The PanCams are 'multispectral'; in other words they capture black and white images at different wavelengths (both visible and invisible) through different filters.[26] To obtain a 'true colour' image, the landscape is filtered through red, green and blue and these separate records are then reconstructed into a colour image.[27] *Curiosity's* MastCam on the other hand acquires single colour images in wavelengths visible to the human eye. As discussed in Chapter 1, the wide 34mm lens and the narrow 100mm lens making up *Curiosity's* MastCam can together attain up to 1600x1200 pixels using Bayer-pattern filters (RGB). These RGB filters are superimposed on the CCD resulting in the generation of three band colour images on board the rover, an example of which is the raw, unprocessed colour image as seen in the three-part image of Mount Sharp.[28]

In "'Seeing Like a Rover': Images in Interaction on the Mars Exploration Rover Mission", Janet Vertesi explains that there is a vital distinction between true and false colour images produced on the *Spirit* and *Opportunity* missions. In these missions, true colour 'refers to a particular combination of filters that approximates the range and type of light sensitivity exemplified by the human eye'.[29] The images taken by the PanCam have the potential to provide 'information on the mineralogical composition of surface materials that supplements and complements data obtained by other MER instruments' by filtering the landscape through other filters.[30] 'False colour' imaging for MER refers to a particular combination of

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[26] As Jim Bell explains:

> Each PanCam camera is equipped with a small eight position filter wheel, providing the only multispectral imaging capabilities for each rover. Fifteen of the 16 filter wheel slots contain filters; one slot (L1) was left empty to maximise sensitivity during low-light and ambient Earth temperature (pre-flight) imaging conditions […] Thirteen of the 15 filters per camera are so called "geology" filters, designed for imaging of the surface or sky, and the remaining two filters are "solar" filters, designed for direct imaging of the Sun.

Three filters on the left PanCam have 'sample wavelengths close to the R, G, and B response of the human photopic function,' (so 'true' colour images could be produced). Jim F. Bell III et al., "Mars Exploration Rover Athena Panoramic Camera (Pancam) investigation," *Journal of Geophysical Research* 108, no. E12, 8063 (2003): 9 & 6, accessed 21 October 2015, http://dx.doi.org/10.1029/2003JE002070.

[27] Janet Vertesi, "'Seeing Like a Rover': Images in Interaction on the Mars Exploration Rover Mission" (PhD diss., Cornell University, 2009): 23, accessed 15 March 2014, http://hdl.handle.net/1813/13524.

[28] Alexander et al., "Camera & LIBS Experiment Data Record RDR Data Products," *Mars Science Laboratory (MSL) Software Interface Specification* (15 April 2015): 35, accessed 2 September 2015, http://pds-imaging.jpl.nasa.gov/data/msl/MSLNAV_0XXX/DOCUMENT/MSL_CAMERA_SIS_latest.PDF.

[29] Vertesi, "'Seeing Like a Rover,'" 25.

[30] Bell et al., "Mars Exploration Rover Athena Panoramic Camera (Pancam) investigation," 3.

images taken through different filters to reveal colours to which the human eye is not sensitive; these include near-infrared, red and blue. *Curiosity's* MastCam also has science filters which can be used to capture false colour images of the Martian terrain (fig. 5.3, pg. 230) but predominantly the images are captured using visible wavelengths and are calibrated to produce 'natural' colour images. These colours, however, can be stretched during scientific work on Earth to make 'enhanced' colour images.

In order for visual imagers to calibrate the images on the ground (to create the 'natural' colour image) an earthly referent is sent on board each rover in the form of a calibration target (fig. 5.4, pg. 230). The 'Caltargets' for MER and *Curiosity* are almost identical: the sundial design allows scientists and engineers to work out the location of the sun and the base of the target consists of '7 spectrally distinct regions: 3 grayscale rings and 4 coloured chips' that are imaged by the cameras in order to 'derive accurate relative reflectance calibration for scenes of interest'.[31] The Caltarget is located on the rover deck, 'roughly 1m behind the mast and on the same (right) side of the rover'.[32] As NASA explains:

> The known colours of materials on the calibration target aid researchers in adjusting images to estimate "natural" colour, or approximately what the colours would look like if we were to view the scene ourselves on Mars.[33]

Curiosity's Caltarget was modified slightly to 'include six small embedded magnets that can capture and concentrate dust from the Martian atmosphere'.[34] These are the red rings visible on *Curiosity's* Caltarget. When the MastCam images are downlinked to Earth they are processed through a calibration pipeline which was developed based on extensive pre-flight testing and using images of the Caltarget captured by *Curiosity* when it first landed on Mars.[35] The Caltarget essentially acts as an aid to help work out the level of calibration needed; it provides a home referent, enabling visual imagers to 'see' that which is unfamiliar to human eyes.

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[31] Kjartan M. Kinch et al., "Dust on the Curiosity Mast Camera Calibration Target," *44th Lunar and Planetary Science Conference* (2013): 1, accessed 26 July 2016, http://www.lpi.usra.edu/meetings/lpsc2013/pdf/1061.pdf; Jim F. Bell III et al., "In-flight calibration and performance of the Mars Exploration Rover Panoramic Camera (Pancam) instruments," *Journal of Geophysical Research: Planets* 3 (6 January 2006): 2, accessed 20 July 2016, http://dx.doi.org/10.1029/2005JE002444.

[32] Kinch et al., 1.

[33] NASA, "Mast Camera and its Calibration Target on Curiosity Rover," 18 March 2013, accessed 27 July 2016, http://www.nasa.gov/mission_pages/msl/multimedia/pia16798.html.

[34] NASA, "Mast Camera and its Calibration Target on Curiosity Rover."

[35] Bell et al., "In-flight calibration and performance of the Mars Exploration Rover Panoramic Camera (Pancam) instruments," 2.

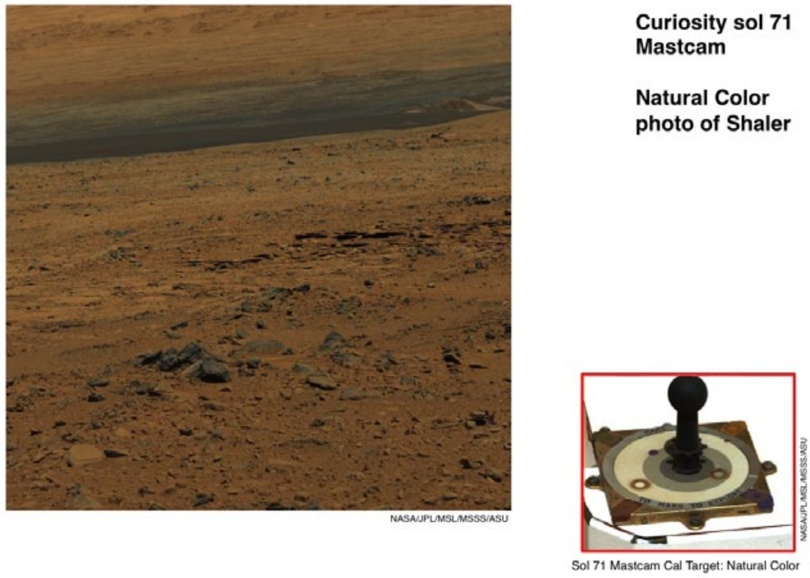

Figure 5.2. *Using Curiosity's Mast Camera to View Scene in 'Natural' Colour*. Image captured on 17 October 2012 (sol 71). Photojournal image addition date: 18 March 2013. Credit: NASA/JPL-Caltech/MSSS/ASU.

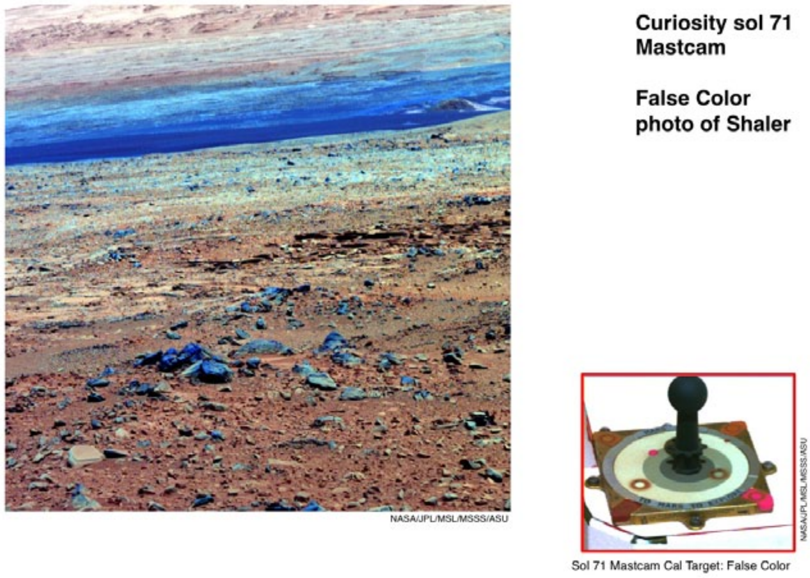

Figure 5.3. *Using False Colour from Curiosity's Mast Camera.* Image captured on 17 October 2012 (sol 71). This red-green-blue composite was generated from images captured using the MastCam's narrowband science filters at wavelengths of 751 nanometers, 527 nanometers and 445 nanometers. Photojournal image addition date: 18 March 2013. Credit: NASA/JPL-Caltech/MSSS/ASU.

Figure 5.4. *MSL MastCam calibration target.* Credit: The Planetary Society.

The calibration target further exemplifies the 'anthropic principle' I touched upon earlier. For Joanna Zylinska, author of *Minimal Ethics for the Anthropocene,* this is the 'tendency to explain the universe from our human standpoint, as if it existed uniquely *for us humans'*.[36] Karen Barad eloquently describes the anthropic principle in *Meeting the Universe Halfway:*

> Gazing out into the night sky or deep down into the structure of matter, with telescope or microscope in hand, Man reconfirms his ability to negotiate immense differences in scale in the blink of an eye. Designed specifically for our visual apparatus, telescopes and microscopes are the stuff of mirrors, reflecting what is out there. Nothing is too vast or too minute. Though a mere speck, a blip on the radar of all that is, Man is the centre around which the world turns. Man is the sun, the nucleus, the fulcrum, the unifying force, the glue that holds it all together. Man is an individual apart from all the rest. And it is this very distinction that bestows on him the inheritance of distance, a place from which to reflect – on the world, his fellow man, and himself.[37]

In a sense, the calibration target enables scientists to 'negotiate immense differences', allowing them to reflect on 'what is out there': the data is captured on Mars and bounced via radio signals to Earth at which point it is calibrated and recalibrated as an image we can see and understand. Just as existence for Barad is 'not an individual affair' but rather one of 'entangled intra-relating', the *Martian Triptych* is a product of numerous procedures and desired viewpoints.[38] The journey the image takes is one of great distance and multiple translations, the image's final resting point is that of the computer screen of an office or home computer. Mars is brought into the terrestrial realm, into a human grasp.

Despite the inclusion of the home referent, Melissa Rice, Assistant Professor of Planetary Science at Washington University, explains that because of the difference in the way colour images are produced for MER and *Curiosity*, our impression of the 'colours of Mars' on each mission is different.[39] This is also reflected in the different terms used to describe the images: for MER they are 'approximate true colour', for *Curiosity* they are 'natural colour'. This discrepancy between the rovers' visions of Mars is comparable on a more human centred level to theories surrounding how individual humans each perceive colour. In his 1953 seminal work *Philosophical Investigations,* Ludwig Wittgenstein writes:

> Look at the blue of the sky and say to yourself "How blue the sky is!" – When you do it spontaneously – without philosophical intentions – the idea never crosses your mind that this impression of colour belongs only to *you.* And you have no hesitation in exclaiming that to someone else. And if you point at anything as you say the words you point at the sky. I am

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[36] Zylinska, 67.

[37] Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter* (Durham, NC: Duke University Press, 2007), 134.

[38] Ibid., ix.

[39] Melissa Rice (Assistant Professor of Planetary Science at Washington University), email message to author, 20 July 2016.

> saying: you have not the feeling of pointing-into-yourself, which often accompanies 'naming the sensation' when one is thinking about 'private language'.[40]

Considering Wittgenstein's idea of a 'private language', it is perhaps quite logical that the Mars rovers each have different (thus somewhat subjective) perceptions of colour. It is known that each of the rover's cameras perceive colour in a slightly different way but it is also interesting to consider how we as individuals might then impose different impressions of the colours of Mars onto the same image from the same mission. In a sense we each have our own inbuilt calibration pipelines through which we process the world around us and in turn images of this world and others.

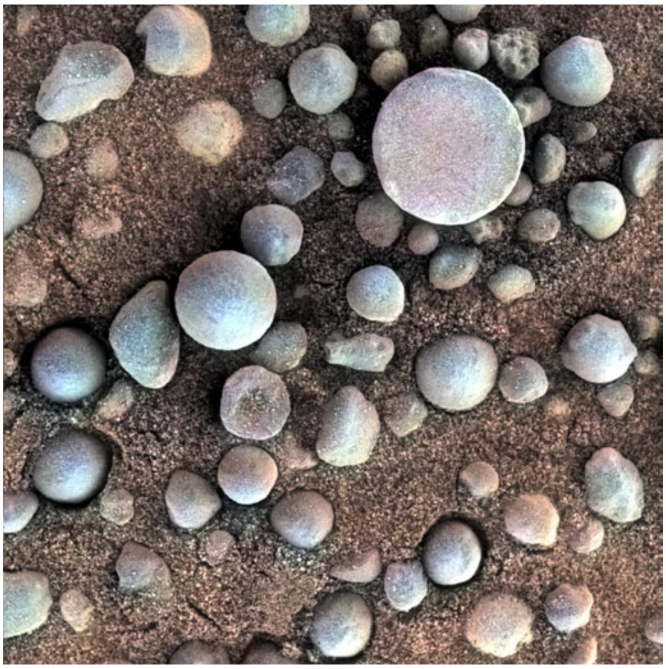

Figure 5.5. *Martian 'blueberries'.* These small 'spherules' were captured by *Opportunity's* microscopic imager with colour information added by from the PanCam on 19 April 2004 (sol 84). The area shown is 3cm across. Image was released in NASA Press release showing *Spirit* and *Opportunity* highlights, 27 January 2015. Credit: NASA/JPL-Caltech/Cornell/USGS.

'False colour' on MER uses a particular combination of filters to reveal information about the composition or mineralogy of rocks, soils and surface features on Mars. In addition, post-processing techniques can draw out specific features of the Martian surface. Raw image data can be 'constructed and reconstructed into multiple visions of the Martian terrain' and Vertesi claims that there is in fact no best way of imaging Mars.[41] Bob Deen, one of the technical leads at the Multi-Mission Image Processing Laboratory at the Jet Propulsion Laboratory uses the example of an image captured by the *Opportunity* rover in 2004 (fig. 5.5) to explain how enhancing the colours of images can enable 'invisible vision':

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[40] Ludwig Wittgenstein, *Philosophical Investigations,* trans. Gertrude E. M. Anscombe, 2nd ed. (Oxford: Basil Blackwell, 1958), 96.

[41] Vertesi, "'Seeing Like a Rover,'" 23 & 25.

> Enhanced colour intentionally exaggerates. Blueberries on the *Opportunity* mission is an example – if you look at a properly calibrated image these round structures aren't blue they are grey. But enhancing the colour makes them blue because there is nothing else blue in the scene [...] what it does is brings out the variations in colour which tells geologists that that area is bluer than that, and that's useful. It's hard to tell that because everything's covered in dust and so it's important to reveal.[42]

Here colour is manipulated in order to 'reveal' useful information for making geological identifications. Vertesi explains that 'this does not imply a change in the underlying dataset: only a change in visual orientation or aspect due to the combination of filtered images'.[43]

However, this is not always apparent and combined with the images' proliferation on the internet, this can often lead to misconceptions about what the terrain actually looks like. Martin Kemp has written on the use of false colour imagery within science, and the assumption that these images portray something 'false'. Such pictures, he states,

> deviate from our normal experience and give a 'false' impression. But in that the surfaces we normally see as coloured are not actually coloured in terms of some kind of inbuilt 'stain', but are perceived as coloured only through our ability to encode certain wavelengths of light in terms of discernibly different hues, the depiction of grass as red is in theory no more and no less artificial than showing it as green. It is simply a question of understanding the code being used.[44]

As I outlined in the introduction to this thesis, Michael Lynch explains that the practice of image manipulation allows 'objects and relationships which were initially invisible [to] become visible and palpable as a result of highly technical skills and complex instruments'.[45] For Lynch, pictures are considered as part of the labour process, and the reconstruction of images using post-production allows the invisible to become visible through immersing oneself in the changing status of the image. It is through the recognition of difference within the process of repetition in the *Martian Triptych* that the glitch disrupts a 'true' perception of what the landscape looks like but also enables us to 'see' Mars differently. James Elkins writes in *The Object Stares Back* (1996) that 'seeing alters the thing that is seen and transforms the seer. Seeing is metamorphosis, not mechanism.'[46] Elkins' statement gains particular poignancy when considering false colour images of Mars. Image manipulation enables us to see in a variety of ways; in the *Martian Triptych* the image morphs from one filtered view to

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[42] Bob Deen (Principal Software Developer at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2015.

[43] Janet Vertesi, "*Drawing as:* Distinctions and Disambiguation in Digital Images of Mars," in *Representation in Scientific Practice Revisited,* ed. Catelijne Coopmans, Michael Lynch, Janet Vertesi and Steve Woolgar (Cambridge, MA: The MIT Press, 2014), 25.

[44] Martin Kemp, *Seen/Unseen: Art, Science and Intuition from Leonardo to the Hubble Telescope* (Oxford: Oxford University Press, 2006), 64.

[45] Michael Lynch, "Discipline and the Material Form of Images: An Analysis of Scientific Visibility," *Social Studies of Science* 15, no. 1 (February 1985): 37, accessed 22 January 2014, http://dx.doi.org/10.1177/030631285015001002.

[46] Elkins, 11-12.

the next, flickering between a representation of the visible and the invisible. The glitch as the perceptible colour shift viewed in the interchange can be seen as a method of becoming both immersed in and repelled from the landscape and image.

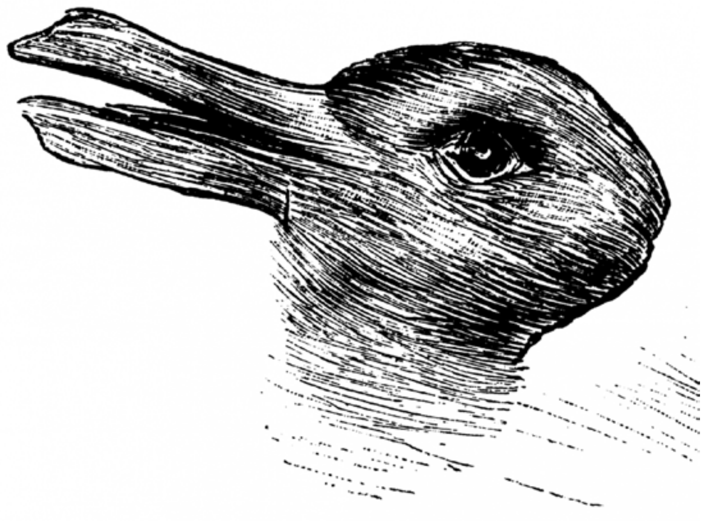

Figure 5.6. Duck-rabbit gestalt drawing, initially published in 1892 in the German humour magazine *Fliegende Blätter* (*Flying Leaves).*

For Vertesi, 'false colour' images are on par with 'true colour' when it comes to scientific value; it is often necessary to see 'different things in the same image' so filtering the image through various colours 'represent[s] different ways of seeing and knowing the Martian surface'.[47] Vertesi uses the analogy of the duck-rabbit gestalt drawing, likening it to the extrication of numerous data sets from the same image. For W.J.T. Mitchell, the duck-rabbit drawing is a 'multistable metapicture'; what occurs in the gestalt flip of the duck-rabbit also occurs by pulling out different colours in Deen's 'blueberries on Mars' example, producing different observations by changing, according to Vertesi, 'the organisation of visual experience'.[48] In the case of the *Martian Triptych,* the raw representational data of Mount Sharp does not inherently change, but our perception of it does. However, unlike the *Martian Triptych*, it is impossible to perceive both the duck and the rabbit at once. It is constantly shifting, from one to the other, depending on how we choose to look at it. In the *Martian Triptych*, it is not a case of how we choose to focus our eyes but more of a case of where we choose to look (at this image or the next). Everything is presented at once, together, in a triptych that makes palpable the focus on the shifting status of the image within scientific discourse. The 'white-balanced' image of Mount Sharp has been manipulated by humans,

[47] Vertesi, "'Seeing Like a Rover,'" 98-99.

[48] William J. T. Mitchell, *Picture Theory* (Chicago: The University of Chicago Press, 1994), 50; Vertesi, "'Seeing Like a Rover,'" 100.

for humans, as a means to understand the Martian terrain through an Earthly gaze. Our expectations of how Mars should look is somewhat perpetuated through the calibration of images; once we have an idea of what Mars looks like (its hazy pink sky and dusty terrain) it would be difficult to see it another way. Similarly, once the Dalmatian in the black and white 'camouflage' drawing (fig. 5.7) has been seen it cannot be unseen. Perhaps we need such images as the *Martian Triptych* and other examples of multiplicities of images in order to destabilise our understanding – without the previous two iterations of Mount Sharp we might easily be tricked into believing the 'white-balanced' version is a place on Earth.

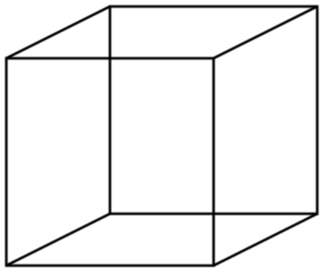

Figure 5.7. *Dalmatian Dog.* First shown in Richard Gregory's *Intelligent Eye,* 1970. Credit: Mighty Optical Illusions.

Figure 5.8. *Necker Cube.* First published as a rhomboid in 1832 by Swiss crystallographer

Vertesi draws on Ludwig Wittgenstein's concept of 'seeing as' to demonstrate how it is possible to see different things within the same image; in the duck-rabbit example we at first might see a duck, and then a rabbit, or vice versa. Similarly the Necker cube appears to flip between pointing up and pointing down.[49] These perceptual shifts are what Wittgenstein calls 'noticing an aspect', and this might also be applied to experiencing a painting or photographic image; on one level we see it as representing an object or landscape, on another we see it as paint on canvas or ink on paper.[50] John Verdi elaborates upon Wittgenstein's changing aspects in *Fat Wednesday:* 'I am most struck in all these cases by my awareness that

[49] John Verdi, *Fat Wednesday: Wittgenstein on Aspects* (Philadelphia: Paul Dry Books, 2010), x.
[50] Wittgenstein, *Philosophical Investigations,* 193.

something has changed about what I see, yet *nothing* has changed in what I see.'[51] In a similar manner to how Vertesi states that there is no best way of imaging Mars, the 'Necker cube does not have a *real* orientation. Its identity consists in its ambiguity.'[52]

But whereas our interchanging perception of the duck-rabbit drawings alter within our brains through a period of prolonged engagement with the image, scientists working with Martian data manually apply filters to change their perception of the landscape. Vertesi terms this form of image manipulation 'drawing as' which she takes from Wittgenstein's 'seeing as'; in order to gain different visual experiences, the scientist must 'draw' the image as '*this* or *that'*.[53] Taking influence from Bruno Latour, Trevor Pinch and Michael Lynch, Vertesi argues that the scientific image may only gain 'analysability if it can present its relevant features to analysis' which is to say that 'it can only be recognisable if it has been *drawn as* something recognisable: a presentation of a particular kind of object, or an object with particular features'.[54] Thus, 'purposeful visual construal' of an object 'brings the practices of drawing and of seeing ever closer together'.[55] But whereas Galileo drew the moon using his own vision and a pencil on paper, '*drawing as*' for Vertesi means reconstructing images and image data: here, '"drawing" can mean to pull or guide, to reveal or conceal, to work with and around material objects, to produce new configurations of space or movement'.[56] Revealing new ways of seeing the same image in order to achieve scientific goals, Vertesi proposes *drawing as* not as a philosophical concept but as a practical one.[57] In the *Martian Triptych* these different ways of seeing the same image are made explicit. Through the process of repetition, of reworking images and disrupting a relationship between the camera's vision (represented in the 'raw' image) and the 'natural' and 'white-balanced' iterations, Mount Sharp is 'drawn' as something perceivable for both a viewer seeing this scene on Mars, and then under an Earthly light. Scientists attempt to gain clarity by performing image manipulation in order to see and reveal different things; the disruption to the order of the single image – as exemplified so explicitly in the *Martian Triptych* – further highlights the notion of the glitch-as-method.

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[51] Verdi, x.

[52] Ibid., 18.

[53] Vertesi, "'Seeing Like a Rover,'" 106.

[54] Vertesi, "*Drawing as,*" 18. Vertesi exemplifies this through Galileo's use of chiaroscuro in drawing his image of the moon; the craters and mountainous features were only distinguishable as such because of the skill of Galileo's hand, whose representational techniques conformed to those already in existence. Ibid., 21.

[55] Ibid., 18.

[56] Ibid., 20.

[57] Ibid., 25.

The images inevitably stray from what our eyes might see (this is part of the glitch) but they do so in a scientifically beneficial way (as a method of revealing). Vertesi uses the term *drawing* to suggest that image manipulation has not just been prevalent in the digital age, but that it has had broader applications across history, sociology, philosophy and scientific practice.[58] The central question of her thesis is how practical image craft constructs 'meaningful, workable relationships with an alien planet' by '*drawing* it *as*' something, not to create a true singular image, but to pragmatically work with images in order to 'shut down' ways of seeing and focus on one aspect of the landscape in question.[59]

The coloured filters upon the *Martian Triptych* are like language, drawing out specific aspects of the landscape for the viewer's perception. The scientists and engineers working with such images must know what to look for, and how to 'see'. *Seeing as* and therefore *drawing as* require a certain amount of imagination in order to function. Wittgenstein uses the example of a simple line drawing of a triangle to exemplify this:

> This triangle
>
> 
>
> can be seen as a triangular hole, as a solid, as a geometrical drawing, as standing on its base, as hanging from its apex; as a mountain, as a wedge, as an arrow or pointer, as an overturned object which is meant to stand on the shorter side of the right angle, as a half parallelogram, and as various other things. You can think now of *this* now of *this* as you look at it, can regard it now as *this* now as *this,* and then you will see it now *this* way, now *this.*[60]

Similarly, referring to the illustration of a cube, Wittgenstein writes that it could be perceived as a 'glass cube', an 'inverted box', a 'wire box' or 'three boards forming a solid angle'. Our interpretation of what the cube stands to represent relies heavily upon the text that is supplied alongside it. The flexibility to be able to '*see* the illustration now as one thing now as another' means that we '*see* it as we *interpret* it'.[61] Wittgenstein continues:

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[58] Vertesi, "'Seeing Like a Rover,'" 106.

[59] Ibid., 132. Maurice Merleau-Ponty's thinking may be used to expand upon this point of scientists wanting (and needing) to see different things in the same image:

> If a friend and I are standing before a landscape, and if I attempt to show my friend something which I see and which he does not yet see, we cannot account for the situation by saying that I see something in my own world and that I attempt, by sending verbal messages, to give rise to an analogous perception in the world of my friend. There are not two numerically distinct worlds plus a mediating language which alone would bring us together. There is – and I know it very well if I become impatient with him – a kind of demand that what I see be seen by him also.

Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 17.

[60] Wittgenstein, *Philosophical Investigations,* 200.

[61] Ibid., 193-94.

> It is possible to take the duck-rabbit simply for the picture of a rabbit […] but not to take the bare triangular figure for the picture of an object that has fallen over. To see this aspect of the triangle demands *imagination.* [62]

Being able to see different features in the Martian terrain requires a different level of imagination; one that is trained upon the act of revealing. The scientist or visual imager must know *how* to reveal information invisible in the raw data image, but they must also have an awareness of what *might* be present in order to enable decisions about processes of working with the images.

Having what Professor of Philosophy C.L. Hardin claims is a multiple 'awareness of contrary attributes' is what occurs in the *Martian Triptych*.[63] Vertesi writes on a false colour image and an approximate true colour image (with adjusted contrast) of Cape Verde as captured by the *Opportunity* rover (figs. 5.9 & 5.10), stating that in the 'two renderings of the same photographic frame we witness a switch between the artefact and the object of analysis'. Whereas the false colour image shows 'composition and texture at the expense of lighting' the true colour image 'reveals stratigraphy at the expense of compositional information'; these images 'represent different ways of seeing and knowing the Martian surface'.[64] Rupturing the relationship between vision and image reveals the use of the glitch as a method to 'see' into the invisible.

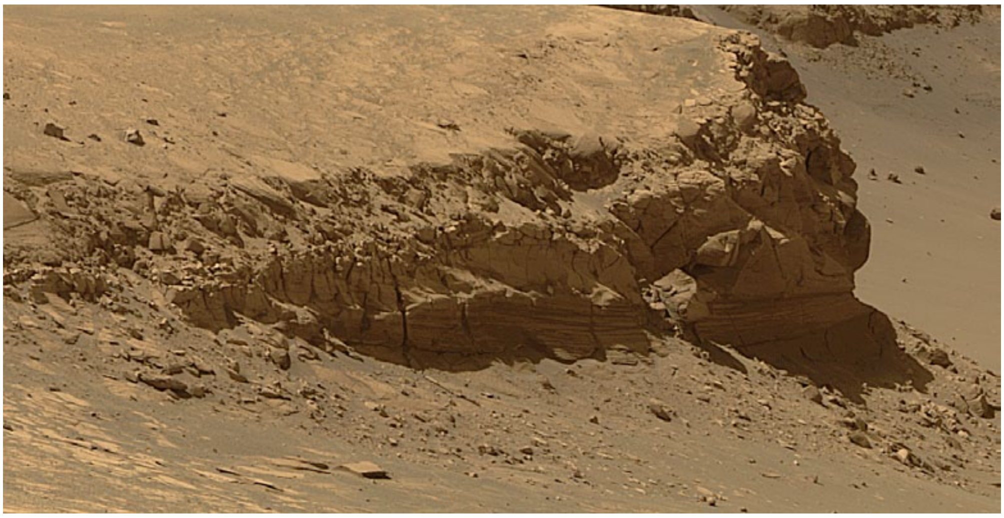
Figure 5.9. *Layers of 'Cape Verde' in 'Victoria Crater' (Enhanced).* This image has been enhanced to bring out details in the shadowed regions. The mosaic was captured by *Opportunity* on 28 September 2006 (sol 952) using the camera's 750-nanometer, 530-nanometer and 430-nanometer filters. Photojournal image addition date: 6 October 2006. Credit: NASA/JPL/Cornell.

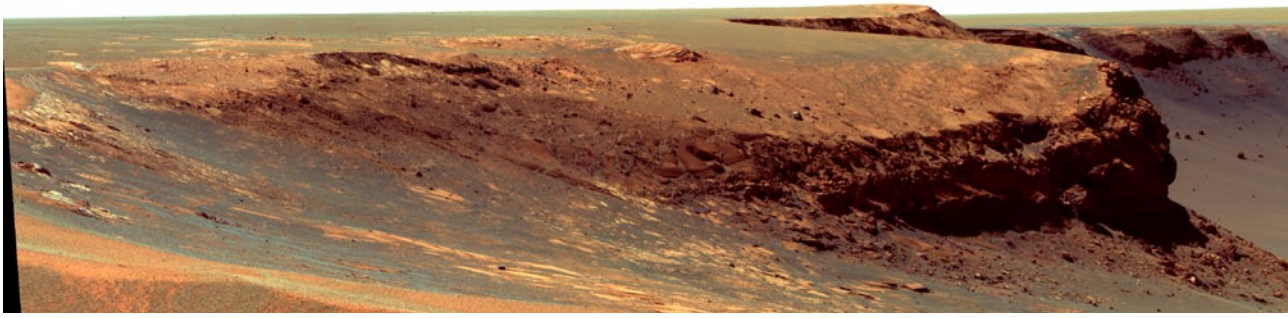
Figure 5.10. *Layers of 'Cape Verde' in 'Victoria Crater' (False Colour).* This is an enhanced false colour rendering of the image shown in figure 5.9. Photojournal image addition date: 6 October 2006. Credit: NASA/JPL/Cornell.

[62] Ibid., 207.

[63] C.L. Hardin, *Colour for Philosophers: Unweaving the Rainbow* (Indianapolis: Hackett Publishing Company, 1988), 107.

[64] Vertesi, "*Drawing as*," 23.





Walter Benjamin discussed the notion of using the camera as a technical apparatus to reveal truths about the unseen. In *The Work of Art in the Age of its Technological Reproducibility,* he claims that it is through the 'optical unconscious' that features perceptually unobtainable by our eyes alone can be revealed:

> It is another nature which speaks to the camera as compared to the eye. "Other" above all in the sense that a space informed by human consciousness gives way to a space informed by the unconscious. Whereas it is commonplace that, for example, we have some idea what is involved in the act of walking (if only in general terms), we have no idea at all what happens during the split second when a person actually takes a step […] This is where the camera comes into play, with all its resources for swooping and rising, disrupting and isolating, stretching and compressing a sequence, enlarging or reducing an object. It is through the camera that we first discover the optical unconscious, just as we discover the instinctual unconscious through psychoanalysis.[65]

Through the act of photography, movement is stilled, becoming static and far from our perception of movement. When Eadweard Muybridge presented his instantaneous photographs of a galloping horse in 1872, there was much controversy as to whether these

[65] Walter Benjamin, *The Work of Art in the Age of its Technological Reproducibility, and Other Writings on Media,* ed. Michael W. Jennings, Brigid Doherty and Thomas Y. Levin, trans. Edmund Jephcott, Rodney Livingstone and Howard Eiland (Cambridge, MA: The Belknap Press of Harvard University, 2008), 37.

pictures were 'real'. They were inauthentic images of how the human eye perceives: the 'camera saw too much'.[66] It is in a similar vein that scientists use representational practices to 'see' beyond appearances in scientific images. Benjamin compares the painter to the magician, and the photographer to a surgeon:

> the magician maintains a natural distance between himself and the person treated […] The surgeon does exactly the reverse: he greatly diminishes the distance from the patient by penetrating the patient's body […] The painter maintains in his work a natural distance from reality, whereas the cinematographer penetrates deeply into its tissue.[67]

The camera and the tools used to manipulate *Curiosity's* images are like those of Benjamin's surgeon, they may penetrate more deeply into reality. As with Muybridge's studies on motion, the technical apparatus on *Curiosity, Spirit* and *Opportunity* see more than the eye. In this way, the Martian terrain can be seen as and for a number of things; as a cliff face or mountain, as composed of different soils, or for its atmospheric make-up. We can also see it as a picture or as numbers.

Using the glitch as a method scientists become professional lookers; immersion lies in the subjective manipulation of images to reveal the invisible. What we have here is not the exteriority of the spectator in Guy Debord's sense (of 'self-dispossession') but of Jacques Rancière's emancipation from spectatorship.[68] For Debord, truth lay in 'non-separation', and he summed up the disorder of the spectator as: 'the more he contemplates, the less he lives'.[69] Rancière defines emancipation as 'the blurring of the boundary between those who act and those who look; between individuals and members of a collective body'.[70] Perhaps in the case of the *Martian Triptych* it is scientist and viewer who, both emancipated, act through the process of looking. The viewer of the *Martian Triptych* must actively engage with the changing status of the image – becoming Rancière's *emancipated spectator* – in order to glean greater truth from an image that depicts a referent that is at its very core separate, distant, existing only within appearance. Looking, manipulation and engagement is restricted to the surface of the image.

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[66] Aaran Scharf, "Painting, Photography, and the Image of Movement," *The Burlington Magazine* 104, no. 710 (May 1962): 186, accessed 20 October 2013, http://www.jstor.org/stable/pdfplus/873665.pdf.

[67] Benjamin, 35.

[68] Jacques Rancière, *The Emancipated Spectator,* trans. Gregory Elliott (London: Verso, 2011), 6-7.

[69] Guy Debord, *Society of the Spectacle* (Detroit: Black and Red, 1983), 23.

[70] Rancière, 19.

Figure 5.11. Screenshot of *Pleasantville,* directed by Gary Ross, 1998.

Colour Upon the Surface of the Visible

In *Chromophobia,* David Batchelor emphasises the havoc colour often wreaks on ordered worlds. In Garry Ross' 1998 film *Pleasantville,* as in Edwin E. Abbott's novel *Flatland,* 'colour makes an unexpected appearance in an otherwise grey universe', it erupts via acts of mischief, disrupting the norm and commencing the 'fall into colour'.[71] In *Pleasantville,* high school students David and his sister Jennifer are transported into the black and white 1950's television sitcom, *Pleasantville*. Gradually the pair disrupt the lives of the programme's characters and bursts of emotion (a concept unknown to the characters before the siblings' arrival) are visually represented by the transformation from black and white into colour. The mother in *Pleasantville* 'falls' into colour when awakened to sexual pleasure; afraid of her monochrome husband her son applies grey make-up to her face and hands but this reversal to black and white is only a temporary solution.

Can the *Martian Triptych* not portray this same fall into colour? To 'fall' implies a sudden movement from a higher level to a lower level, which often results in the falling object hitting the ground. To 'fall' also implies to fail, to 'fall from grace' is an example. In her essay "In Free Fall: A Thought Experiment on Vertical Perspective" Hito Steyerl discusses the

[71] Batchelor, *Chromophobia,* 67, 68. Batchelor gives further examples of films that 'use non-colour' to indicate 'a kind of endless sameness': *The Wizard of Oz* (1939); Michael Powell and Emeric Pressburger's *A Matter of Life and Death* (1946); Sergei Eisenstein's *Ivan the Terrible, Part 2,* (1958); Samuel Fuller's *Shock Corridor* (1963); and Wim Wender's *Wings of Desire* (1987). Batchelor, *The Luminous and the Grey,* 70.

'spatial and temporal orientation' taking place in visual representation over the years.[72] From linear perspective that favoured the horizon line to satellite technologies that look down upon the Earth, perspective now is one of an imaginary floating observer and an imaginary stable ground, 'a new visual normality – a new subjectivity safely folded into surveillance technology and screen-based distractions'.[73]

> Falling means ruin and demise as well as love and abandon, passion and surrender, decline and catastrophe. Falling is corruption as well as liberation, a condition that turns people into things and vice versa […] But falling does not mean a new certainty falling into place. Grappling with crumbling futures that propel us backwards onto an agonising present, we may realise that the place we are falling toward is no longer grounded, nor is it stable. It promises no community, but a shifting formation.[74]

As our eyes traverse the *Martian Triptych* the representation of landscape 'falls' to Earth: first we see the landscape as the camera perceived it, then how we might perceive it through our own eyes on Mars and lastly as if the landscape had literally been brought to Earth and viewed within our atmosphere. This fall also speaks to temptation and desire, to see the landscape in the only way we know how. For Batchelor, colour can bring about a 'shattering of unity'.[75] In the *Martian Triptych* this comes about through the imposition of colour: the three images become increasingly contaminated by applying something that from the outset is not supposed to be there. In sweeping away the dust layer that unifies the 'natural' landscape, definition is heightened in the 'white-balanced' version of Mount Sharp, making features easier to 'see'. Yet the tiers of landscape in this image appear to refer to separate worlds. The band of orange dirt appears unnaturally placed in the 'white-balanced' image; it belongs to the previous iteration. The failure of the triptych to present the image of Mars in a unified, single image is what generates the fall. The fall is one into an ungrounded and unstable image.

Unlike colour in *Pleasantville* which comes from *within* the characters and the objects themselves, the colour applied to the view of Mount Sharp actually has greater likeness to the grey makeup, it is *cosmetic.* Batchelor writes:

> The cosmetic is essentially visible, essentially superficial and thinner than the skin on which it is applied. Cosmetics adorn, embellish, supplement. If colour is cosmetic, it is added to the surface of things, and probably at the last moment. It does not have a place *within* things; it is an afterthought; it can be rubbed off.[76]

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[72] Hito Steyerl, "In Free Fall: A Thought Experiment on Vertical Perspective," *E-Flux* 24 (April 2011): n.p, accessed 1 September 2016, http://www.e-flux.com/journal/24/67860/in-free-fall-a-thought-experiment-on-vertical-perspective/.

[73] Ibid.

[74] Ibid.

[75] Batchelor, *Chromophobia,* 82.

[76] Ibid., 51-52.

Imposing a filter atop of the image of Mount Sharp is a fleeting attempt to grasp at order, yet this filtered colour of the *Martian Triptych* may indeed be digitally rubbed off, reverted to the unprocessed colour image; it is not within raw image data, it is merely a thin superficial layer, pressed up against the surface of the visible in an attempt to bring order to the unknown. For Roland Barthes colour is 'a coating applied *later on* to the original truth of the black and white photograph […] an artifice, a cosmetic', it is an imposition *after* the event.[77]

If colour were applied only to the surface of the visible then the visitor to this virtual image space would have a similar experience to the visitor of Maurice Benayoun's *World Skin.* As I discussed in Chapter 3, the visitors of *World Skin* were actively encouraged to participate in the destruction of image space through taking photographs of the virtual environment. Using a camera to capture views of the scene erased the photographed portion of the image from the overall space. Photography was used as a 'weapon of erasure', negating the image it cast an eerie shadow according to the visitors' perspective at the moment of capture and as the virtual space shifted revealing more of the landscape, visitors were able to see which points had been left untouched by the camera's gaze.[78] The camera removed only the surface of the visible, just as colour-balancing the image of Mount Sharp only alters the surface of the image. The landscape in its (albeit impalpable) reality remains unchanged. As discussed in Chapter 1, the photograph acts as a framing mechanism, presenting a fragment of a scene which was perceivable for the viewer at the moment of capture: Barthes' 'that-has-been'. The idea that our perspective of Mars is very much framed by the technology through which we see is exemplified dramatically in the RSVP terrain model of Chapter 4. RSVP gives solid form to that which remains invisible; the perceivable terrain is stretched across the model in black and white whilst the unknown features are represented by the Martian brown flat colour. This model makes it easy to identify what can be seen by the rover, and what remains out of vision's reach at that given moment. Both Benayoun's *World Skin* and RSVP's terrain model highlight art historian Benjamin Buchloh's claim that: 'photography appropriates only the visual aspects of surfaces that are apparent at the moment the photo is taken'.[79]

In *World Skin* the erased fragments maintain a presence of departure, but this departure is only skin deep, a pixel-thin layer. The speculative writing at the beginning of

[77] Roland Barthes, *Camera Lucida: Reflections on Photography,* trans. Richard Howard (1981; repr., London: Vintage, 2000), 81.

[78] Maurice Benayoun, "World Skin: A Photo Safari in the Land of War," Maurice Benayoun, 1998, accessed 20 August 2014, http://www.benayoun.com/projet.php?id=16.

[79] Benjamin Buchloh, "Readymade, Photography, and Painting in the Painting of Gerhard Richter," in *Neo-Avantgarde and Culture Industry, Essays on European and American Art from 1955 to 1975,* by Benjamin Buchloh (Massachusetts: The MIT Press, 2000), 379.

this chapter suggests an imaginative projection into the virtual space of the 'white-balanced' image; how might we experience this virtual landscape if we were to glide through it as if it were a similar space to Benayoun's immersive environment? Instead of being physically enveloped by the flesh of the world, with the body as a locus of perception, how might the Martian landscape emerge in a three-dimensional virtual rendering of the digitally filtered image of Mount Sharp?[80] Travelling into the image the white-balanced layer of what was visible to the MastCam at the moment of capture might remain the same, whilst everything else would flicker back to its original state of raw unprocessed colour.

It is only upon driving the rover further into the landscape that scientists can perceive what lies beyond. Yet viewing the *Martian Triptych,* we see only the surface of the visible. We are not present within the landscape and as such we cannot gain the kind of perceptual knowledge that Maurice Merleau-Ponty speaks of. The unseen sides of Merleau-Ponty's lamp example (as outlined in Chapter 4) are 'not imaginary, but only hidden from view'; they are 'anticipated' surfaces that would be revealed upon movement; they are invisible from vision but present within the viewer's vicinity.[81] Yet the same does not apply to the non-visible parts of Mount Sharp beyond *Curiosity's* field of view. Although we must assume the landscape continues beyond the edges of the picture or behind the band of terrain in the foreground, its presence is non-existent for us. These aspects of the landscape can only be 'anticipated' but the truth held within this anticipation remains unverified. It is only the *seen* side that we grasp as present; the *Martian Triptych* gives us only the surface of the visible. It is through our imagination that we can step into this image, into the flickering interchange of the coloured light upon the surface.

Colour and Light: The Painted Diorama and the White-balanced Image of Mars

In the *Martian Triptych* colour is used to stage illusion. As the images move from left to right we step further into the imaginary. Invented in 1822, Louis-Jacques-Mandé Daguerre's painted diorama used colour – in the form of filtered light – to stage a similar kind of illusion. The diorama consisted of highly illusionistic trompe l'oeil paintings, upon which the interplay of lights on translucent canvas presented windows onto the world that visitors genuinely believed to be real. As with the *Martian Triptych* coloured filters were applied *after* the image's inception to reveal the painted scenery during different lights. Rivalling the

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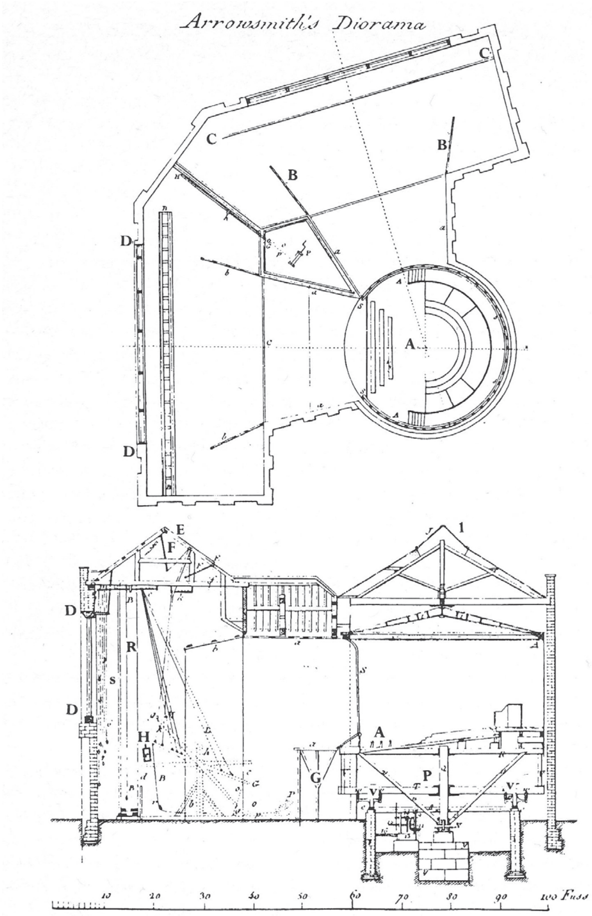
[80] The idea of the body as a locus of perception, enveloped in the flesh of the world is put forth by Merleau-Ponty, *The Primacy of Perception,* 178.

[81] Ibid., 13-14.

panorama in terms of trickery, the painted diorama sat somewhere between an art exhibition and a theatre set, the patent specifying that it would be

> an improved mode of publicly exhibiting pictures or painted scenery […] and of distributing or directing the daylight upon or through them, so as to produce many beautiful effects of light and shade.[82]

Similar to the theatre, the paintings were set back from the auditorium at a distance of about 13 metres and were displayed at the end of a long tunnel which helped to give the paintings depth, whilst also concealing the edges of the canvas.[83] There were usually two paintings per room, which were hung behind curtains that lifted when the show began to reveal carefully controlled lights animating the image spaces. Visitors entered this darkened room and sat or stood on a platform which rotated in order for the second painting to be brought into view when the showing of the first had ended. The canvases were very large (often measuring 27x16 metres), flat or slightly curved, and were painted with translucent and opaque paints on the front and back of an oiled canvas.[84]



Key to Regent's Park Diorama
A Revolving Auditorium
B-B and **C-C** in the plan and **R** in the section represent the dioramic picture
D-D are the rear windows providing light behind the picture
E and **F** are skylights and shutters regulating the illumination from the front of the picture
G and **H** is the system of levers and weights to operate cords at **K, L** and **M** to open and close shutters and **P** a crank to control the system
1 Skylights
s coloured blinds behind picture
v v 18in. wheels (two out of a set of eight) on which the auditorium revolved about its

Figure 5.12. Illustrator unknown, *Regent's Park Diorama*. Image shown in Ralph Hyde, *Panoramania!* (London: Trefoil Publications in association with Barbican Art Gallery, 1988), 110.

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[82] Helmut and Alison Gernsheim, *L. J. M. Daguerre: The History of the Diorama and the Daguerreotype* (London: Secker and Warburg, 1956), 13.
[83] Ibid., 18.
[84] Bernard Comment, *The Panorama*, trans. Anne-Marie Glasheen (London: Reaktion Books, 1999), 57.

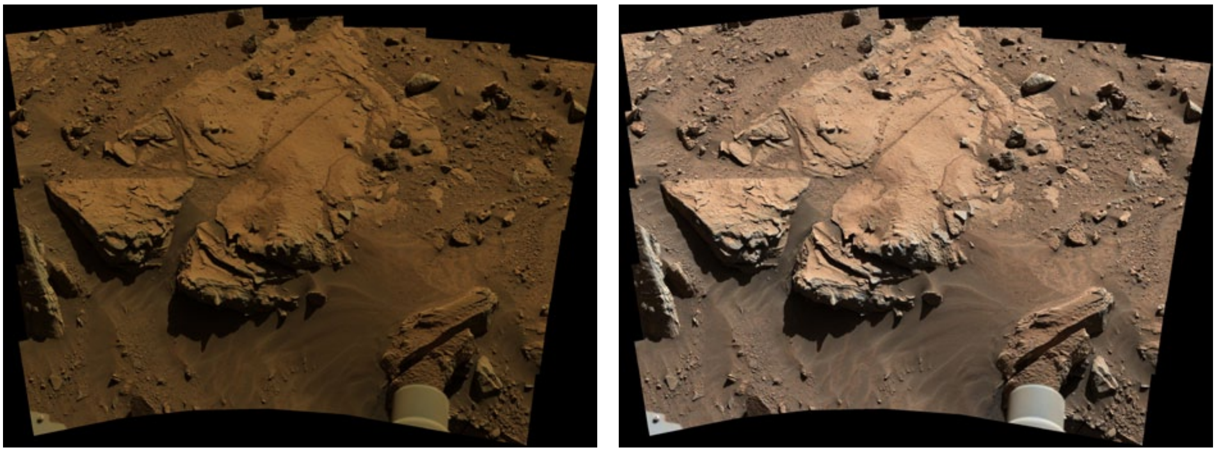

Figure 5.13 a-b. Image of sandstone slab taken by *Curiosity's* Mastcam on 23 April 2014 (sol 609). The image on left is the raw, un-calibrated version, the image on right has been calibrated to show what rocks would look like under Earth-like lighting. Photojournal image addition date: 25 April 2014. Credit: NASA/JPL-Caltech/MSSS.

Because of the scale of these historic illusory spaces, similarities could easily have been drawn between the *Mars Window* panorama at *Visions of the Universe* and the painted diorama. However, my interest here is not the objective of immersing viewers in image space through scale, rather it is the use of projected light upon the flat surface of the image, with an aim of generating the illusion of looking *through* a window upon another world. Colour and light are the means by which the viewer becomes immersed. In the *Martian Triptych,* Mount Sharp is filtered through different colours and lights, rather than the effects being directly integral to the reality of the landscape itself. For Daguerre's diorama, 'gradual changes in light were intended to transform the painting in such a way that the same landscape would be first seen at different times of the day and in different weather conditions'; the light was projected from a skylight through numerous coloured screens which could be controlled through pulleys and counterweights to interchange the lighting effects.[85] The light was projected onto the back of the painting (as I have already stated *dia*: through and *horama:* view) so the painting itself seemed to be the source of light.[86]

The first diorama opened on 11 July 1822 with a painting by Daguerre, *The Valley of Sarnen*, and one by Charles Bouton (with whom Daguerre had developed the diorama), *The Interior of Trinity Chapel, Canterbury Cathedral.* Regarding the interior of *Canterbury Cathedral* one reporter writes;

> The visitors, after passing through a gloomy anteroom, were ushered into a circular chamber, apparently quite dark. One or two small shrouded lamps placed on the floor served to light the way to a few descending steps, and the voice of an invisible guide gave directions to walk

[85] Ibid., 57; Gernsheim, 18.
[86] Timbs, 2.

> forward. The eye soon became sufficiently accustomed to the darkness to distinguish objects around, and to perceive that there were several persons seated on the benches opposite an open space, resembling a large window […] Few could be persuaded that what they saw was a mere painting on a flat surface […] This impression was strengthened by perceiving the light and shadows change, as if clouds were passing over the sun, the rays of which occasionally shone through the painted windows, casting coloured shadows on the floor.[87]

A reporter at *The Times* gives their impression of *The Valley of Sarnen*:

> The most striking effect is the change of light. From a calm, soft, delicious, serene day in summer, the horizon gradually changes, becoming more and more overcast, until a darkness, not the effect of night, but evidently of approaching storm – a murky, tempestuous blackness – discolours every object, making us listen almost for the thunder which is to growl in the distance, or fancy we feel the large drops, the avant-couriers of the shower […] The whole thing is nature itself.[88]

Unlike the panorama, the diorama could represent different times of day, reflecting nature through its changing moods and weather. Few people believed that they were being deceived, and considered themselves to be gazing through windows onto scenery beyond. 19th century American novelist and poet Herman Melville writes on the diorama that 'light was a complex interweaving of faith and fantasy, an indissoluble mixture of illumination and illusion'.[89]

Light was projected through the back of the canvas to create a luminous surface of an apparently interchanging image of landscape. Drawing on Ludwig Wittgenstein's writing on colour and luminosity, David Batchelor writes on the distinction between luminous and surface colour:

> At its simplest a luminous colour is one usually seen through a transparent medium – such as stained glass or coloured plastic – with a light source behind it. A surface colour is produced largely by light reflecting off the surface of a material.[90]

But, as he continues, this distinction quickly becomes confused:

> There are for example cases in which what I see is both a surface colour and a luminous colour, such as when a material has a transparent glaze on its surface. In this instance light is reflected both off the surface of the material and through the glaze directly above that surface.[91]

For Daguerre's invention then we might have witnessed a combination of luminous and surface colour; the painting's surface colour did not alter, but the colour produced by passing light through filters did. The *Martian Triptych* is customarily viewed through a screen: without the backlight of the display the image would fall away into blackness. When viewed in this capacity the *Martian Triptych* – as with all screen images – is a luminously coloured image. Altering the colours of the landscape-as-image imposes a second kind of luminous filter upon

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[87] Gernsheim, 15-16.
[88] Ibid.
[89] Herman Melville quoted in Batchelor, *Chromophobia,* 53.
[90] Batchelor, *The Luminous and the Grey,* 50.
[91] Ibid.

the surface of the visible which can be seen as Batchelor's 'transparent glaze'. Directly above the (albeit immaterial) surface of the image it transforms an already luminous terrain into a shimmering illusion. As our eyes scan the repeated view of Mount Sharp we witness a flickering between 'raw', 'natural' and 'white-balanced'. This oscillation between different versions of the same image highlights the temporal nature of colour balancing in image manipulation. As such, the *Martian Triptych* acts as a reminder of the 'fragility of artificial light', the pixels and points making up this digital representation of an intangible and distant landscape.[92] Here colour flickers; it is temporal and ethereal.

The perceptual shift occurring through scanning the three images is comparable to the change of aspect between the duck and rabbit in Wittgenstein's example. As we scan from left to right the relationship the image has with reality becomes tenuous and we discern the immaterial nature of digital images. As with the flip between seeing either paint on canvas or a window onto a landscape the level of distance and perceptual engagement with the *Martian Triptych* directly affects our understanding of the image make-up. As white seeps into the third image, details are revealed, bringing the landscape closer to Earth.

In the appendix of *Confronting Images* (2005) titled "The Detail and the *Pan*" philosopher and art historian Georges Didi-Huberman discusses the proximity of the viewer as having a direct correlation to how a pictorial illusion holds together. On moving in to view a painting to discern some finer detail (he uses the work of Titian as an example) illusion breaks down in a violent act of 'getting closer'; the closer one gets to the painting the less awareness one has of the overall picture.[93] Likewise, with the *Martian Triptych,* honing in upon the 'white-balanced' image is an attempt to gain 'a more precise form', but as Didi-Huberman continues, 'the close-up gaze manages only to undo matter and form, and, doing this, despite itself, it condemns itself to a veritable tyranny of the material' producing 'nothing more here than interference, obstacle, "contaminated space"'.[94] The close-up gaze is merely a 'desire' which results in the exit of a 'clear and distinct object of representation'.[95] Proximity occurs in the *Martian Triptych* through the imposition of colour which enables the viewer to see things that were at first glance invisible. Although we do not get physically closer to the landscape, the landscape as represented in the image is drawn nearer to an Earthly approximation, if only at the level of vision.

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[92] Ibid., 52-3.

[93] Georges Didi-Huberman, *Confronting Images: Questioning the Ends of a Certain History of Art,* trans. John Goodman (University Park, PA: The Pennsylvania State University Press, 2005), 230.

[94] Ibid., 236

[95] Ibid.

The representation of Mount Sharp is not strictly given a 'new' colour; instead it is stripped of its Martian hues through the 'white-balancing' process. For Ludwig Wittgenstein in *Remarks on Colour,* white may not exist as a 'transparent colour': 'We don't say of something which looks transparent that it looks white.'[96] White, he argues, can only be blended into colours, making them 'cloudy' by removing the '*colouredness*'.[97] But white is not 'blended' with the Martian colours in the 'white-balanced' version of Mount Sharp, rather the atmospheric dust of Mars is erased, making way for whiteness which here signifies an absence. 'Is cloudy that which conceals forms', Wittgenstein asks, and 'conceals forms because it obliterates light and shadow?'[98] 'Isn't white that which does away with darkness?'[99] Removing the 'colouredness' of the view of Mount Sharp, the *Martian Triptych* makes way for different levels of visibility, revealing what is clouded by the atmospheric dusts. This could be compared to early Kodak film stocks that privileged lighter skin tones, reflecting a similar mode of adjustment to a certain kind of idealised (and biased) normal.[100] Of course the *Martian Triptych* is not a racially biased image, but it could be viewed as Earth-biased, in that it privileges a human standpoint. The correlation here is between Kodak film's inability to represent non-whiteness and our inability to perceive the landscape accurately under anything but Earth-light. The question of both is that the subject represented is not necessarily invisible, we just don't know how to see it. White-balancing in the *Martian Triptych* is also a form of Earth-balancing.

Light is vital to our perception of colour, yet at the same time our expectations of the colour of different things is largely coded by memory and experience. Surface colours are perceived as properties of objects because of the phenomenon of colour constancy, as Merleau-Ponty explains:

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[96] Wittgenstein's text speaks very much to painting and the painter's colour palette. Ludwig Wittgenstein, *Remarks on Colour,* ed. Linda L. McAlister and Margarette Schättle, trans. Gertrude E. M. Anscombe (Oxford: Blackwell, 1977), 36e.

[97] Ibid., 15e.

[98] Ibid.,

[99] Ibid.

[100] Early colour Kodak film photography tended to have a bias towards 'whiteness', contradicting the presumption that film photography was impartial. 'Shirley' cards were used as industry standard colour reference cards between the 1940s and 1970s and the accuracy of colour balance in photographs was based on skin tones of white women and colourful surroundings. Lighter coloured skin tones photographed very well, but photographs of darker skin tones, especially in images that depicted both light and dark, showed subjects with little or no visible facial features due to differences in required exposure levels. It wasn't until the 1990s when Kodak developed a new film (Kodak Gold Max) that film photography was able to capture different skin tones. Michael Zhang, "Here's a Look at How Colour Film was Originally Biased Toward White People," PetaPixel, 19 September 2015, accessed 30 July 2016, http://petapixel.com/2015/09/19/heres-a-look-at-how-color-film-was-originally-biased-toward-white-people/.

> The table is, and remains brown throughout the varied play of natural or artificial lighting. Now what, to begin with, is this real colour, and how have we access to it? We shall be tempted to reply that it is the colour which I most often see as belonging to the table, the one which it assumes in daylight, a short distance away, under 'normal' conditions, which means those which occur most frequently. When the distance is too great or when the light has a colour of its own, as at sunset or under electric lighting, I substitute for the actual colour a remembered one, which predominates because it is imprinted within me by numerous experiences. In this case the constancy of colour is a real constancy.[101]

For Merleau-Ponty then, 'the real colour persists beneath appearances', which allows us to essentially see the object as continuously the same colour.[102] Colour becomes subtly interchangeable in the *Martian Triptych,* altered by the filter that is placed upon the surface of the image. On the other side of the camera's lens however, the Martian landscape in its physical, albeit impalpable reality, remains unchanged.

We have no first-hand experience of this landscape lying beyond the filtered image, no innate knowledge about the colour properties of the rocks, the sky, or the sand. Upon looking at a black and white image of a landscape, we understand that the bark of the tree is 'brown' and the grass is 'green': what particular shade of brown or green depends of course on the specific object under examination and the lighting conditions. But we can nevertheless relate to such an image, using our sense of embodied perception as a guide to understanding surface colour that is not represented in the veil of black and white. Our perception of the colour of Mars, however, is totally dictated by images, and images that – as is explicitly made aware in the *Martian Triptych* – are manipulable and interchangeable. Such was the debate in 1976 when NASA's *Viking 1* lander became the first spacecraft to view Mars from the planet's surface. The first pictures sent back showed a blue sky, which Carl Sagan quickly announced was due to the filters on *Viking's* camera not being calibrated correctly.[103]

The viewer of the *Martian Triptych* looks through predisposed filters upon the image of a landscape; our experience of Mount Sharp is dictated by the visual imager at NASA much in the same way that the spectator of the painted diorama looked upon an illusion commanded by Daguerre and the person behind the scenes controlling the coloured filters.

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[101] Maurice Merleau-Ponty, *The Phenomenology of Perception,* trans. Colin Smith (London: Routledge & Kegan Paul, 1962), 304.

[102] Ibid., 305.

[103] Alan Boyle, "Colour Controversies Started with Mars, Not with #TheDress," *NBC News*, 28 February 2015, accessed 5 March 2015, http://www.nbcnews.com/science/space/color-controversies-started-mars-not-thedress-n314601. In February 2015 a similar controversy took place in the news and on social media when a single image of a dress sparked a huge online debate about the garment's true colours. Whilst more than 50% of people surveyed saw gold and white, the other half (who were in fact correct) saw black and blue. Adam Rogers, "The Science of Why No One Agrees on the Colour of this Dress," *Wired,* 26 February 2015, accessed 5 March 2015, http://www.wired.com/2015/02/science-one-agrees-color-dress/.

The viewer of the painted panorama was mobile, whereas the diorama, as Jonathan Crary observes, was 'based on the incorporation of an *immobile* observer into a mechanical apparatus and a subjection to a predesigned temporal unfolding of optical experience'. This, Crary writes, 'removed the autonomy from the observer' in which he/she 'was a component' in a 'machine of wheels in motion'.[104] Scientists adjusting the colour balance and applying filters to such images – although perhaps physically immobile – become components within the changing status of the scientific image, as 'professional lookers'. We look upon the *Martian Triptych* as a static observer in front of our computer screen and bear witness to the flickering interchange between 'raw', 'natural' and 'white-balanced'.

In 1834, Daguerre developed the double-effect diorama, a technique that created the illusion of a scene during the day and then during the night. For this, the first effect was painted on the front side of a transparent canvas, the second effect was painted on the other side by shining light through the canvas so that the artist could preserve and paint over the transparent parts of the first effect with grey opaque paints. Lit through coloured screens, Daguerre achieved what he termed 'the decomposition of form'; when green and red parts of the painted image were illuminated by red light, red objects would disappear whilst green ones would appear black and vice versa.[105] This enabled features not visible in the first effect to emerge in the second and perhaps this holds the most striking similarity with the *Martian Triptych* as features unperceivable in 'Mars light' can all of a sudden be made visible through 'Earth-light'. John Verdi might call this 'disambiguation', a term often used by philosophers in relation to the duck-rabbit drawing:

> When I look at the duck-rabbit against a background of ducks, I see it only as a duck. It likely will not even enter my mind that it could be seen as something else. The context of ducks hides its rabbit aspect and prevents me from seeing it […] The context seems to lock the duck-rabbit into one aspect or the other, transforming it from an ambiguous figure into an ordinary one. In the words of psychologists, the background "disambiguates" the duck-rabbit. It forces the picture to become one thing or another to my eyes and keeps it from alternating between its two forms. Something seems to be gained in the clarity that the background provides, a stability in appearance lacking when the duck-rabbit is seen out of context.[106]

White-balancing then 'disambiguates' the Martian landscape; placing the landscape within a background and lighting we can (virtually) comprehend. This disambiguation remains effective providing we view the white-balanced image alone; seeing it alongside the 'raw' and 'natural' image iterations however highlights the variety of ways in which we see and

[104] Jonathan Crary, *Techniques of the Observer* (Cambridge, MA: The MIT Press, 1990), 112-13.
[105] Gernsheim, 32.
[106] Verdi, 109.

experience this alien planet. Ambiguity – a question of the 'right' way to see Mars – lies at the heart of the *Martian Triptych.*

Such '*seeing as*' examples as the *Martian Triptych* 'are not "found" but crafted experiences' in which 'pixel pushing' constitutes a vision, a skilled interpretation of data reflecting the interests of particular scientists.[107] Scientists use digital manipulation to see what they want to see, and the images are not, in the words of E.H. Gombrich, 'faithful record[s] of a visual experience but the faithful construction of relational model[s]'.[108] In the 'white-balanced' reconstruction of Mount Sharp the atmospheric qualities of Mars have been removed from the scene; familiarising the landscape in this way is designed to lure out scientific information to assist scientists in making discoveries about the terrain. Mars is seen only through its image and any neutral depiction we might hope of gleaning evaporates as re-presentation takes over.

In the *Martian Triptych* the dust is swept away, the glitch-as-method making the landscape intelligible but not tangible. Although the purpose of the *Martian Triptych* is to understand the landscape, using the glitch as a method is what estranges it. Through its fall into 'white-balance' the landscape is alienated from its origins and instead of being immersed in the landscape of Mars, we must navigate a flickering interchange in which our perception of the real landscape is fractured by a desire to bring the unknown into an Earthly grasp.

David Batchelor writes:

> If surface veils depth, if appearances masks essence, then make-up masks a mask, veils a veil, disguises a disguise. It is not simply a deception; it is a double deception. It is a surface on a surface, and thus even farther from substance than 'true' appearance.[109]

The filtered light comes from one direction, it screens the image, veiling the flat landscape with a translucent film painted only onto the surface of the visible: the *Martian Triptych* is not three versions of the same *landscape* but three versions of the same *image*. Clutching at order, this fall into the superficial fractures the relationship between vision and representation.

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[107] Vertesi uses the term 'pixel pushing' to describe the digital manipulation of images. Vertesi, "'Seeing Like a Rover,'" 102.

[108] Ernst H. Gombrich, "Standards of Truth: The Arrested Image and the Moving Eye," in *The Language of Images*, 4th ed., ed. William J.T Mitchell (Chicago: University of Chicago Press, 1980), 182.

[109] Batchelor, *Chromophobia,* 54.

Chapter 6

Staging and Re-staging Mars: The Mars Yard

Figures 6.1 a-b. Photographs of the Mars Yard being used to test the European Space Agency's *ExoMars* rover's autonomous navigation system. Photographs taken on 27 August 2014 by author, courtesy of Airbus Defence and Space.

As re-presentations of unknown worlds, *Curiosity's* images of Mars hold strong ties to romantic notions of exploration inherent in early travel photography, 19th century painted panoramas, and Daguerre's painted diorama. These different forms of images attempt to reconstruct for the viewer the experience of looking upon exotic scenery and newly discovered lands, bringing the unknown into a graspable realm. Prevalent in all the image forms I have examined thus far is the underlying notion of staging an illusion; the Martian panorama stages a 360º all-encompassing experience; in the 3D image a staged illusion appears as our brains fuse together the stereoscopic pair of images; the white-balanced image of Mount Sharp stages the impossibility of experiencing Mars in a familiar light. In all cases the image of Mars is reconstructed in a more immersive manner yet in each the image remains trapped behind some kind of screen, inherently two-dimensional. This chapter explores the reconstructed image of Mars in three-dimensional, physical form: the 'Mars Yard'.

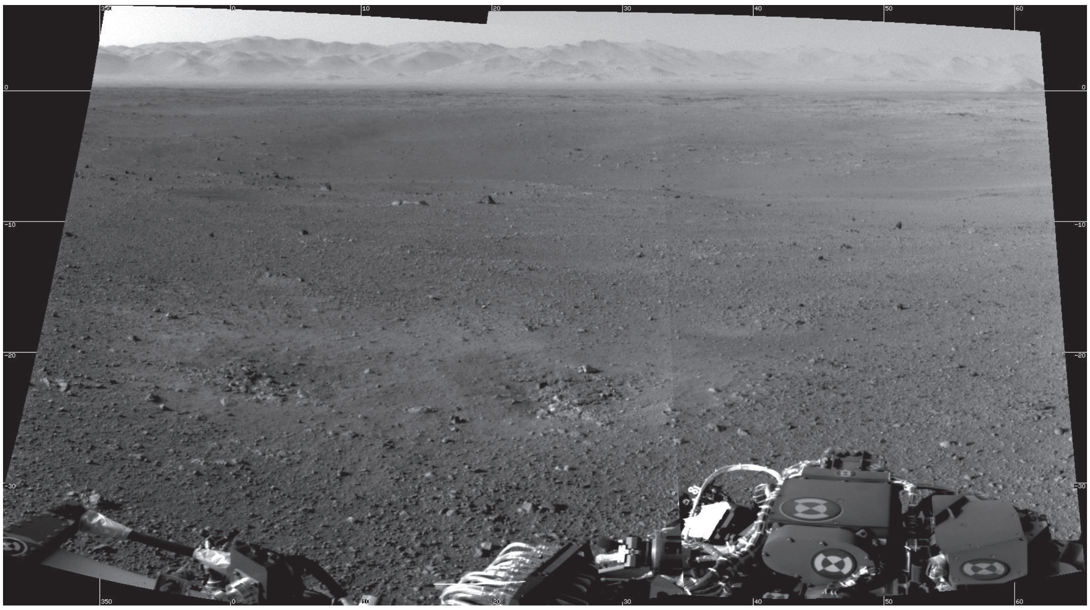

Figure 6.2. *Curiosity's New Home,* 8 August 2012. Credit: NASA/JPL-Caltech.

I began this thesis with a composite of the first two full resolution images the *Curiosity* rover captured with its Navigation Cameras. *Curiosity's New Home* seems to embody many of the attributes this thesis has explored; we look past a frame through a 'window' onto another world and the inhospitable landscape appears oddly familiar and welcoming due to its representation in black and white. But our view through this window is disturbed by the seam: this is the glitch. The rover maintains its position in the foreground, oddly three-dimensional against the flattened out two-part image of Mount Sharp. As *Curiosity's* images go, this is a relatively simple reconstruction: *Curiosity's New Home* makes no attempt to envelop the viewer in image space. The landscape is clearly demarcated behind a frame; its content has no chance of spilling out into our world, physically or in the imagination, it recedes beyond the black void holding it in place.

I would like to return to *Curiosity's New Home* as a way into an examination of the Mars Yard. At face value the Mars Yard could not be more different from *Curiosity's New Home*: it uses actual physical structures to simulate the Martian terrain, rather than re-presenting it within the confines of a photograph. The Mars Yard then is a different kind of 'image', a reconstruction of an illusory space in real space: a three-dimensional image. But despite these differences, it is in the connections both forms of image have to another historical model that bridges may be found, that of the museum diorama. *Curiosity's New Home* shimmers on the border between two-dimensionality and an illusion of space in the dialogue between the foreground body of the rover and the flatness of background highlighted by the join between the two images. The Mars Yard environment embodies this dialogue between image and rover, but whereas landscape and rover remain intangible in *Curiosity's New Home* (being withheld behind a screen), a staged reconstruction of the image of Mars (in the form of actual sand and rocks) meets a test rover in the Mars Yard. The Mars Yards that belong to NASA and the European Space Agency present a different kind of immersive encounter: instead of immersion being for the disembodied eye, these spaces become immersive testing grounds for the rover to assess engineering capabilities both before a mission launches and during the mission to rehearse problematic manoeuvres.

Fundamental to this chapter is the dialogue between object and image as a means to create an illusory space. Although the use of faux terrain in painted panoramas played a large role in the success of the illusion, objects served as an addition to it as a means to obscure the boundary between viewer and painted space. In the Mars Yard objects have the same, if not more significance than the 2D image, but the objects are also intrinsically *part* of an image which is in itself physical and palpable for the rover and for the human visitor to the space. This is an image whose surface we can reach out and touch.

The first part of this chapter offers an alternative reading of *Curiosity's New Home* in light of the painted diorama's concept of a 'through-view'. Re-examining the black and white image of Mount Sharp within the context of another 'through-view' – this time the museum dioramas which became popular in the late 19th century – I propose that *Curiosity's New Home* might be seen as a black and white photographic representation of a staged illusion. The photographic work of artist Hiroshi Sugimoto will function to support this argument. What makes these museum dioramas interesting in relation to this study of immersion in another land is that they take us beyond the realm of pure image space to include fragments of nature in a synthesis of object and image, similar to that of a Mars Yard.

In the Mars Yard being used to test ESA's upcoming Mars rover (due to launch in 2020), object and image come together to reconstruct a vast simulation of the Martian environment. The second part of this chapter explores the Mars Yard in relation to Jean Baudrillard's definition of simulation and uses Paul Virilio's theories surrounding machine vision to address how the rover sees the Yard in a different manner to the human viewer. Lacking human imagination and recognising only the flatness of the picture plane, the rover sees the image as a glitch.

Revisiting the photographic works of Sugimoto in relation to the work of Debby Lauder, the latter part of this chapter investigates the ability of the photographic lens to create a feeling of proximity; in photographing objects-as-image (Sugimoto) and making photographs into objects (Lauder) a slippage occurs, resulting in a glitch that is more difficult to pin down, seemingly occurring at the very heart of the image. Using Sugimoto's strategy of photographing as an act of getting closer, this chapter concludes with a series of photographs I captured at the Mars Yard.

Whereas in previous chapters I have commenced with a speculative and subjective interpretation of the image, this chapter takes the reverse approach. At the end, photography serves as the speculative act, performing an immersive encounter which translates object and image back into image. The purpose of this is to determine if imposing a photographic frame can re-stage such an overtly constructed and reconstructed space in order for Mars to *appear* more real and present within the image. As the image is – for now at least – the only way of seeing and knowing Mars, it seems appropriate to return to the two-dimensional, not only to prove that Mars remains trapped behind the veil of its own image, but to highlight the vastly important role imaging plays in our understanding, imaginings and virtual encounters with alien terrains.

Figure 6.3. Photographer unknown. *The Whitney Memorial Hall of Pacific Bird Life,* 1939. Image shown in Stephen S. Quinn, *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History* (New York: Abrams, 2006), 19.

Figure 6.4. Alaska Brown Bear diorama. Credit: American Museum of Natural History.

Figure 6.5. Diorama of fighting moose. Credit: American Museum of Natural History.

Figure 6.6. Diorama of American Bison. Credit: Noel Y. C., courtesy of American Museum of Natural History.

Curiosity's New Home as Museum Diorama

In *Curiosity's New Home* the glass screen seems to tilt away from us at its uppermost edge, held in place by a solid black surround. Beyond the screen lies the body of *Curiosity,* framing the bottom half of the image, connecting us with the Martian world, like faux terrain or a prop positioned at the front of a theatre stage. Yet this is not a physical set, nor is it representative of real colour, and it is in both these regards that *Curiosity's New Home* is reminiscent of Hiroshi Sugimoto's black and white photographs of the habitat dioramas at the American Museum of Natural History in New York. The first habitat diorama was created by taxidermist Carl Akeley in 1889 at the Milwaukee Public Museum and Akeley began working at the Museum of Natural History in 1909. Many of the dioramas were executed in the 1920s and 30s and Sugimoto began photographing the displays in 1976, continuing to return to them in his practice. Over four decades Sugimoto has photographed the dioramas four times.

As a more three-dimensional 'through-view' than Daguerre's previously discussed painted dioramas, the habitat dioramas at the Museum are, to quote museum artist and author Stephen Quinn, a 'fusion of art and science', 'windows on nature'.[1] Depicting instances in time at locations specific to the chosen animal, these dioramas were moments of discovery for the viewer at a time before television and internet, just like Daguerre's dioramas were in the age before photography and travel. Quinn goes on to examine that

> the best dioramas duplicate the wonder of an intimate, personal encounter with a "real" creature in its habitat. We come away transformed by the wilderness world we have glimpsed […] Time has stopped. Birds soar in suspended animation. Animals gaze in perpetual fixed attention. Clouds hover motionless in azure blue skies. Behind the glass, all of nature is locked in an instant of time for our close examination and study […] arrested in a moment.[2]

The dioramas consist of a landscaped foreground, faux terrain in the form of vegetation and rocks and a curved painted background which is crucial to the illusion of space, giving the impression that the scene extends back and beyond the museum framework which holds it. All these elements must be seamlessly combined in order to create the most life-like natural habitat possible; it is, as the diorama artist James Perry Wilson observes, 'art to conceal art', the imitation of nature so close that the artist's hand became invisible.[3]

The diorama is a three-dimensional, reconstructed image. Yet the illusion is still one of a stage set, to be viewed from one side, as if replicating a large photograph in three-dimensions; the wooden surround that holds the piece of toughened glass in place may be

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[1] Stephen S. Quinn, *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History* (New York: Abrams, 2006), 6.

[2] Ibid., 8.

[3] James Perry Wilson quoted in Quinn, 12.

likened to the black framing mechanism of *Curiosity's New Home.* To cite Brian O'Doherty's *Inside the White Cube*, it prevents the image from being 'stepped into'.[4] Neither the two-dimensional image taken by *Curiosity*, nor the three-dimensional image of the diorama are perfectly smooth, uninterrupted photographic renditions; one's own reflection on the glass works in a similar manner to the seam in *Curiosity's* image, reminding the viewer of an interface.

In the diorama, two-dimensional image space is stretched forwards by about 1.5 metres to form a physical environment dictated by the taxidermy species on show. The habitat dioramas, the stereoscopic photographs, and *Curiosity's New Home* all share one thing in common: the illusion of space is very real, but the illusion of reality itself is somewhat detached. There is something not quite right about how the constituent parts of the images interlink; the 'suspended animation', the 'motionlessness' is unnerving. Both *Curiosity's New Home* and the museum diorama portray an image, held in a limited space between the background and the foreground, withdrawn behind a screen. Short for the *proscenium arch*, in theatre the proscenium is the frame separating the actors on stage from the audience, 'pro' meaning before and 'scenium' meaning stage. The proscenium acts as a kind of window frame through which the action is played out, designating the space between viewer and image it helps maintain the illusion, often with the use of curtains which are drawn to hide scene changes. The proscenium is a frame through which we understand we can look and be immersed in a combination of object and image. As is the case in theatre, in the museum dioramas and in *Curiosity's New Home,* we always see the frame. There is no way of entering these picture planes; we cannot get *within* the image space or be enveloped by it. The illusion of the diorama and *Curiosity's New Home* is one of a stage set we can only experience virtually and in the imagination. It is this sandwiching of reality in a stage set like illusion that seems to make the unknowable withdraw further from our presence and into the uncanny.[5]

Figure 6.7. The Prehistoric Life Diorama, 2005. Image shown in Stephen S. Quinn, *Windows on Nature: The Great Habitat Dioramas of the American Museum of Natural History* (New York: Abrams, 2006), 71.

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[4] Brian O'Doherty, *Inside the White Cube: The Ideology of the Gallery Space* (Berkeley: The Lapis Press, 1976), 18.

[5] The uncanny, as described by Sigmund Freud in his 1919 essay "The Uncanny" is an instance in which the familiar becomes foreign and frightening, resulting in a simultaneous attraction and repulsion in the viewer: it is 'that class of the terrifying which leads back to something long known to us, once familiar'. 'Uncanny' comes from the German Unheimlich, the opposite of Heimlich 'meaning "familiar", "native", "belonging to home"'. According to Freud the uncanny is often subjective. Sigmund Freud, "The Uncanny," 1919, accessed 17 October 2016, http://web.mit.edu/allanmc/www/freud1.pdf.

Similar to panorama painters who travelled to distant lands gathering sketches for their paintings, the diorama artists travelled to remote destinations in order to collect the animals and evidence of their habitat.[6] Digs revealing fossilised remains of plants and dinosaurs enabled a reconstruction of an ancient forest in the Liaoning Province in China as it would have appeared one hundred and thirty million years ago and this particular diorama (fig. 6.7) is interesting for this study because it represents a 'world we can only imagine'.[7] There is a distance of time as well as a distance of space in the rendering of places unknown and without referent. Many of the dioramas show animals that are slowly becoming, if not already, extinct; whereas panoramas represented new lands, places of the future, these habitat dioramas seem to reflect the opposite. In reinventing a lost land, the Prehistoric Life diorama dredges up the past, making the unknowable imaginable, representing the impossible. It is in this sense that *Curiosity's New Home* seems to have a strong relationship with these dioramas, especially when seen in the context of photographer Sugimoto, whose re-imaging of the dioramas in black and white – in which the museum framework is removed through cropping – is an attempt to bring these places closer to an embodiment of reality. Turning the dioramas into a *picture* renders these fake places as strangely realistic. In the case of the dioramas the frame-as-glitch requires distance and perspective in order for it to be revealed; zooming in upon the diorama and removing its frame creates a level of proximity and intimacy with its subject matter. By making the glitch invisible Sugimoto penetrates the diorama, stepping into it with his camera as a close-up and more tactile form of viewing. Photography is used as an immersive encounter with the diorama-as-image.

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[6] Here we see a blurring of roles between painter, zoologist and palaeontologist, and on a wider scale the blurring of art and science.

[7] Quinn, 22.

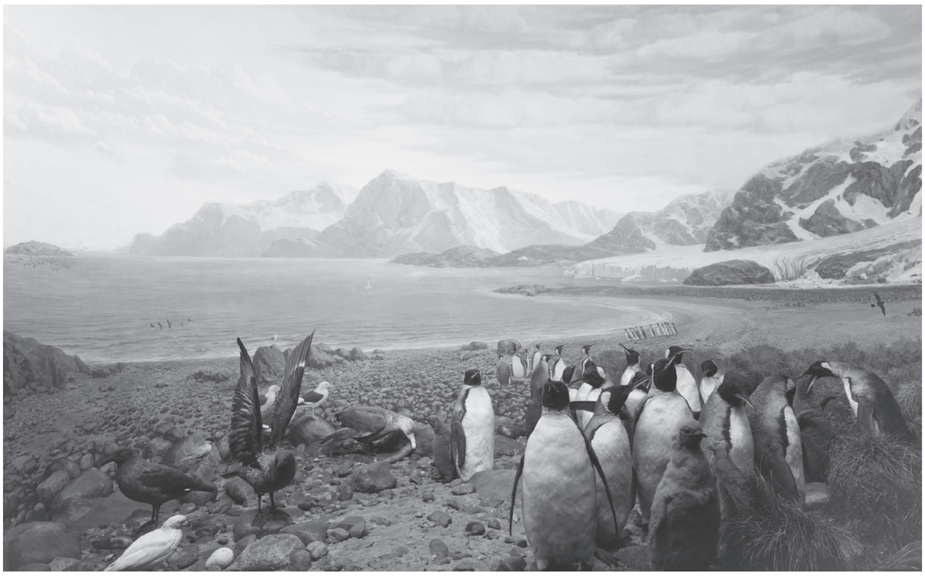


Figure 6.8. Hiroshi Sugimoto, *Birds of South Georgia*, 2012, gelatin silver print, 47 x 73" (119.4 x 185.4 cm). Courtesy of the Artist and Marian Goodman Gallery.
Figure 6.9. Hiroshi Sugimoto, *Wapiti*, 1980, gelatin silver print, 47 x 83" (119.4 x 210.8 cm). Courtesy of the Artist and Marian Goodman Gallery.
Figure 6.10. Hiroshi Sugimoto, *Ostrich – Wart Hog*, 1980, gelatin silver print, 47 x 83" (119.4 x 210.8 cm). Courtesy of the Artist and Marian Goodman Gallery.

Sugimoto's black and white photograph of ostriches could have been taken by one of the diorama artists in the field for use, along with notes and sketches, in reconstructing the scene back in the Museum. The diorama as faked illusion has presence in the here and now, yet Sugimoto's photograph seems somehow to be inextricably linked to an authentic moment in the past, to something that once occurred. Upon visiting the dioramas in his mid-20s in 1974, Sugimoto made the following discovery:

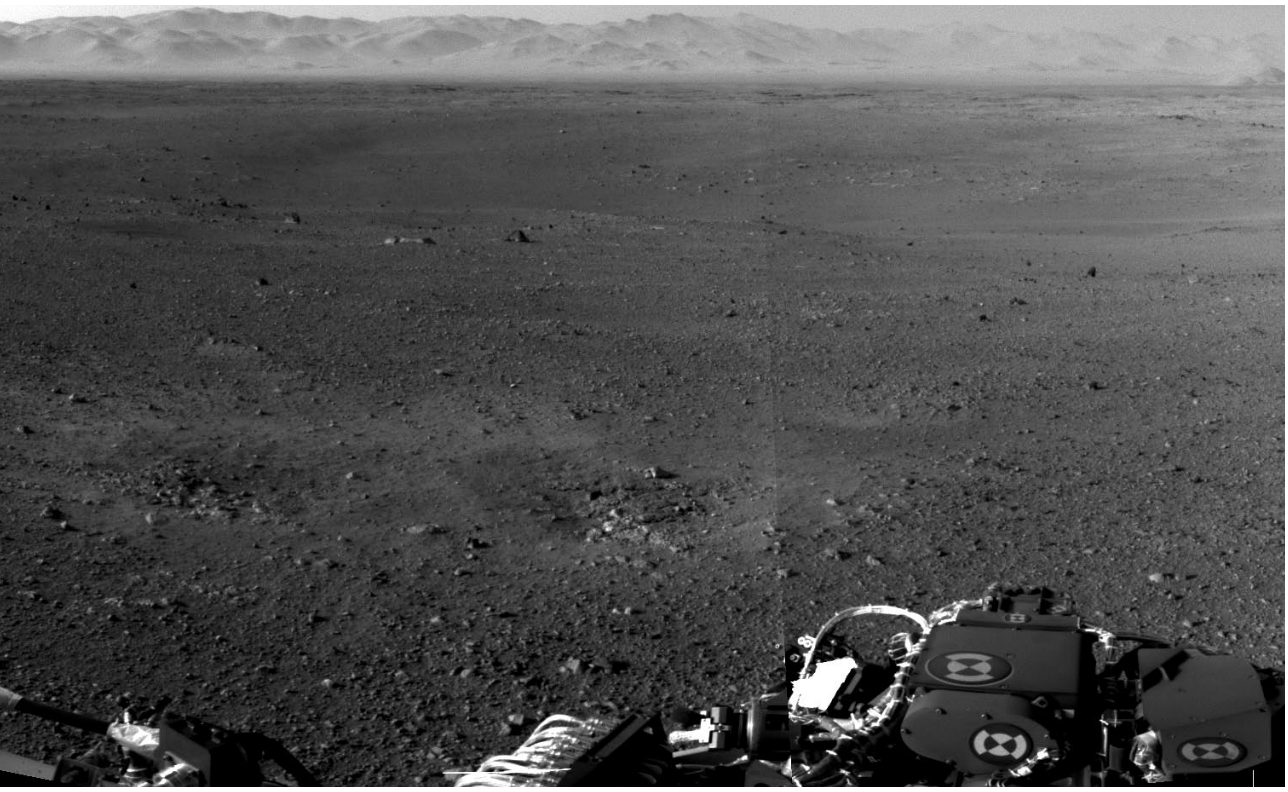
> The stuffed animals positioned before painted backdrops looked utterly fake, yet by taking a quick peek with one eye closed, all perspective vanished, and suddenly they looked very real. I had found a way to see the world as a camera does. However fake the subject, once photographed, it's as good as real.[8]

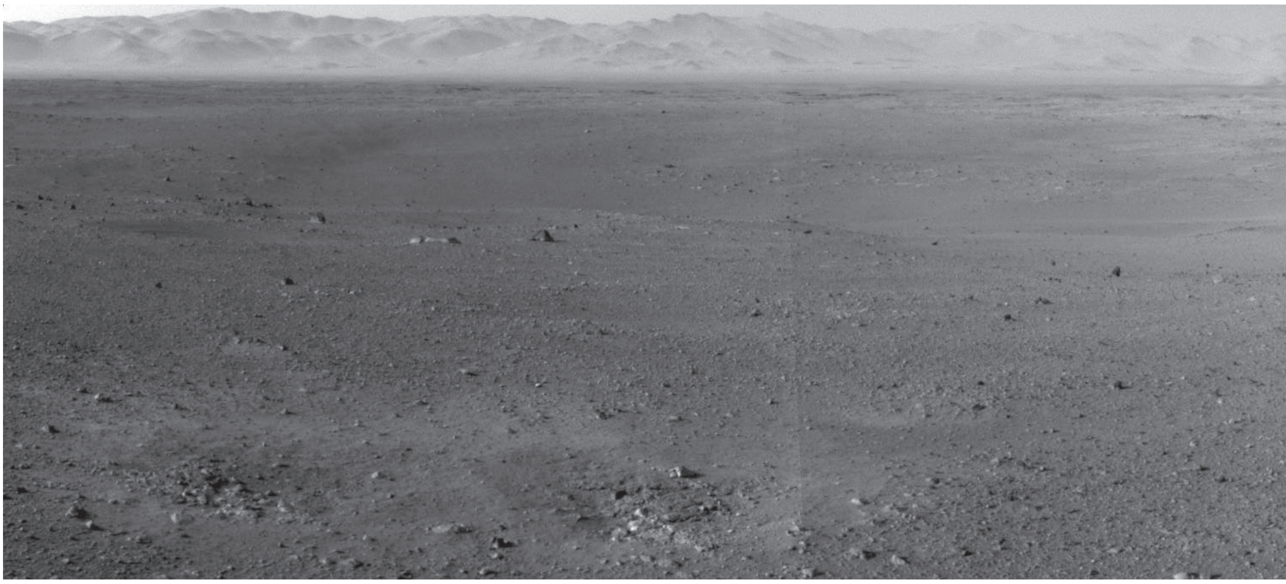
Sugimoto's photographs hold a basis in physical reality insofar as they are reflections of the scene in front of the camera. But the subject they depict is in itself an image. For Sugimoto, the dioramas are so fake that they need the 'one-eyed' vision of photography to regain a level of authenticity; making the scene in front of him *less real* and therefore *less fake* perversely renders it more real. In Sugimoto's photographs the visible museum context of the diorama is removed, thereby the artist collapses the frame and steps into illusion with the camera. Using long exposures and large format photography of the 19th century, Sugimoto 'brings the image close to the real but stops just shy of complete persuasion', undermining truth so that the image 'inhabits a space between the thing depicted and the photograph itself', a space in which the diorama as an image shifts to the fore.[9] As with his long exposures of cinema screens (exposures that last for the entire length of the film) the diorama images represent Sugimoto's 'desire to photograph the idea of photography'.[10] The scene is not real and in this trick of the camera's to make the scene *almost* look real a rupture occurs at the very heart of the image; it is a photograph of something real, but that real is in itself an illusion.[11] The animal dioramas are stage sets, ghosts of reality that hint at something alive and dead at the same time. Animals have been frozen in time and Sugimoto's photographs penetrate their surface, freezing illusion at its very core.

It is arguably the removal of the museum context that allows us to perceive Sugimoto's photographs as representations of the scene itself. It is the framing of *Curiosity's New Home* that draws our attention to the glitch; following the upper limits of the frame we can observe how these two images have been overlaid and we are innately aware of the act of looking. Would the removal of the framing device from *Curiosity's* two-part image render a more

[8] Kerry Brougher and David Elliott, *Hiroshi Sugimoto* (Tokyo: Hatje Cantz, 2006), 45.
[9] Ibid., 22-23.
[10] Ibid., 27.
[11] Ibid., 22.

realistic image (fig. 6.11a)? Arguably the body of the rover stands out in stark relief, as if it were part of another space altogether. Perhaps then if we remove the rover from the foreground the image may appear less like a photograph of a stage set and more like a photograph of the landscape itself (fig. 6.11b). But there is still the presence of the seam. It is only upon cutting the image in two (fig. 6.11c) and presenting one half of it that its appearance as a reconstructed landscape disappears, enabling us to see it for what it is, or for what it isn't; a single black and white photograph that makes an alien landscape seem familiar. It also seems to be through the process of zooming in and a kind of myopia caused through being too close that highlights the importance of proximity; the seeming 'reality' here is in the detail. Is this the ultimate trick? As with Sugimoto's photographs there is something about this blurry grey-scale landscape that is strange and superficially real.





Figures 6.11 a-c. Series of cropped renditions of *Curiosity's New Home.* Original image credit: NASA/JPL-Caltech, edits by the author.

Mars Reconstructed: The Mars Yard

Simulations of the Martian environment here on Earth are used as testing grounds for rover engineering. These spaces are artificially constructed in outdoor yards or indoors in warehouses. The names given to such spaces differ: 'Mars Yards'; 'Roverscapes'; and 'Marscapes'. These simulated terrains exist in the UK, France, Germany and the USA. In addition to these built environments, Mars analogue sites (places on Earth with assumed geological, biological or environmental parallels with Mars) are used in Utah, Arizona, the Arctic, Canada and Hawaii; dry conditions and geological similarities make these terrains suitable testing grounds for long distance driving and scientific experiments. The remainder of this chapter focuses on the 'Mars Yard'; concerned with spaces of illusion and embodiment in an image it is beyond the scope of this thesis to discuss the pre-existing real landscapes of Mars analogue sites. The interest in the 'Mars Yard' lies in the physical reconstruction of a Mars-like environment through the combination of image and object.

Research for this chapter has included visits to three simulated Mars terrains; the 'Roverscape' at NASA Ames in Silicon Valley, California; the 'Mars Yard' at the Jet Propulsion Laboratory in Pasadena, California; and the 'Mars Yard' at Airbus Defence and Space in Stevenage, UK. Both the Roverscape at Ames and the Mars Yard at JPL are outdoor testing spaces; their focus is on driving the test rovers over various terrains. The Mars Yard at Airbus on the other hand is an indoor space that combines a large panoramic 'Mars mural' with simulated Martian terrain and is being used to test the European Space Agency's *ExoMars* rover, due to launch in 2020. It is the combination of image and object at this final example that draws the greatest similarities with immersive illusory spaces and the museum diorama. For this reason, it will be the predominant focus for the remainder of the chapter, but in order to give a flavour for the different types of Mars Yards being used, as well as to show the differences between NASA's Mars environments and ESA's, I will briefly outline the outdoor spaces at Ames and JPL.

Figures 6.12 a-d. Photographs of NASA Ames Research Centre's Roverscape in Moffett Field, CA. Photographs taken on 10 November 2015 by author, courtesy of NASA Ames Research Centre.

NASA Ames 'Roverscape':

As is evident in figures 6.12 a-d, the Roverscape at NASA Ames is a large, outdoor, predominantly flat terrain. This facility is primarily used by the Intelligent Robotics Group (IRG) to test the driving capabilities of their rovers. The rovers being tested in this Roverscape are not necessarily destined for Mars: their current *KRex* rover for instance is being tested for future lunar missions.[12] Maria Bualat, Deputy Lead for IRG explains that the construction of the new Roverscape had to take into account the advancing capabilities of the rovers they are testing. *KRex* can drive over practically any surface and this dictated much of the design of the space.[13] The main section of the space is covered by a pulverised granite and the surrounding areas are made up of native dirt. The large granite rocks in the space are used to test the rover's driving capabilities; *KRex* can drive over objects up to half a metre in size. In addition, there are a number of fake plastic rocks; easily moveable these features provide obstacles for the rover to drive around and are often used as demarcation, to tell visitors and members of the press to stay on one side of the yard.[14] In addition to the rocks, the Roverscape has a large terrain feature mimicking the walls of a crater: because the water table is very high in Silicon Valley, the crater had to be built up rather than down (figs. 6.13 a-b, pg. 270). The square patches of cobbles, small pebbles, flaky granite and sand as seen in figure 6.15 (pg. 270) are not actually driven over; these surface textures are imaged by the rovers' cameras and IRG has worked with other groups at NASA Ames in order to work on the autonomous characterisation of materials.[15]

[12] Maria Bualat (Deputy Lead for the Intelligent Robotics Group, NASA Ames Research Centre, California), interview by author, Moffett Field, CA, 10 November 2015.

[13] One constraint was the proximity of one of Ames's wind tunnels: there are restrictions about what one can build in the path of a wind tunnel that would create turbulence, so nothing of any height could be built in the Roverscape. Ibid.

[14] These rocks can be bought in home improvement stores in the USA as decorative features to hide water pumps etc. Ibid.

[15] Ibid.

Figures 6.13 a-b. Photographs showing the built-up crater in NASA Ames Research Centre's Roverscape. Photographs taken on 10 November 2015 by author, courtesy of NASA Ames Research Centre.

Figure 6.14. Plastic rocks at NASA Ames Research Centre's Roverscape. Photograph taken on 10 November 2015 by author, courtesy of NASA Ames Research Centre.
Figure 6.15. Patches of various materials which are imaged by the rover. Photograph taken on 10 November 2015 by author, courtesy of NASA Ames Research Centre.

Jet Propulsion Laboratory 'Mars Yard':

Figures 6.16 a-d. Mars Yard at the Jet Propulsion Laboratory in Pasadena, CA. Photographs taken on 2 November 2015 by author, courtesy of JPL-Caltech.

Figures 6.17 a-b. The rover is driven over different surfaces. Photographs taken on 2 November 2015 by author, courtesy of JPL-Caltech.

JPL's Mars Yard is a purpose-built testing ground used to test the engineering capabilities for *Curiosity* and NASA's upcoming *Mars 2020*.[16] It has also been used for testing MER. As is evident in the images this Mars Yard has a wide variety of different surfaces and slopes to drive over including soft sand and dirt, and bedrock material such as fractured flat surfaces, small loose rocks and sharp embedded rocks. There are also larger rocks used to test hazard avoidance.[17] Rover driver for *Spirit, Opportunity* and *Curiosity* John R. Wright explains:

> Sand is to test mobility, primarily, so you want the types of sand that the rover is going to be driving in. There are multiple types of sand. You need to have rocks that represent hazards and don't represent hazards, to work out how well it's going to drive over them.[18]

The rocks and terrain are shifted around the Mars Yard to provide different scenarios for the rover.

The Mars Yard at JPL was used for testing during the design and build of the *Curiosity* rover but it is also used when the rover encounters problems on Mars. It is used to test a number of things, from its autonomous hazard avoidance, hill climbing ability and slip performance in different materials to wheel wear characteristics.[19] Faults are replicated in the Mars Yard and the rover's Earth bound replicas are used to carry out drives before they are

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[16] NASA explains that *Mars 2020* will 'investigate a region of Mars where the ancient environment may have been favourable for microbial life, probing the Martian rocks for evidence of past life'. The rover's current launch date is summer 2020. NASA/JPL-Caltech, "Mars 2020," accessed 12 September 2016, http://www.jpl.nasa.gov/missions/mars-2020/.

[17] John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 2 November 2015.

[18] Ibid.

[19] John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), email message to author, 14 October 2016.

implemented by the real *Curiosity* on Mars. Wright explains how the yard was used to figure out how *Curiosity* was getting so many holes in its wheels:

> They had gotten holes in the wheels driving it around here on Earth, but thought it wouldn't be a problem, as gravity on Mars is one third of Earth's. But this wasn't the case. So they were trying to figure out why, so they analysed the ground and figured out that the rocks were sharp, but we could put the whole weight of the rover on the rock and it wouldn't punch a hole in it […] so it turns out that the rocks that we were used to, that *Spirit* and *Opportunity* encountered, were relatively loose, so when you hit them they would kind of roll over. These rocks were embedded, so it was just a sharp point. So what happens is that the front part of the wheel hits it and it starts to roll up, whilst the rest of the wheels are pushing forward, so you end up putting this pressure between the wheel and the rock, so when you finally get to the top, tension is released and this was causing the damage. That's what they were able to figure out in this yard.[20]

There is an exact replica of *Curiosity* (minus the nuclear reactor and radios) which is used to see how it drives and how the arm operates under different conditions. Further to this, there are also 'scarecrow' models (fig. 6.18) which are used to drive up and down the hills and over different terrains. As Wright explains, the scarecrow is 'a mobility mock-up, stripped down so it weighs the same on Earth as the real one does on Mars. It's got the same drive mode, steering and electronics for driving around.'[21]

Figure 6.18. 'Scarecrow' rover, driving component of *Curiosity* used for testing in the Mars Yard. Photograph taken on 2 November 2015 by author, courtesy of JPL-Caltech.

The Mars Yard at JPL aims to replicate the Martian terrain in order to understand a distant land here on Earth from the point of view of the rover. The Yard is built and terrains are reconstructed entirely with the rover in mind. Although the rocks, dirt and embedded materials are arguably images in that they simulate the Martian terrain (the colour is even similar) it is not a space that conjures up any great sense of being on Mars for the human viewer.

[20] Wright, interview.
[21] Ibid.

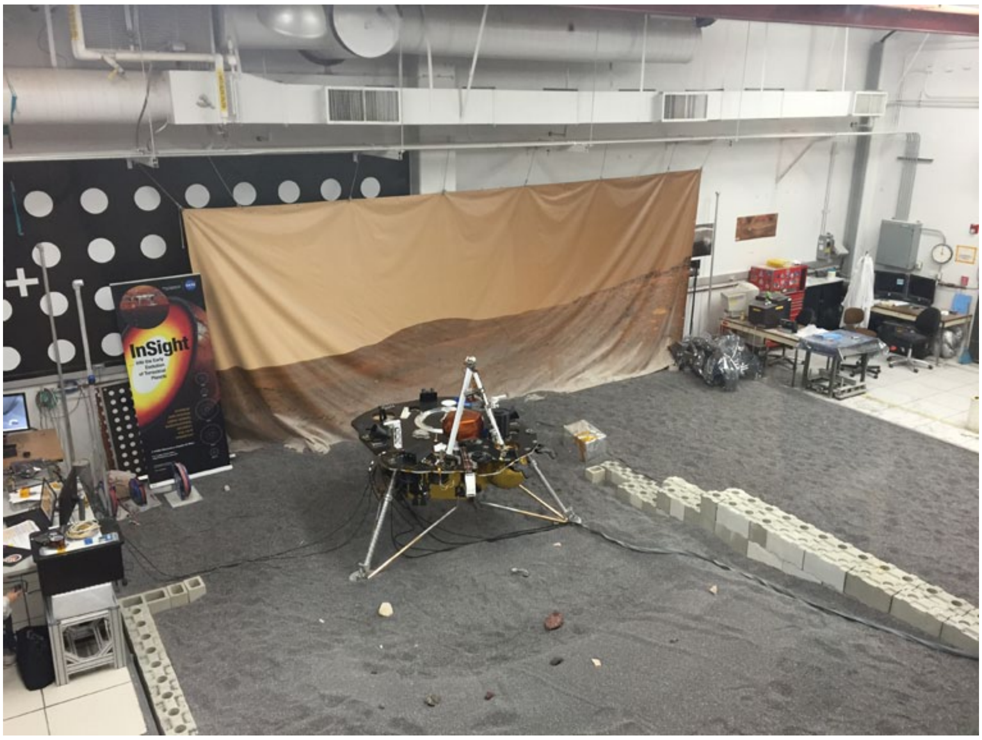

Figure 6.19. Indoor Mars Yard at the Jet Propulsion Laboratory. Photograph taken on 2 November 2015 by author, courtesy of JPL-Caltech.

Whereas longer and more sophisticated drives can be done in the large outdoor yard, JPL also has a small indoor yard predominantly used to test MER and the upcoming *InSight* mission.[22] The indoor yard, as seen in figure 6.19, is protected from the environment. *Opportunity* and *Spirit* (when it was still operational) drove in soft material, so testing inside ensured the rovers were not being driven across grounds that caked up due to moisture.[23] The lighting in the indoor yard is also more controllable and there is a large colour image hung against one wall. It is interesting to consider the purpose of this from a public outreach point of view: although the yard is very much a practical indoor testing ground it is also seen by visitors on the JPL public tour. The inclusion of the backdrop image and the information board about *InSight* just to the left of the picture no doubt caters to means beyond scientific and engineering purposes.

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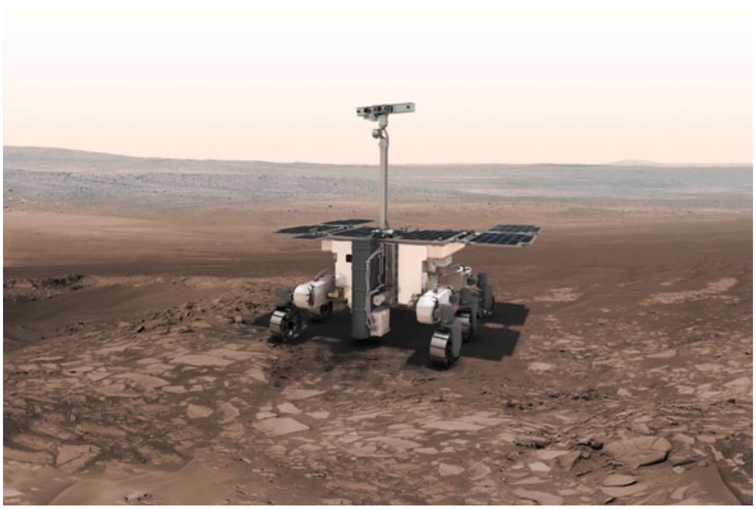
[22] Based on the design of the *Phoenix* lander, NASA's *InSight* mission is due to launch in 2018 and will use geophysical instruments to 'delve deep beneath the surface of Mars, detecting the fingerprints of the processes of terrestrial planet formation'. It will measure ground movements and temperature below the surface to determine how Mars and the other terrestrial planets formed. NASA, "NASA Approves 2018 Launch of Mars InSight Mission," InSight, 2 September 2016, accessed 14 October 2016, http://insight.jpl.nasa.gov/home.cfm.

[23] Wright, interview.

Airbus Defence and Space Mars Yard:



Figures 6.20 a-e. Photographs of the Mars Yard being used to test the European Space Agency's *ExoMars* rover's autonomous navigation system. Photographs taken on 27 August 2014 by author, courtesy of Airbus Defence and Space.

Figure 6.21. Simulation of the European Space Agency's *ExoMars* rover, due to launch in 2020. Credit: ESA.

At the Airbus Defence and Space centre in Stevenage in the UK teams of engineers have built a large 'Mars Yard' for use to test out the European Space Agency's *ExoMars* Rover, due to launch in 2020. The yard is designed specifically to test and perfect the autonomous navigation system ESA will be using to drive their rover across the Martian surface.[24] *ExoMars* will investigate the possibility of life on Mars by testing the planet's atmosphere and by taking samples from the ground. As ground beneath 1.5 metres is protected from the sun's radiation, the rover will use a 2 metre drill with an inbuilt infrared camera to penetrate the Martian surface – specifically between rockier escarpments where loose material has piled up – in the hope of detecting life.[25] *Curiosity* is looking for *signs* of life and habitable environments, *ExoMars* however will have a life-detector on it.

Unlike *Curiosity*, *ExoMars* will not have a nuclear reactor and will be powered purely by solar panels; as such it is only due to last for six months. To ensure that more scientific experiments are done in this limited time, it is essential that the rover gets to and from its targets more quickly than previous missions, and without human intervention.[26] This rover will be able to drive 70 metres a day without continued commands from ground, and the Mars Yard's primary goal is to test out this autonomous navigation system. To quote Alvaro Giménez, ESA's Director of Science and Robotic Exploration, 'a facility like this enables us to develop sophisticated navigation systems to "teach" Mars rovers how to drive autonomously across the Red Planet'.[27] The Yard will also be used after the rover has landed to help overcome problems that may occur throughout the mission's duration.

Principal Systems Engineer for the *ExoMars* Rover Vehicle Project Paul Meacham explains how the autonomous navigation system works: a target is uploaded to the orbiter, which then signals this information to the rover on the ground. As soon as this signal is received, the rover begins to perceive the terrain autonomously.[28] To do this the rover is equipped with two navigation cameras positioned 150mm apart; using data captured by these cameras it is able to construct a stereo view of the landscape. Mission Systems Engineer at Airbus Defence and Space Alastair Wayman elaborates on the process:

> The rover will stop in one position and it will use the stereo cameras to take one set of stereo images looking to the left, one set looking straight ahead, and one set looking to the right. It

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[24] Jeremy Close (Director of UK Communications at Airbus Defence and Space) interview by author, Stevenage, 24 April 2014.

[25] Ibid.

[26] Ibid.

[27] ESA, "Mars Yard Ready for Red Planet Rover," Space Science, last modified 27 March 2014, accessed 28 March 2014. http://www.esa.int/Our_Activities/Space_Science/Mars_yard_ready_for_Red_Planet_rover.

[28] Paul Meacham (Principal Systems Engineer, *ExoMars* Rover Vehicle Project), interview by author, Stevenage, 22 May 2014.

> then combines them into a 3D terrain model, and then based on the heights of rocks, it will assign values to the different pathways on how risky it is to go there. It will make its own decisions on if the rock is too big, or if the slope is too steep. It will try and minimise its cost and find the easiest and safest route forwards. It will only do this in 2 metre chunks.[29]

The further away the terrain gets from the rover, the more the stereo base line of the navigation cameras converge; although the cameras can 'see' up to about 15 metres away, this data cannot be trusted past about 4 metres or so. As the rover moves through and perceives the terrain in more quality, older data from previous images is replaced.[30]

'Simulating the Martian surface, complete with rocky obstacles', writes ESA, the Mars Yard at Airbus 'provides a realistic training ground for developing such a sophisticated navigation system'.[31] The yard is 30x13 metres in size and is filled with 300 tonnes of built-up sand.[32] This sand can be moved around to create different terrains and similarly with the painted panoramas, real and faux rocks estimate the sizes and shapes of those seen on Mars to enhance the sense of reality, for both the rover and human viewer.[33] In addition to the replicated Mars terrain, the main wall and the one adjacent to it are covered with a large panoramic visualisation of the Mars landscape taken by one of the Mars Exploration Rovers and this is where this yard differs to the ones at JPL and NASA Ames. The inclusion of the image at Airbus' Mars Yard invokes a desire to increase the sense of immersion, to reconstruct an impossible landscape here on Earth in a spectacular display. Yet the inclusion of this large image is not solely for aesthetic purposes; Director of UK Communications for Airbus Defence and Space Jeremy Close maintains that the 'Mars mural' gives a 'realistic view for the rover to be tested in'.[34] The Mars mural image was colour calibrated slightly to match the sand in order to maintain some uniformity for the rover's navigation system.[35] In the interest of consistency, and due to the expense of the photographic mural, the surrounding walls and doors of the rest of the space are painted in the 'right pantone shade

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[29] Alastair Wayman (Graduate Mission Systems Engineer at Airbus Defence and Space), interview by author, Stevenage, 27 August 2014.

[30] Meacham, interview.

[31] ESA, "Mars Yard Ready for Red Planet Rover."

[32] Paul Meacham comments on the choice of sand:

> The sand in the Mars Yard is representative in two key ways: firstly, Martian sand is very dry so doesn't clump together, which makes driving over it very difficult. Secondly is the grain size: the sand that's in the Mars Yard is not a 'formal simulant' but is very close and is the one found most commonly on Mars. Mostly the grain size on Mars is reasonably large, similar to that found on beaches, however testing is also carried out on rarer, finer forms of sand.

Meacham, interview.

[33] Wayman, interview.

[34] Close, interview.

[35] Meacham, interview.

of Martian Brown', to 'ensure the rover's navigation cameras are confronted by as realistic a scenario as possible'.[36] Paul Meacham explains:

> The actual landscape that the rover sees on that panorama is not actually that important; as far as the rover is concerned, it doesn't matter if it is all painted one colour or if it is a representation of Mars […] The reason why you would paint a colour or hang a mural is to make sure that there are no large differences in exposure. On one of our old Mars Yards we just had a white wall. The cameras have a rather simplistic way of doing auto exposure; take a picture, check exposure across whole image, adjust it and then take another. So if they have a large white object in the middle of it, the camera gets confused about what the exposure levels should be, mainly because on Mars, you do not get any large changes of exposure like that. In essence, that's what is important for us, it's not important what the image represents, it just allows us to do the transition from the colour and light level of the terrain to the wall.[37]

Furthermore, the lighting in the Mars Yard is equivalent to what it would be during Martian daytime (200 lumens) to guarantee the correct processing of images.

It is not just the combination of objects (the sand and rocks), image and illumination that reconstruct the Martian environment. Mars' gravity is also simulated in the pared-down versions of the test rovers. As the gravity on Mars is approximately 38% of that on Earth, the test rovers in the Yard are powered by cables rather than batteries so that they weigh 30% of the real one, ensuring that they get the same reaction driving over the terrain.[38] Although the test rovers are not direct replicas of the one that will eventually land on Mars, it is through this compensation that the gravity of Mars is simulated.

Simulation and the Image as Glitch

This Mars Yard undoubtedly goes to great lengths to simulate a realistic and immersive training ground for the rover, yet the inclusion of the actual image of Mars (rather than just a wall painted 'Martian Brown') enhances *our* levels of immersion as well. It is in this inclusion of the Mars mural that this reconstruction of Mars draws strong ties to both the painted panoramas discussed in Chapter 3 and the museum dioramas discussed in the first half of this chapter. In between the times when the terrain is shifted to allow for new scenarios and obstacles for the rover, this Mars Yard is a static, frozen reconstruction animated only by the rover at times of testing. But unlike the painted panoramas that attempted to reconstruct a true-to-nature replica of a historical moment or place, the Mars Yard is not a duplication of a specific location. It is a generalised conception of a particular type of environment: a physical, three-dimensional image without a referent. Even the image making up the panoramic mural – the one representation offering some kind of indexical link

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[36] Close, interview; ESA, "Mars Yard Ready for Red Planet Rover."
[37] Meacham, interview.
[38] Close, interview.

to an albeit unseen reality – has been stretched, repeated, copied and pasted to fit the room. It is in this conception of an image without a referent that the Mars Yard can be seen to hold strong ties with Jean Baudrillard's ideas on simulation and the hyperreal.

In *Why Hasn't Everything Already Disappeared* (2009), Baudrillard argues that the construct of a digital image is very different to that of an analogue photograph. An analogue photograph for Roland Barthes contains the world insofar as it is a physical rendition of light upon the surface of a negative: it has an indexical link with reality.[39] It captures reality, but at the same time reality dies there, disappearing forever.[40] The construct of a digital image on the other hand is very different and as Baudrillard claims, 'nothing dies or disappears there. The image is merely a product of an instruction and a programme.'[41] The computer-simulated image, like the Mars Yard, is not indexically linked to reality, but a construction appearing as such. In imaging technologies such as CGI, there is often little or no basis in actual reality and as Baudrillard has claimed, the image is subject to a degree of violence:

> [It] emerges ex-nihilo from numerical calculation and the computer. This puts an end even to the imaging of the image, to its fundamental 'illusion' since, in computer generation, the referent no longer exists and there is no place even for the real to 'take place,' being immediately produced as "Virtual Reality".[42]

Is this what occurs in the Mars Yard? Perhaps of all the case studies I have focused on, the Mars Yard truly is an image without a referent, a pure 'virtual reality' for an equally simulated robotic explorer.

In *Simulations* (1983), Baudrillard outlines that in postmodern culture we have lost contact with the real world because it is always preceded by its simulation. As such, 'simulation is no longer that of a territory, a referential being or substance. It is the generation by models of a real without origin or reality: a hyperreal.'[43] To illustrate his point Baudrillard outlines three 'orders of simulacra'. In the first 'order of appearance' the image is a *'counterfeit'*: as the 'dominant scheme of the "classical" period, from the Renaissance to the industrial revolution' where illusion was seen as imitating the real, but 'never abolished difference', maintaining 'an always detectable alteration between semblance and reality'.[44]

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[39] Roland Barthes, *Camera Lucida: Reflections on Photography,* trans. Richard Howard (1981; repr., London: Vintage, 2000).

[40] This is argued by Christian Metz in *The Imaginary Signifier: Psychoanalysis and the Cinema,* trans. Celia Britton, Annwyl Williams, Ben Brewster and Alfred Guzzetti (Bloomington: Indiana University Press, 1977).

[41] Jean Baudrillard, *Why Hasn't Everything Already Disappeared?* trans. Chris Turner (Calcutta: Seagull Books, 2009), 49.

[42] Ibid.

[43] Jean Baudrillard, *Simulations,* trans. Phil Beitchman, Paul Foss and Paul Patton (Cambridge, MA: Semiotext[e], 1983), 2.

[44] Ibid., 83, 94-95.

In the second order of simulacra Baudrillard refers to Walter Benjamin's *The Work of Art in the Age of its Technological Reproducibility,* to claim that with the industrial revolution and mass production, appearances are not interrogated as 'only the obliteration of the original reference allows for a generalised law of equivalence, that is to say the *very possibility of production*'.[45] In this second order the distinction between the real and its copy becomes blurred. The third order is that of *simulation* and for Baudrillard this is the 'reigning scheme' of the age we now live in, and it is here that we encounter the reproduction with no original: the simulation *precedes* the real.[46] For Baudrillard, this means

> the collapse of reality into hyperrealism, in the minute duplication of the real, preferably on the basis of another reproductive medium – advertising, photo, etc. From medium to medium the real is volatilised; it becomes an allegory of death, but it is reinforced by its very destruction; it becomes the real for the real, fetish of the lost object – no longer object of representation, but ecstasy of denegation, and its own ritual extermination: the hyperreal [...] *the hallucinatory resemblance of the real with itself.*[47]

In the case of Mars, the satellite or rover image (images are instrumental mapping tools) always 'precedes the territory' and in the Mars Yard the artificial terrain precedes the real Martian terrain.[48]

Similarly constructed spaces are used in the military to rehearse strategies and missions before they are carried out in real life.[49] Constructed villages and buildings are used as safe testing grounds in the same way the Mars Yard is used to ensure the rover's safe traversal across different terrains. Both forms of staging are means of becoming familiar with scenarios, procedures and identifying problems before stepping into the unknown. How these rehearsal spaces are used by the military is explored by artists Adam Broomberg and Oliver Chanarin in their series *Chicago* (2006); Geissler/Sann's *Personal Kill* (2005-2008); An-My Lê's *29 Palms* (2003-2004); Claudio Hils' *Red Land, Blue Land* (2000) and Christopher Stewart's *Kill House* (2005). These works are detailed and accompanied by essays in Christopher Stewart and Esther Teichmann's book *Staging Disorder* (2015). As Stewart and Teichmann examine:

> The portrayal by the artists of mock domestic rooms, aircraft, houses, streets and whole fake towns designed as military and civilian architectural simulations, in preparation for real and imagined future conflicts in different parts of the globe, provoke a series of questions concerning the nature of truth as it manifests itself in current photographic practice. In capturing an already

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[45] Ibid., 94, 97, 98.
[46] Ibid., 83.
[47] Ibid., 141-42.
[48] Baudrillard draws on the Borges tale in which 'the cartographers of the Empire' drew 'a map so detailed' that it covered the territory exactly. Ibid., 1.
[49] It is interesting to note the connection between military and space industries; JPL was initially funded by the military when it was founded in 1958 and the exploration of space in the mid 20th century was partly driven by military motivations.

> constructed reality […] the works offer a mediation on the premeditated nature of modern conflict and an analysis of a unique form of architecture where form is predicated on fear rather than function.[50]

These spaces are simulations, images without referents that construct possible future scenarios. The photographs then are a result of imaging an image and the air of strangeness comes about by the lack of motion, the sense that something has occurred, or is about to occur, but only ever as an image of a not yet 'that-has-been'. As Broomberg and Chanarin write on their works: 'Everything that happened, happened here first, in rehearsal.'[51] In his essay "Photography as Rehearsal / Rehearsal as Photography", David Campany states that 'preparation or rehearsal is a kind of experience at one remove, in which behaviour is converted to an image of itself.'[52] As the soldiers in the staged military sites become actors, so too does the rover become a performer, a simulation of its future version re-enacting the procedures on Mars. As physical images without a direct referent, these spaces are, to cite Alexandra Strata in her essay "Rehearsals", 'a negation of place' which are 'equally a negation of time'. Strata continues:

> The temporality of simulation sites is one of perpetual simultaneity, a non-time where the actual and the possible are interchangeable, on an indefinite holiday from history. Stranger than stage sets, which only pretend, these sites substitute, stuck on a permanent loop of disaster-rehearsal.[53]

These places are images that exist as images of themselves in the same way the Mars Yard is an image: both physical and constructed these are images that are tangible in themselves but that get us no closer to the real warzone or actual Martian terrain. The image is one of Christopher Stewart's 'anticipatory fantasy' for which there will always be an element of unpredictability and the unknown when these rehearsed actions are carried out later in 'real life'.[54] As such, the image remains disconnected from reality; in the Mars Yard we enter the image, but reaching out and touching the sand or the flat surface of the Mars mural does not get us closer to a sense of being there on Mars. We cannot know what the real Mars truly looks and feels like; the Mars Yard then does not reproduce a reality distinguishable from its representation, instead it is a space born from the image (of our *preconceptions* of what Mars looks and feels like), a staging and restaging as the terrain gets shifted for different scenarios. But for the test rover who will never go to Mars the image is the reality. The skeletal test

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[50] Christopher Stewart and Esther Teichmann, *Staging Disorder* (London: Black Dog Publishing, 2015), 6.

[51] Broomberg and Chanarin quoted in ibid., 6.

[52] David Campany, "Photography as Rehearsal / Rehearsal as Photography" in Stewart and Teichmann, 17.

[53] Alexandra Stara, "Rehearsals" in Stewart and Teichmann, 15-16.

[54] Campany, 20.

rover and the physical construction of Mars are both images of themselves, and as Baudrillard states: 'it is dangerous to unmask images, since they dissimulate the fact that there is nothing behind them'.[55]

It seems appropriate then that when the rover points its stereo cameras at the Mars mural it sees neither a landscape nor an image of landscape. As Paul Meacham explains: 'The rover doesn't see into it, it sees it as an obstacle, it sees it as a flat surface.'[56] In *The Vision Machine* (1994) Paul Virilio writes about a future of machines 'not only capable of recognising the contours of shapes, but also of completely interpreting the visual field' of '*sightless vision* whereby the video camera would be controlled by a computer'.[57] Virilio's 'vision machine' is very much alive in advanced robotics today and is certainly evident in the 'seeing' capabilities of ESA's *ExoMars* rover.[58] For Virilio foreseeing technological advances in 1994, 'the computer would be responsible for the machine's – rather than the televiewer's – capacity to analyse the ambient environment and automatically interpret the meaning of events' in an '*automation of perception*'.[59] The *ExoMars* rover is designed – to appropriate Virilio's words – to delegate 'the analysis of objective reality to a machine'.[60] Virilio comments on the types of imagery these machines might create, designating them as virtual images or 'optical imagery with no apparent base, no permanency beyond that of mental or instrumental visual memory'.[61] As Baudrillard writes on virtual reality as images without substance, Virilio's thinking might be applied to the reconstructed staged image that is the Mars Yard: this space can be defined as a virtual reality because it is an image without a referent and not a moment indexically linked to a concrete reality. The Mars Yard is 'immediately produced as virtual reality'.[62]

Furthermore, Virilio comments on the '*industrialisation of vision'* in relation to the '*splitting of viewpoint,* the sharing of perception of the environment between the animate (the living subject) and the inanimate (the object, the seeing machine)'.[63] Might this 'splitting of viewpoint' be seen in the individual perceptions of the rover and the human engineer at the Mars Yard? The engineer creates the '*expert system*' programming the rover how to 'see' and

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[55] Baudrillard, *Simulations,* 9.
[56] Meacham, interview.
[57] Paul Virilio, *The Vision Machine*, trans. Julie Rose (Bloomington: Indiana University Press, 1994), 59.
[58] Such research is being carried out at NASA Ames' Intelligent Robotics Group and Imperial College's Robotic Vision Group.
[59] Virilio, 59.
[60] Ibid.
[61] Ibid.
[62] Baudrillard, *Why Hasn't Everything Already Disappeared?* 45.
[63] Virilio, 59-60.

understand obstacles, yet our visual perception of the environment is different to how the rover images it.[64] Having the ability to safely traverse the space, the rover gains its own autonomy. Virilio writes:

> Once we are definitely removed from the realm of direct or indirect observation of synthetic images created *by the machine for the machine,* instrumental virtual images will be for us the equivalent of what a foreigner's mental pictures already represent: an enigma.[65]

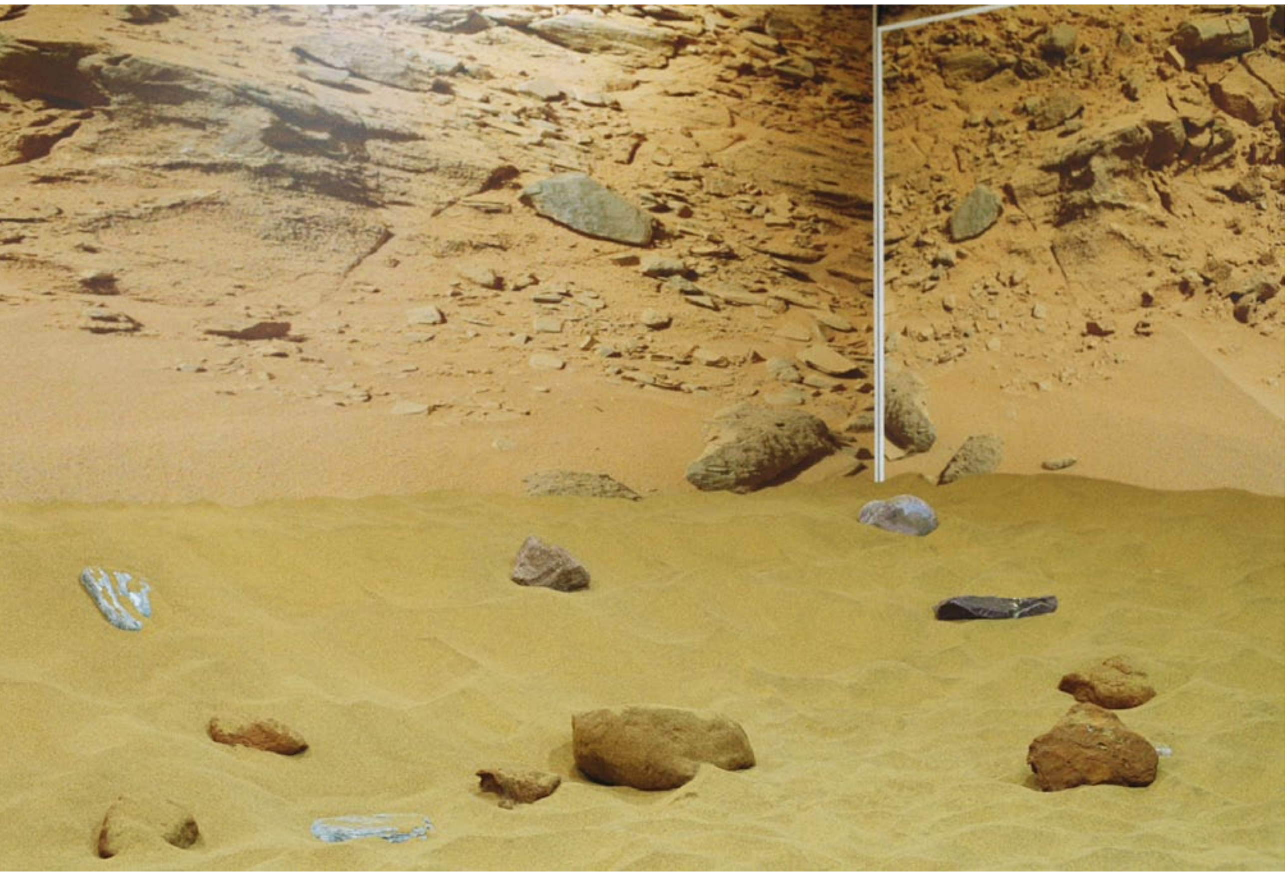
We cannot see as the rover sees and this visual divide is highlighted in the rover's ability (or inability) to see the mural of Mars as a space that can be inhabited imaginatively. Unlike *our* ability to grasp the overall Mars Yard space with a level of imagination (and subjectivity – we want to 'step' into and onto the image of Mars) the rover sees the environment objectively, as a terrain to be traversed and a series of obstacles to avoid. For the rover then the image becomes a kind of glitch; it sees the image for what it is in its material form. Disruptions in the space of the image are perceived 'as they physically are, as flat surfaces, as corners'.[66] As Meacham explains:

> How the rover will interpret [the mural] is that it will see it as an obstacle, because it's programmed to percept the terrain and analyse it to figure out where the rocks are, and to produce a 3D picture and position the rover in it. If the rock is too big or the slope is too steep, it will not go anywhere near it. It sees the wall as essentially a giant rock, as a discontinuity. We are teaching it to recognise what a rock looks like – we teach it to look for differences in elevation of about 10cm and it sees the wall as a giant elevation change. The rover therefore marks it as an obstacle.[67]

In this sense, the rover's perception of the space is perhaps truer than a human's; the rover sees the space for what it is, whereas we have the ability to project our imagination onto it and see it as a landscape. Interestingly here it is the machine that reveals the artifice of the illusion.

Figures 6.22 a-f. Highlighting the 'glitches' at the Mars Yard. Photographs taken on 27 August 2014 by author, courtesy of Airbus Defence and Space.

[64] Virilio argues for 'seeing machines' as having 'expert systems'. Ibid., 60.
[65] Ibid.
[66] Meacham, interview.
[67] Ibid.



Object into Image: Proximity through the Lens

In *The Eyes of the Skin* (2012) architect Juhani Pallassmaa writes:

> The gradually growing hegemony of the eye seems to be parallel with the development of the Western ego-consciousness and the gradually increasing separation of the self and the world; vision separates us from the world whereas the other senses unite us with it.[68]

Whereas the rover does not need the panoramic mural (it could make do with a brown wall), the combination of object and image in the Mars Yard confirms the anthropocentric need for such immersive spaces. It is our need to both see and touch an image of Mars that allows for us to imaginatively – and in this case physically – step into its image. But this seeing and touching does not necessarily account for an immersive experience; Alastair Wayman speaks on the fabrication of the Mars Yard and how we as human viewers experience the glitches that inevitably serve to break the illusion:

> Creating a space of immersion is hard to do right, because it is so powerful, any little thing, any small glitch, you pick up on it, because your brain thinks "that's not real". Whereas if you see it on a TV, your mind can kind of smooth over the framing device, but if you are looking at it in a really immersive way, it's much harder, and you notice those glitches.[69]

In a theatrical production our eyes focus on the action being played out behind the proscenium. In the museum diorama we can move in closer to the glass screen and eliminate the surrounding frame through our own proximity to the diorama-as-image. Sugimoto goes one step further in smoothing over the framing device of the dioramas in his cropping and composition. The glitches are removed to present a fabricated image as an image appearing to have real life referents. The (diorama) image as the real thing is thus removed in Sugimoto's series.

The glitches in the Mars Yard are embodied in the frame, which manifests itself in the corners of the walls, the seams between the patched together mural, the breeze blocks painted with the Martian Brown flat colour and the undulation of the loosely hung mural, its folds catching the simulated Martian light.[70] These elements seem to draw out Slavoj Žižek's 'real thing' (see Chapter 2), creating a peculiar dialogue between the imaginary space of the Mars mural and the constructed illusion brought about by the combination of object, image and surrounding warehouse setting. In Ray Bradbury's 1950 short story *The Veldt,* originally published as *The World the Children Made*, the author tells of a nursery space with interactive

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[68] Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses,* 3rd ed. (Chichester: Wiley, 2012), 28.

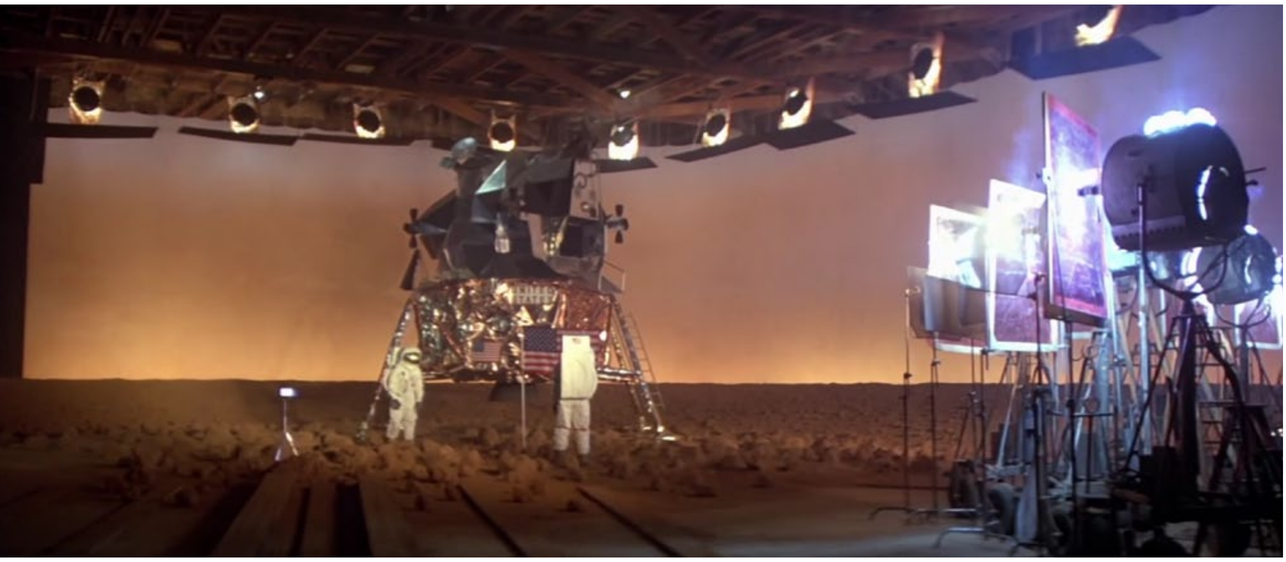
[69] Wayman, interview.

[70] As Sir David Brewster wrote on the painted panorama, the slightest movement or imperfection of illumination was enough to fracture illusion and it was in the same manner that this image was affected. Sir David Brewster, *The Stereoscope: Its History, Theory and Construction* (1856; repr., London: The Fountain Press, 1971), 2.

image walls and ceiling which conjure up the children's desires. The children invent a virtual space of Africa, complete with hungry lions and upon stepping into the room the father becomes disturbed by the reality of the illusion, 'the only flaw' being 'the open door through which he could see his wife, far down the dark hall, like a framed picture, eating her dinner abstractly'.[71] It is in a similar manner that the physical makeup of the environment disrupts illusion in the Mars Yard; the corners of the space, the disparity of the sand to the image and the light casting shadows on the sky, all play their part in producing an awareness of the frame through which we view this image of a reconstructed landscape.

Figure 6.23. Screenshot of *Le Voyage Dans la Lune (A Trip to the Moon),* 1902, directed by Georges Méliès.

Figure 6.24. Screenshot of *Capricorn One,* 1977, directed by Peter Hyams.



[71] Ray Bradbury, *The Veldt*, 1950, accessed 8 March 2014, http://www.veddma.com/veddma/Veldt.htm.

Georges Méliès *Le Voyage Dans la Lune (A Trip to the Moon)* (1902) reconstructed for the viewer one perception of an alien landscape and it was the trick of the camera, in removing everything but the moon landscape, that increased the illusion. Is it possible then to step into the reconstructed image of Mars with a camera? An onscreen reconstructed image of Mars can be seen in Peter Hyams' 1977 film *Capricorn One.* The film details the story of three astronauts headed for Mars; as mechanical failures emerge just before lift-off, NASA removes the men and launches the spacecraft anyway. The astronauts become actors as they are recorded in a film studio landing on Mars: the men are pictured descending the spacecraft on what looks like, and is proffered to be, the planet's terrain. As Sugimoto's photographs expertly crop out any framing devices, NASA's film camera avoids depicting the factory backdrop of the set. The spectators of NASA's film, watching on their televisions at home, are deceived and believe they are seeing real footage of Mars. Cropping the scene in *Capricorn One* produces a more realistic representation of the Martian terrain and as with the painted panorama, framing is paramount in holding the illusion together. It is the frame in *Curiosity's New Home* that draws our attention upwards to the seam, to the realisation that this is a framed view of an invisible and impenetrable alien landscape. As I experimented with earlier in my cropping of *Curiosity's New Home,* it is evident that a removal of the frame renders a more realistic image. It is us as omniscient observers of the film *Capricorn One* who get to see the makings of the image and fake Mars landing: as the (real) film camera zooms out we see the industrial lighting, the edges of the stage scenery and the surrounding warehouse structure come into view. Our momentary immersion in the image of an image of Mars is fractured as we are reminded of the artifice.

As with Sugimoto's diorama photographs, the image (on the television screen for the film's spectators) brushes up against another image (that of the physical construction of Mars) and this junction between the virtual and physical image arguably results in a further glitch. This is expressed by Edward Dimsdale in a short essay titled "Because This Is Not Heaven: Major Implications of Minor Imperfections" in which Dimsdale writes on the term 'glitch' in relation to Debby Lauder's photographic works entitled *The Fold* (2013) and the writing of theorist Simon O'Sullivan. In *The Fold* (figs. 6.24 a-c, pg. 293)*,* Lauder 'resuscitates' photographs of a pair of 16th century marble sea monsters: taking the photographic prints as sculptural material, Lauder refashions the image as an object.[72] Displayed on plinths and encased in glass boxes these are tangible photographic surfaces that

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[72] Edward Dimsdale, "Because This is Not Heaven: Major Implications of Minor Imperfections," in *The Skin of the Image,* ed. Beverly Carruthers, Wiebke Leister and Esther Teichmann (London: University of the Arts, 2015), 14.

we cannot touch. On defining the glitch, Dimsdale calls upon the early use of the term within the US space programme and cites Rosa Menkman to designate the glitch as both a failure and an aesthetic (as I have already outlined in Chapter 2). But Dimsdale also cites the Yiddish definition of '*glitsh,* meaning "slippery area"' which seems to be prevalent in Lauder's photographic works as through the process of translating object to image to object,

> unexpected surfaces emerge, in the seismic shifts experienced by the paper support; fresh contours are galvanised into being; the skins of the images are emphatically, irrevocably, re-sensitised. In each *glitching* operation, the photograph *takes on* the attributes of the sculptural, whilst sculpture *takes up* the photographic as raw material.[73]

As the photographic substrate 'slips' between object and image a glitch occurs.[74] 'Glitching' in this case translates image into object, yet the presence of the image as the primary material irrevocably remains.

Dimsdale draws on Simon O'Sullivan's essay "From Stuttering and Stammering to the Diagram: Deleuze, Bacon and Contemporary Art Practice" to state that this slipping between object and image can become

> a process in which photography is freed from itself, in which a rupturing of representation is provided, and by means of which the photograph is put into contact with forces other than itself.[75]

The glitch as a 'process', 'an event of the new, as potentiality' then can be described as

> any circuit-breaker that experiments with a medium, that seeks to undo conventional assumptions, that transforms standardised practices into novel processes, that are then generative of new formations, with new aesthetic and even new political consequences.[76]

For O'Sullivan, the glitch is 'co-produced through object and subject […] it names a passage between the two'.[77]

> The glitch names two moments or movements. To break a world and to make a world […] The glitch is then a moment of critique, a moment of negation – but also a moment of creation and of affirmation. Indeed, the glitch – in whichever regime it operates and ruptures – is the "sound" of this something else, this something *different* attempting to get through. [78]

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[73] Ibid., 13, 14.

[74] This 'slipping' has ties to the 'flicker' of the image in the *Martian Triptych* between 'raw', 'natural' and 'white-balanced', the glitch happening somewhere in between the translation between each iteration.

[75] Dimsdale, 14.

[76] Ibid.

[77] Simon O'Sullivan, "From Stuttering and Stammering to the Diagram: Deleuze, Bacon and Contemporary Art Practice," *Deleuze Studies* 3, no. 2 (December 2009): 249-50, accessed 12 September 2016, http://dx.doi.org/10.3366/E1750224109000622. 249-50

[78] Ibid., 251.

Figures 6.25 a-c. Debby Lauder, *The Fold,* series of printed photographs on Hahnemühle Photo Rag, glass cases & plinths, case 1: 47cm l x 28cm w x 30cm h; case 2: 40cm l x 24cm w x 30cm h; case 3: 31cm l x 24cm w x 30cm h, 2013. Images courtesy of the artist.

As Debby Lauder's works slip between photograph-as-image and photograph-as-object the glitch occurs not as something seen – a scratch, seam or frame – but as something deeper on the level of understanding what a photograph should and can be. In the operation of 'glitching', image becomes object whilst remaining as image. This slippage can also be felt in Sugimoto's diorama photographs as the diorama as a three-dimensional image becomes a flat screen. But unlike Lauder's works Sugimoto does not 'free photography from itself'; instead it is the diorama-as-image that is freed in it becoming a photograph. Passing from an image that exists as both physical and painted into a photographic rendition, a feeling of proximity is achieved through seeing through a lens. Photography, in its ability to crop and flatten, construct and reconstruct another space, allows its viewers to get closer to the diorama-as-image whilst also innately withholding the diorama's animals just beyond our grasp.

Like Sugimoto's dioramas, the Mars Yard at Airbus Defence and Space calls for another strategy for 'stepping into the image'. In removing the frames of the dioramas Sugimoto's photographs come close to becoming convincing black and white images of animals in their natural habitat. The act of photography arrests these moments of already frozen activity, the boundary between real and painted space only just distinguishable. It is in this act of photography that Sugimoto steps into the diorama image with his camera, using it as a device to transform an illusion into something almost real, almost palpable as the image folds in upon another image. The Mars Yard is an image of Mars that seems to call for this kind of immersive encounter, one that appeals to the flatness and two-dimensionality of the photographic image to render the hyperreal as an *almost* convincing 'counterfeit' of an albeit intangible referent. Photography in this case might be used as a 'glitching' operation, a passing between image and object into image which breaks the circuit of evidence of reconstruction in the removal of the physical frame via the imposition of a photographic frame.

Stepping into the Image of Mars: An Immersive Encounter through Photography

I would like to conclude this chapter with an account of my visit to the Mars Yard and a series of photographs I captured during my encounter. Although the images of Airbus' Mars Yard that have been presented throughout this chapter are my own, it is these final six that take the place of the speculative writing used at the beginning of Chapters 2 through to 5. In collapsing the frame-as-glitch and using the photographic lens as an immersing mechanism, I hoped to step ever closer to the image of Mars, reconstructing a reconstruction that exists – for now at least – only within the space of the image.

Upon signing in and being a given a visitor's badge I was led from the reception of Airbus Defence and Space past a series of industrial looking warehouses used to build spacecraft and satellites for various clients. Crossing over a road that linked all the factories together I was directed down some steps and into a building reminiscent of high school science laboratories: the corridors were narrow, the carpets and walls slightly shabby, and the lack of pictures seemed in an odd way to compensate for what lay ahead. Through a series of glass-fronted doors and swipe card accesses I was being taken to Mars. Getting to the Mars Yard was, in a sense, similar to my experience of the *Panorama Mesdag* in The Hague: I had been prepared for what I was about to witness through my preceding internet research, but the corridors and doors acted as a sort of buffer, through which I forgot about the world outside.

Stepping into a white control room I was confronted with three large black mirrors; the lights had not yet been switched on in the Yard. Straining to catch a glimpse of the constructed landscape beyond, I observed my own reflection in the windows separating me from Mars. As the lights were switched on the image of Mars flickered into view, the skeletal body of a test rover becoming clearer as the lights slowly warmed up to temperature. I cast my eyes upon the scene, through the black mirrors that had been transformed into windows: my first real experience of the Mars Yard was through a screen, through a thick panel of glass that ordinarily separated operators from the terrain. But unlike our computer screens – the most typical window to planetary worlds – this was a framed view that could be collapsed.

To enter the space, I descended a short flight of steps and through another door leading out of the control room. The terrain was elevated, separated from the side of the room by a low wall made up of breeze blocks painted Martian Brown. In order to access the terrain, I had to walk up a shallow ramp, climbing up and onto the sand, into the image of Mars. Rocks lay scattered across the terrain, collapsing the frame and stepping out my feet sank slightly, shoes filling with sand. The panoramic mural was distorted, stretched to fit and pieced together over the crevices and contours of the walls. Wrinkled in places, its undulating surface reflecting the Martian glow it was a patch-worked illusion. Mars had been stitched together, the glitches around me invading my vision, my immersion only partial as I honed in upon the rover tracks in the sand and picked up a fake Mars rock.

The only possibility I had of stepping into the image was through the framing device of my camera, curtaining off peripheral vision and carefully choosing the viewing angle so that distortion and composition were eliminated. Mounting the camera on a tripod I knelt down to look through the viewfinder; Mars was trapped in the tiny space of an image and only through the viewfinder did it begin to look like an actual landscape. My camera became a mechanism that enabled a certain level of immersion: by perceiving through the lens, I was able to glimpse an image of Mars. Yet it was a struggle and I had to get close to the panoramic visualisation to block out the ceiling, and the edges of the walls. I found it worked well if I focused my camera lens on the rocks and terrain in the foreground, and let the background image withdraw into soft focus; using a shallow depth of field effectively diminished the appearance of imperfections. Imaging the sky became problematic: the lights had been positioned too close to the image and cast shadows upon its uppermost surface. Photographing deeper into the landscape and eliminating the sky the terrain began to look realistic, but this realism revealed itself only through *two-dimensions*: a representation of a reconstruction. I was reminded of the image enhancing mechanism in Ridley Scott's film *Bladerunner* (1982); when the protagonist Deckard traverses the image through a machine, zooming in and out and seemingly around and behind objects represented in the image. In this scene the two-dimensional image appears to act as an interface to a three-dimensional world and through a process of panning and enlarging Deckard reveals more than what was initially present. The frame seemingly collapses drawing us into an impossible three-dimensional space. Like the *Bladerunner* example the Mars Yard is an image space that can be traversed, straining towards a vision of truth by traversing the image space with another image. Yet the panoramic mural remained superficial and impenetrable, the distortion of the panoramic mural and the slight disparity in colour between the faux terrain and the sand in the image drawing attention to the reconstructed nature of this image of Mars.

Figures 6.26 a-f. *Into the Image of Mars.* Photographs taken on 27 August 2014 by author, courtesy of Airbus Defence and Space.

Conclusion

This thesis has offered an examination of some of the tools and technologies scientists and engineers are using to collapse the frame and step into the image of Mars. 'Collapsing the frame and stepping into the image' has referred to a particular type of virtual engagement with images in their more immersive forms; technologies that attempt to 'collapse the frame' of the standard window, allowing us to *imagine* 'stepping into' the image of Mars. Speculative and descriptive writing has been used throughout to perform these subjective immersive encounters with images, which, up until Chapter 6, had been on the level of imagination. For the research carried out in the final chapter, I was able *physically* to step into the image of Mars: as a reconstruction of a reconstruction, the Mars Yard is a space in which image and object come together to simulate future scenarios. The Mars Yard also seemed to address simultaneously elements explored in previous chapters: its panoramic visualisation coupled with its faux terrain; the stereo capability of the rover that sees the image for what it really is; the necessity for colour matching; and the desire to get ever closer, to feel as if one could reach out and touch a distant alien landscape. As an image without a referent, the Mars Yard embodies the notion of the *image-as-image.*

The research has presented a synthesis of approaches: from an art historical and theoretical perspective concerned with the presentation and re-presentation of the virtual image (be it of the 18th/19th century or the present-day), studies on perception and vision, through to subjective accounts, I have addressed immersive encounters with contemporary rover images of Mars. This thesis has outlined innovative imaging technologies and modes of understanding used in Mars exploration today, demonstrating the historical roots from which such technologies stem; the panorama and the 3D image are prime examples of how immersive forms of visualisation have been developed from 19th century models. The thesis has also presented new links between historical models and scientific imaging practices in the drawing together of the painted diorama and false colour image, and the museum diorama and Mars Yard. In this way, perhaps this study can be seen as a kind of 'pre-history' for immersive imaging techniques used in space exploration; as space agencies endeavour to see further into the darkness of space and make visible the invisible, modes of visualisation will always be indebted to previous technological developments from the broader history of visual culture.

I posed a number of questions in the introduction which the proceeding chapters, based on a series of case studies, attempted to unpick. I would now like to return to these questions as a means to form the basis for an overview of the themes and arguments this thesis has offered.

How do contemporary imaging devices affect our perception of Mars? And what are the problems raised by representations of a reality we are unable to physically experience and see for ourselves? Chapter 1: "The Martian Landscape as Reconstructed" offered a detailed examination of the imaging devices on *Curiosity* and critiqued a set of examples in relation to photographic theory. This chapter drew attention to the constructed nature of *Curiosity's* images, arguing that these images cannot be seen as objective because they are subject to so many mediating factors: the camera's lens; in-built colour registration; downlink processes and calibration on Earth; the construction of mosaics to form a wider picture; not least the fact that such images represent an unseen referent that has yet to be verified first-hand by humans. This chapter substantiated how and why *Curiosity* enables *and* mediates our experience of the landscape; these images are not indexically linked to their referent as analogue photographs are (on the level of light and chemical processes) but rather are digital re-presentations that draw to the fore the problematic nature of visioning the invisible in a world in which 'even the *straight*, un-manipulated photograph has been under attack' since the 1970s.[1]

Can we better understand the virtual landscape of Mars through immersive imaging techniques, or are these simply illusions? Although this thesis has sought to argue that the panorama, the 3D image, the false colour and white-balanced image and the Mars Yard *are* simply illusions, it is through my discussions with scientists, engineers, and through engaging with these images during prolonged periods of looking that I can conclude that such immersive forms *do* in fact allow for better understanding of this virtual landscape. The panorama allows for a more encompassing experience, giving better situational understanding. The 3D image enables the viewer to better comprehend the topography, ridges, dips and hazards in the terrain. And the false colour and white-balanced image, through a process of manipulation, can draw out invisible features on a chemical and geological level. This is not to say that I believe the images get us any closer to 'being there', rather they get us closer to a sense of being there *virtually*, allowing us to glimpse a vision of Mars that is at the very heart distant and detached: a vision of *Mars-as-image*. In the final example of the Mars Yard we do not engage with Mars through the mediation of an onscreen image, rather we can gain an understanding of how the rover will navigate the terrain. The image of Mars becomes pure simulation (the Mars Yard does not represent an actual place); Mars recedes from our grasp but the *image* as a tangible entity pushes to the fore. Here we have a proximal relationship and a virtual encounter *with illusion*.

[1] Martha Rosler, "Image Simulations, Computer Manipulations: Some Considerations," *Digital Dialogues, Photography in the Age of Cyberspace* 2, no. 2 (1991): 52.

What form does the glitch take, and at what point does it invade these immersive spaces, throwing us back into the realm of the image? In the Martian panorama the glitch manifests itself in the frame and the presence of the rover which reveal themselves in our desire to traverse the image and expose more of the landscape in FutureFlight Central. It is in the desire to see ever further and get closer to the image that the viewer's body becomes a glitch as it blocks the projected light of the *Mars Window* panorama. In the Martian panorama the glitch uncovers the illusion's failure to 'entrap' the viewing subject in the reality of Mars; despite attempts at making Mars all encompassing, the landscape remains trapped within a flat impenetrable image. In the 3D image the glitch manifests itself in a variety of ways. In the stereoscope it is fracture, dust, void and veil; these elements surface during prolonged periods of looking. In the RSVP terrain model the glitches are the gaps in image data – represented by the Martian brown flat colour – that make present that which is unseen by the rover's gaze. Representing the limits of the rover's visibility this is a glitch that is necessary for the rover driver, making evident the unknown and therefore the areas that should be navigated around. In the anaglyph the glitch is colour, which surfaces again after long periods of looking, or which unexpectedly 'lacerates' the eye when we come upon an element of the scene which does not fuse entirely into 3D. The glitches in the 3D image serve to open up a space that hovers on the border between two- and three- dimensions, a space which obscures the landscape beyond, meaning Mars (as a physical, three-dimensional landscape) might only be *glimpsed.* In the colour-balanced *Martian Triptych* the glitch takes the form of the colour change between 'raw', 'natural' and 'white-balanced', which, whilst fracturing the relationship between vision and representation (hence why it might be called a glitch) is also used as an immersive method to reveal different aspects in the Martian terrain that would otherwise remain unseen. Colour-balancing then reveals the invisible, and the glitch invades any notion of one 'true' vision of Mars. Here we are immersed in a flickering interchange that occurs only on the surface of the image, at the level of superficial, technological vision.

It is the *Martian Triptych* example that most clearly answers affirmatively the final question I set out in the introduction; *can the glitch be seen as a method towards another kind of visibility, enabling us to 'see' and encounter Mars in productive ways?* In the *Martian Triptych,* the set of images become an 'active reconstruction' which makes evident the level of human intent and the desire to see Mars from a human perspective, which is present in both the panorama and 3D image.[2]

[2] As outlined in the introduction to this thesis, Michael Lynch argues that images within the scientific labour process are 'active reconstructions' because they have a basis in reality but are often reworked and manipulated to reveal scientific information. Michael Lynch, "Discipline and the

The rovers send back technological postcards of a distant land that space agencies and private companies believe will one day be explored and colonised by man.[3] The cost involved in space exploration and human space flight is exponential, but with images comes visibility and with visibility comes knowledge, the driving force behind humanity's desire to answer one of the biggest scientific questions of our time: are we alone in the universe? At the heart of the image forms I have explored throughout this thesis lies the desire to place our human, Earth-bound vision at the forefront of seeing: whether to experience the representation as 'life-sized', in 3D, through Earth-goggles or as a physical terrain that might be stepped into and onto, Mars has been reconstructed in its image to enable us to get to grips with an unknown land. This is a land that someday humans may walk upon and the virtual image forms, especially that of the Mars Yard, are a kind of preparation or rehearsal for the first human explorers.

As discussed in Chapter 6, Christopher Stewart labels the photographs taken of army test spaces as '*anticipatory photography'*.[4] He writes: 'Whilst *aftermath photography* extends the temporal relationship to conflict by showing its residue, these photographs of rehearsal spaces extend the depiction to the anticipatory – the time before conflict arrives.'[5] But whereas 'the future, projected in the space documented by these artists, is one of fear', the rehearsal space of the Mars Yard is very much one of hope for the future.[6] The *ExoMars* rover hopes one day to traverse and drill into the surface of Mars and looking at the Mars Yard space in a broader context of Mars exploration, such immersive image forms ready us for human exploration.

Yet there is still a way to go, and as this thesis has hoped to demonstrate, the landscape of Mars is, for now, very much intangible; a virtual landscape seen and experienced only

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Material Form of Images: An Analysis of Scientific Visibility," *Social Studies of Science* 15, no. 1 (February 1985): 59, accessed 22 January 2014. http://dx.doi.org/10.1177/030631285015001002.

[3] The *Mars One* organisation for instance is planning one-way trips to Mars to set up colonies on the surface by 2032. Elon Musk's privately funded *SpaceX* programme hopes that in 40-100 years, humans will be living on Mars in self-sustaining colonies of one million people. NASA are developing the capabilities to send humans on a return trip to Mars in the 2030s.

[4] Christopher Stewart, "Anticipatory Photography and the Architecture of Catastrophe," in *Prova 3,* ed. Chantal Faust (London: Royal College of Art, 2016), 41.

[5] Ibid., 42. David Campany states:

> Preparation or rehearsal is a kind of experience at one remove, in which behaviour is converted to an image of itself. Preparing for war, or rehearsing to give a public speech we 'go through the motions' in relative safety. It is not the real thing. We experience ourselves experiencing in order to get ourselves ready. We do things at an estranged and heightened level of representation before we do them 'for real'. That's what rehearsal is. So, in significant ways photographs are prospective images and rehearsal is imagistic prospecting.

David Campany, "Photography as Rehearsal / Rehearsal as Photography" in *Staging Disorder,* ed. Christopher Stewart and Esther Teichmann (London: Black Dog Publishing, 2015), 17.

[6] Stewart, 42.

through images. *Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images* has examined images of a place we cannot see unaided: distance, the unknown and the impenetrable are at the heart of the images I have explored. As the image is, for now, the only means by which can see and explore Mars, perhaps we need to lay claim to its vastly important nature within our understanding of an unknown land. Although the focus has been on critiquing such immersive forms of illusion, drawing out the glitches to highlight their constructed and illusory nature, it is testament to the image that I return to it in Chapter 6 as the very means by which to address the notions of reality and unreality, construction and reconstruction, illusion and glitch that have been the focus of this thesis. Images do something that writing cannot and this alone points to the powerful reliance on imagery and virtual experiences within the scientific field of visioning the invisible.

'Working on Mars'

I would like, finally, to touch upon some of the technologies this thesis has omitted from its discussion, the decisions of which have been led by issues of accessibility. As my personal subjective accounts have been paramount to both the beginning of each chapter and the development of my argument it has seemed inappropriate to include technologies I have not been able to access first-hand. These include: CAVE displays, which might have been included in my discussion of the Martian panorama; 3D monitors and liquid crystal glasses; and most notably the recent collaboration between Microsoft and NASA on the *OnSight* project, an augmented reality headset which lays claim to giving scientists the ability to 'work on Mars'.[7] Until mid-2016 *OnSight* was held under a non-disclosure agreement and it was not until December 2016 that I had the opportunity to test the technology; this was kindly facilitated by Professor Sanjeev Gupta and Dr Steven Banham at Imperial College London.

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[7] This technology is being heralded as an immersive means to explore Mars from a scientific perspective, allowing scientists to plan which areas of the landscape they would like to investigate, image and drill, but *OnSight* is also being used to explore data from previous sols in more detail. In addition, scientists from all over the world can explore the data 'together'; each scientist has their own 'avatar' within the virtual environment that the other users can see. The avatar's 'gaze ray' (a line of coloured light emanating from the avatar's eyes) enables other users to see where they are looking and each user is able to lay flags to pinpoint areas of interest or possible spots for further exploration by the real *Curiosity* on Mars. As NASA/JPL state:

> images, even 3D stereo views, lack a natural sense of depth that human vision employs to understand spatial relationships […] [*OnSight*] provides access to scientists and engineers looking to interact with Mars in a more natural, human way.

NASA/Jet Propulsion Laboratory, "NASA, Microsoft Collaboration Will Allow Scientists to 'Work on Mars,'" 21 January 2015, accessed 14 December 2016, http://www.jpl.nasa.gov/news/news.php?feature=4451.

As the most current technology being used in immersive Mars exploration it seems fitting to conclude my thesis with a speculative account of *OnSight.*

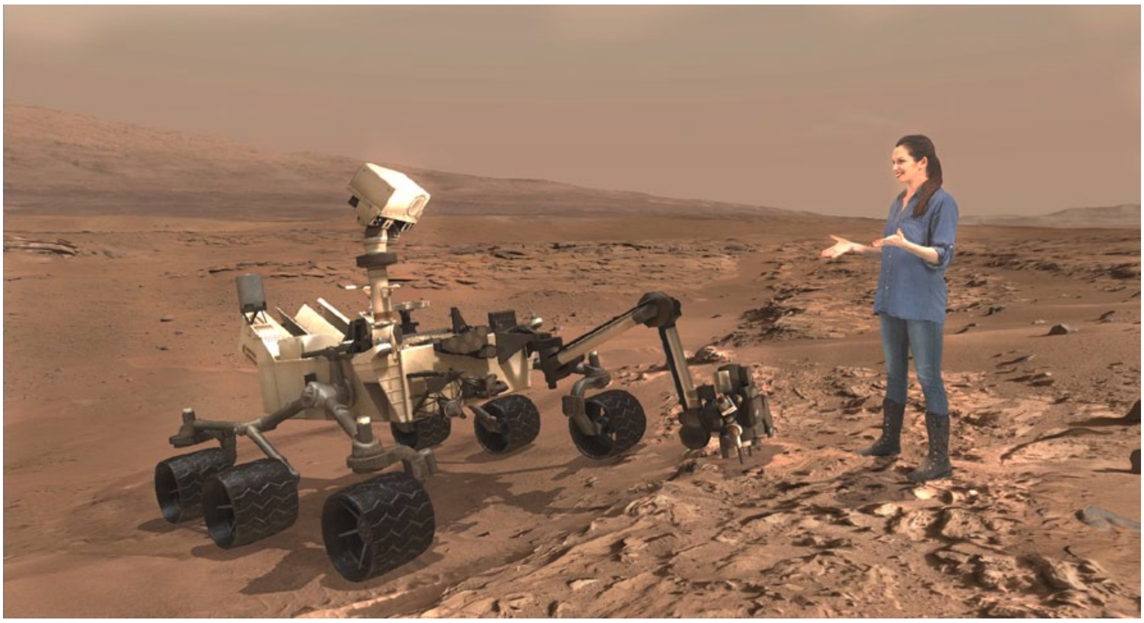

Figure 7.1. *Erisa Hines, a driver for the Mars Curiosity rover, based at JPL, talks to participants in "Destination: Mars,"* 30 March 2016. Credit: NASA/JPL-Caltech/Microsoft.

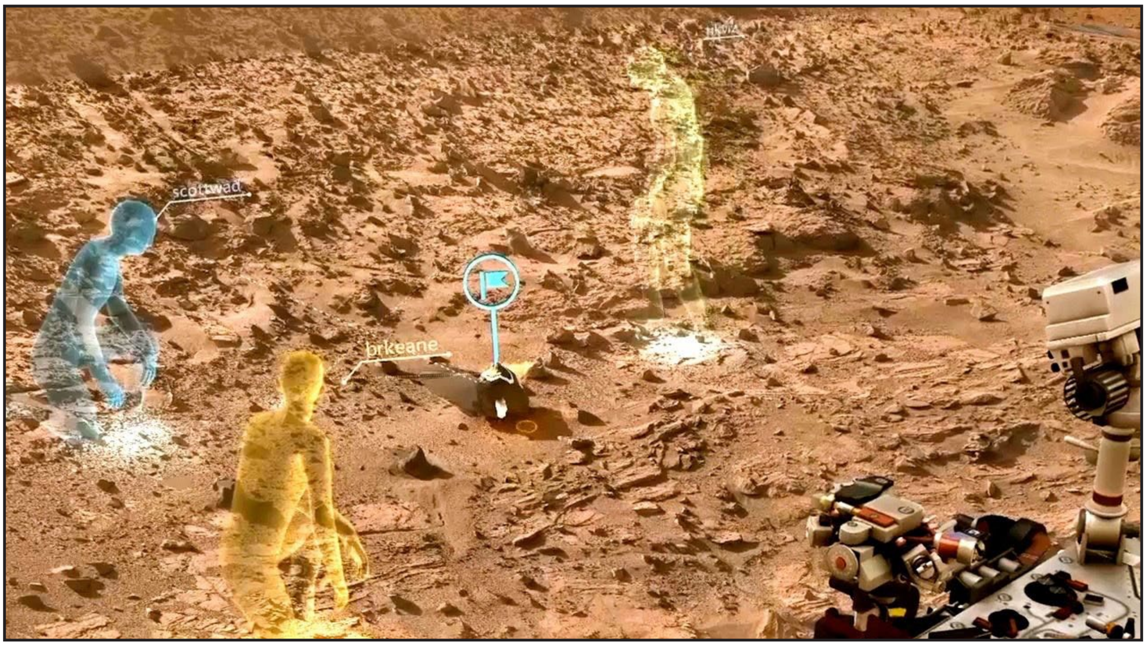

Figure 7.2. Screen view from *OnSight,* 21 January 2015. Credit: NASA/JPL-Caltech.

Figure 7.3. Microsoft HoloLens headset. Credit: Microsoft.

OnSight uses Microsoft's HoloLens – an augmented reality headset – to display recent *Curiosity* data. The software constructs a three-dimensional environment from MastCam and NavCam images, together with satellite imagery taken by the HiRISE camera on the Mars Reconnaissance Orbiter.[8] The kinds of promotional images that accompanied the announcement of *OnSight* in January 2015 are fairly different to the actual experience. As the software combines NavCam and MastCam images, the virtual environment is actually a patchwork of colour and black and white. Upon donning the headset and clicking through to the Mars dataset what you see is essentially a kind of 'window' onto Mars; the screen has an aspect ratio of 16:9 and it takes up the centre of the user's vision. Unlike virtual reality whereby you are totally immersed in a simulation, augmented reality overlays the virtual and the real: peripheral vision (anything outside of that screen to the right, left, bottom or top) is taken up by real life surroundings. Although this might at first be seen as a limitation (a glitch, or series of glitches jolting us back to reality) Dr Steven Banham states that an awareness of the user's real surroundings prevents them from tripping up, or, as rover driver John R. Wright observes, prevents them from feeling sick.[9] As such, the technology can be used for prolonged periods of engagement. As the user moves their head or rotates on the spot a three-dimensional rendering using photographic data of the Martian landscape is revealed behind a window. As the user walks about in real space, so too does the perspective

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[8] Project Manager for *OnSight* Jeff Norris explains:

> The 3D reconstruction is created via a terrain processing pipeline developed by my team that takes as input the stereo images acquired by the rover's cameras. The pipeline extracts range information by using a process called stereo correlation, and then uses that range data to build a 3D model of the shape of the terrain called a "mesh". The mesh is then coloured using texture maps that are also derived from the images.

Jeffrey S. Norris (Founder and Director of JPL Ops Lab, NASA, California), email message to author, 26 March 2015.

[9] Dr Steven Banham (Postdoctoral Research Associate, Earth Science and Engineering department, Imperial College London), interview by author, London, 13 December 2016; John R. Wright (Data Visualisation Developer IV at Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 3 November 2016.

through the window change: through the image-as-screen Mars can be seen from different viewpoints.

The *OnSight* units access the data via the internet by connecting to the JPL servers: 'When the rover moves', Banham explains, 'we get an email notification of a new "scene" which automatically downloads when you open *OnSight*, after turning the device on.'[10] The virtual environment is dictated by the rover and its cameras' stereoscopic reach. From its vantage point *Curiosity* can image its near surroundings in high resolution, but as we saw in the RSVP terrain mapping tool used for rover driving (Chapter 4) 'seeing' behind objects is not a simple case of walking into the landscape and looking from a different perspective. Unlike RSVP that represents the unseen sides of the landscape in a different colour, *OnSight's* objective is to increase levels of immersion; unseen sides of rocks and terrain features are estimated, rather than being left blank. The further away from the rover the user gets, the more infill the software has to do. As a result, these features appear slightly distorted as the photographic data is stretched over the underlying polygon mesh.

The user is able to reveal aspects of Mars by physically walking about and looking around to gain greater situational understanding for the terrain around the rover, just as they might if they were 'there on Mars'. Project Manager for *OnSight* Jeff Norris elaborates on this:

> *OnSight* tries to engage many of the same senses that a geologist would have when exploring a location on Earth. A very important sense that *OnSight* engages but a traditional computer monitor does not is *proprioception*, the body's sense of its own position and movement. Because we rapidly and accurately track the position of the scientist's head as they move around in their office, we can show them the views of Mars that they would have if they were moving in the same way on Mars. This is what creates [a] "first-person perspective".[11]

This thesis has drawn on the writing of Maurice Merleau-Ponty for many aspects concerning how we perceive three-dimensions, colour and the existence of absent objects or the unseen sides of objects. Most notably, I have utilised Merleau-Ponty's emphasis on experiencing the world from *within* the body as the locus of perception, his claim that the world is all around us, not in front of us, to suggest a certain stepping into the image of Mars.[12] Immersive technologies attempt to envelop us in the image and this thesis has offered subjective encounters on different iterations of the image of Mars; how the image might be stepped into imaginatively and physically (in the case of the Mars Yard). With *OnSight* the body is quite literally placed at the centre of the experience; the user must move his/her body to reveal

[10] Banham, interview.
[11] Norris, email message.
[12] Maurice Merleau-Ponty, *The Primacy of Perception,* trans. James M. Edie (Illinois: Northwestern University Press, 1964), 178.

more of the landscape and in the words of Brian O'Doherty 'the Eye urges the body around to provide it with information – the body becomes a data-gatherer'.[13] But with *OnSight* our vision and body become oddly detached; reaching our hand out in front of us – as if to point towards something through the window – it disappears, existing behind the screen within physical and not virtual space. Despite the body being integral to *how* the illusion is revealed, the eye is isolated, being the only entity present in the image of Mars. To appropriate O'Doherty: 'the eye is abstracted' from a (this time mobile and not anchored) body 'and projected as a miniature proxy into the picture to inhabit and test the articulations of its space'.[14]

It is important to note that although *OnSight* is an incredibly exciting experience, and perhaps the most immersive so far, the technology is not without its limitations and it raises questions of the interplay between two- and three- dimensions and issues of the frame which have been paramount throughout this thesis. Being an augmented reality headset the 'window' onto Mars appears against our real-life surroundings and as such it is not fully immersive. As with the types of 3D imaging discussed in Chapter 4, the experience of the Martian terrain through the *OnSight* window only allows the user to *glimpse* a virtual image of Mars. The glitch in *OnSight* does not lie in the presence of the *image* pushing to the fore, but in the presence of the *screen* (the window) that floats about occupying a strange space between the user and their real surroundings. However, the notable difference between this technology and the other forms of images I have discussed is the ability of the user to physically move about and intuitively reveal more of the landscape. The level of immersion for *OnSight* then is not the technology's ability to give a full 360° view of an environment (for Mars to invade all areas of vision) but is in the act of movement to reveal the *depth* of the virtual image.[15]

With *OnSight* there is the definite wow-factor and seductive novelty of new illusions; like the Victorian stereoscope or 3D TV. With new technologies appearing all the time, perhaps there is something in the ephemeral nature of technologies in re-presenting images

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[13] Brian O'Doherty, *Inside the White Cube: The Ideology of the Gallery Space.* Berkeley: The Lapis Press, 1976, 52.

[14] Ibid., 18.

[15] In this regard there is a correlation between *OnSight's* window onto Mars and the 3D oil painting in the 50th anniversary special of *Doctor Who,* titled *the Day of the Doctor* (2013). The painting, titled *No More (Gallifrey Falls)* is 'Time Lord Art, bigger on the inside, a slice of real time…frozen.' The Doctor in *Doctor Who: The Day of the Doctor,* directed by Nick Hurran, DVD, BBC (2013). As the Doctor's assistant Clara moves forwards to inspect the painting she is able to reach out and into its apparently deep interior; her movement (and that of the camera's) reveals the painting's inner depths. Unlike the 3D painting that may be stepped into (or out of, we discover as the plot unfurls) we are not granted this same fulfilment of desire with the window onto Mars in *OnSight.* This window remains one onto virtual space, a space never to be physically traversed.

of Mars that reflects our human desire to see ever more clearly and in a more immersive manner, to get closer and closer to a feeling of touching and being in the landscape, if only – for now at least – on the level of vision. The desire to 'see' and to imagine in more immersive ways has been the key thread tying my chosen case studies to their historical counterparts. It is important to note that although my focus has been Mars, the implications of the research span wider fields, contributing to current debates in the arts and humanities surrounding image authenticity and the growing theorisation of the virtual non-art image in a digital age, as well as presenting alternative perspectives to scientists and engineers working with *Curiosity* data. The 'invisible visions' offered by *Curiosity* are constructed via technologies that both mediate perceptions and deepen our understanding of a place we cannot experience first-hand. As such, the interdisciplinary methods I have used to address technological seeing could also be applied to other fields that rely on the perspectives of machine-made images: photojournalism; drone warfare; surveillance; optical aids used for army operations; deep space telescopes; sonar being used to map the ocean floor; and the X-rays, ultrasound and molecular imaging used in medicine.

Broadly speaking, this thesis has been concerned with the relationship between constructed, reconstructed and imagined images for which the 'glitch' functions to reveal some kind of reality, be it the reality of the artifice, a truth that is invisible to human vision, or to negate reality entirely in favour of simulation. Perhaps, then, this study gains particular poignancy in current times; in a world of 'post-truth' and 'alternative facts' we are seeing an increasing blurring of the boundary between what is real and what is false.[16] The endless and perhaps futile endeavour to understand everything has, according to documentary film-maker Adam Curtis, brought about a period of 'hypernormalisation' in which the West has 'retreated into a simplified, and often completely fake version of the world'.[17] The importance of imagery within this context is indisputable; the image is a form of information, whether true or false, that provides an alternative view to our immediate surroundings. The image is a visual entity to which we are perpetually drawn. In a sense then, this thesis reveals a deeper,

[16] In the wake of Brexit and the US presidential election the term 'post-truth' gained wide-spread use in 2016 and was named Word of the Year by the Oxford Dictionaries. The word is 'an adjective defined as relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief'. English Oxford *Living* Dictionaries, "Word of the Year 2016 is…" accessed 30 January 2017, https://en.oxforddictionaries.com/word-of-the-year/word-of-the-year-2016. The phrase 'alternative facts' was used by US Counsellor to President Trump Kellyanne Conway to refer to a false statement made by the press secretary Sean Spicer in a statement regarding the size of Trump's inauguration audience.

[17] Adam Curtis, "Hypernormalisation," The Medium and the Message, last modified 11 October 2016, accessed 30 January 2016, http://www.bbc.co.uk/blogs/adamcurtis/entries/02d9ed3c-d71b-4232-ae17-67da423b5df5.

more insatiable desire that lies at the heart of all types of imaging; to re-live, re-construct or imagine something that is unseen because of its distance from us in time and space.

Figure 7.4. Photograph of author during *OnSight* demonstration, 13 December 2016. Credit: Dr Steven Banham.

I would like to finally conclude with a subjective encounter of *OnSight.* Perhaps this will form the launch pad of future writings.

The following encounter took place on 13 December 2016 and the virtual environment encompassed datasets from sols 1526 – 1547 (22 November – 13 December 2016). During this time the rover had been parked for a few days whilst engineers ran diagnostics on the drilling mechanism; as such the rover was able to image its immediate surrounds in high resolution detail.

Lowering the headset over my eyes and adjusting the headband I looked through tinted glasses at the office surroundings of the Royal School of Mines at Imperial College London.

A window slotted down into view. With an almost opaque but luminous translucency this window was hard edged and glowing against the dull grey of the real office carpet and surrounding white walls. But unlike Alberti's fixed veil this window was mobile, almost fragile. Floating and glimmering the window followed the motion of my head, persistently present within my direct field of vision, in front of and against, yet within the office interior. A screen which was simultaneously a window, appearing only for me. A personal portal out onto Mars.

The screen flickered and the laying out of a polygon mesh announced the forthcoming emergence of landscape. The terrain began to materialise, expanding outwards rapidly from my immediate surroundings and into the distance, a patchwork of greys and Martian browns in high and low resolution. Revolving on the spot I looked out towards the mountainous rim of Gale Crater; a dusty grey in the distance, offset against a shimmering soft pink sky.

As I knelt down to examine a portion of the ground the window shrank in size. Zooming in physically and virtually I saw cracks and crevices in the rocks, the strata in the bedrock, granules of sand and tiny pebbles. As I reached out to touch and feel the surface under my gaze my hand evaporated, my body belonging to a space exterior to my vision.

As I stepped back Curiosity *flickered into view. The large immobile body of the rover was coated in a thin film of dust, trapped here, in the virtual image of Mars. As I advanced forth in an attempt to inspect its wheels,* Curiosity *vanished. In an instant I became the rover, seeing the surrounding terrain from its vantage point, its body merged with mine.*

As I walked backwards once more I looked out towards the distant horizon. The environment appeared perversely trapped within a pixel-thin layer, a three-dimensional image held somehow within a two-dimensional display. This was a virtual opening that did not require a click or swipe of the finger to reveal what lay beyond the borders. Here I was present virtually in the image, a presence that relied on my own physicality; the position of my head in relation to my body. A three-dimensional image of Mars that I was in control of revealing.

Revealing. The act of revealing coincided with the act of concealing. Movement enabled me to penetrate the environment contained within the image, but did not allow me to bypass the screen. Movement revealed depth but concealed width. The window could not be enlarged, the frame could not be collapsed, the image-as-screen could not be stepped into.

I looked upon markers in the landscape, upright poles that marked where Curiosity *had been and for how long. My gaze lingered and the rover's path became illuminated, snaking through the landscape from one point to the next. A glowing path into the past of a landscape it would not see again. Upon walking towards this point in the landscape I revealed the depth of image, a depth of space, a depth of time.*

And yet I was not limited to walking alone, nor to the four walls of the office. I could reach the outer edges of Curiosity's *vision through teleportation. Speeding back through time, through space, and into the reconstruction of Mars-as-image.*

Appendices

Appendix A
Timeline of Mars Observation and Exploration

Before 1500: Mars appears a fiery red and follows a strange loop in the sky.
Babylonians study Mars as early as 400 BC and call it Nergal – the king of conflicts.
Egyptians notice stars remain fixed whilst the sun and other objects in the sky (Mercury, Venus, Mars, Jupiter and Saturn) move.
Greeks and Romans: Greeks name the planet Ares after their God of War and the Romans call it Mars.[1]

1500s: Danish astronomer Tycho Brahe (1546 – 1601) makes calculations on the position of Mars 20 years before the telescope is invented.[2]

1609: Johannes Kepler (1571 – 1630) publishes *Astronomia Nove (New Astronomy)* containing his first two laws of planetary motion. The first law assumes Mars has an elliptical orbit. Before this time it was classical belief that all orbits must be perfect circles.[3]

1609: Mars is observed for the first time through the telescope by Galileo Galilei (1564 – 1642).[4]

1659: Dutch astronomer Christiaan Huygens (1629 – 1695) draws Mars recording a large dark spot and notices this spot returning at the same time each day. From this Huygens calculates that Mars has a 24 hour period.[5] Hyugens also observes Mars is only a little over half the size of Earth.[6]

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[1] NASA, "Early Times," NASA Mars Exploration: All About Mars, accessed 2 December 2016, http://mars.nasa.gov/allaboutmars/mystique/history/early/.

[2] NASA, "1500s," NASA Mars Exploration: All About Mars, accessed 2 December 2016, http://mars.nasa.gov/allaboutmars/mystique/history/1500/.

[3] NASA, "1600s," NASA Mars Exploration: All About Mars, accessed 2 December 2016, http://mars.nasa.gov/allaboutmars/mystique/history/1600/.

[4] Ibid.

[5] Ibid.

[6] Rob Manning and William Simon, *Mars Rover Curiosity: An Inside Account from Curiosity's Chief Engineer* (Washington: Smithsonian Books, 2014), 2.

1666: Giovanni Cassini (1625 – 1712) determines Mars' day is 24 hours and 30 minutes long.[7]

1698: Huygans publishes *Cosmotheros* which speculates on intelligent extra-terrestrials.[8]

1704: Giancomo Miraldi (1665 – 1729) observes white spots at the poles which he correctly identifies as icecaps in 1719.[9]

1777 – 1783: British astronomer Sir William Herschel (1738 – 1822) studies Mars with a telescope and believes that all planets are inhabited, even the sun.[10]

1784: Herschel mistakes dark areas on Mars as oceans and lighter regions as land and speculations about life on Mars begin to grow. He correctly observes that Mars has a tenuous atmosphere.[11]

1809: French amateur astronomer Honore Flaumergues (1755 – 1935) notices yellow clouds, which were later discovered to be dust clouds. [12]

1813: Flaumergues observes the ice cap melting in the spring and concludes Mars is hotter than Earth.[13]

1840: Wilhelm Beer (1797 – 1850) and Johann von Maedler (1794 – 1874) determine the rotational period of Mars as 24 hours, 37 minutes and 22.6 seconds (its current accepted time is 24 hours, 37 minutes, 22.7 seconds).[14]

1867: Pierre Jules Janssen (1824 – 1907) publishes a map of the planet with continents and oceans.[15]

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[7] NASA, "1600s."
[8] Ibid.
[9] NASA, "1700s," NASA Mars Exploration: All About Mars, accessed 2 December 2016, http://mars.nasa.gov/allaboutmars/mystique/history/1700/.
[10] Ibid.
[11] Ibid.
[12] NASA, "1800s," NASA Mars Exploration: All About Mars, accessed 2 December 2016, http://mars.nasa.gov/allaboutmars/mystique/history/1800/.
[13] Ibid.
[14] Ibid.
[15] Ibid.

1877: Giovanni Schiaparelli uses a 25 centimetre telescope to draw a map of the surface, recording in detail large structures he calls 'canali,' meaning channels. This term is misinterpreted to mean 'canals' with the implication, drawn also from the linearity of Schiaparelli's representation, that these structures were made by Martians to irrigate the planes. These features later proved to be an optical illusion and are now known as *Valles Marineris*.[16]

1877: Asaph Hall (1829 – 1907) discovers the moons, calling them Phobos, Deimos and Ares.[17]

1894: Percival Lowell (1855 – 1916) begins to observe Mars from his observatory in Arizona. He makes drawings of the 'canals' and spends many years investigating and writing about them, pushing the theory that they were proof of life on Mars.[18]

1895: Lowell publishes *Mars*.

1906: Lowell publishes *Mars and Its Canals.*

1908: Lowell publishes *Mars as the Abode of Life*

1870s – 1960s: During this period many science fiction stories emerge focusing on Martian invasions and humans travelling to Mars to encounter alien beings which take both alien and human-like form. Notable examples include: *War of the Worlds* (1898) by H.G. Wells*; A Princess of Mars* series (1912 – 1943) by Edgar Rice Burroughs; *Out of the Silent Planet* trilogy (1938) by C.S. Lewis; *The Martian Chronicles* (1950) by Ray Bradbury; *The Sands of Mars* (1951) by Arthur C. Clarke; *The Martian Way* (1952) by Isaac Asimov; *The Sirens of Titan* (1959) by Kurt Vonnegut; *Martian Time Slip* (1964) and *The Three Stigmata of Palmer Eldritch* (1965) by Phillip K. Dick.
Technological innovations enable space agencies to begin their first attempts at Mars exploration in the early 1960s. From 1965 NASA's *Mariner* and *Viking* missions reveal the canals as an illusion and discover that Mars is in fact a hostile environment. By the 1970s

[16] Xavier Barral, *This is Mars* (New York: Aperture, 2013), 235.
[17] NASA, "1800s."
[18] Ibid.

the idea that there might once have been ancient civilisations living on Mars is abandoned and science fiction turns to ideas of human colonisation and terraforming.

10 October 1960: USSR probe (retroactively named *Marsnik 1*), weighing 480kg. Fails to reach Earth orbit.[19]

14 October 1960: USSR probe *Marsnik 2,* weighing 480kg. Fails to reach Earth orbit.[20]

24 October 1962: USSR flyby *Sputnik 22,* weighing 900kg. Fails to leave Earth orbit after the final rocket stage explodes.[21]

1 November 1962: USSR flyby *Mars 1,* weighing 893kg. Communications fail en route.[22]

4 November 1962: USSR lander *Sputnik 24,* mass unknown. Fails to leave Earth orbit.[23]

5 November 1964: USA flyby *Mariner 3*, weighing 260kg. Solar panels do not open, preventing flyby.[24]

28 November 1964 – 20 December 1967: USA flyby *Mariner 4,* weighing 260kg. Arrives at Mars on 14 July 1965 and passes within 9,845 kilometres of Mars' surface after an eight-month journey. Planet's thin atmosphere confirmed to compose of carbon dioxide in range of 5-10 mbar. Small magnetic field detected. *Mariner 4* now in solar orbit.[25]

30 November 1964: USSR flyby *Zond 2,* weighing 996kg. Contact lost en route.[26]

24 February 1969: USA flyby *Mariner 6*, weighing 412kg. Arrives at Mars on 24 February 1969 passing within 3,551 kilometres of planet's equatorial region. Takes measurements of

[19] NASA, "A Chronology of Mars Exploration," NASA History Program Office, 16 April 2015, accessed 4 December 2016, http://history.nasa.gov/marschro.htm.
[20] Ibid.
[21] Ibid.
[22] Ibid.
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.

surface and atmospheric temperatures, surface composition and pressure of the atmosphere. Captures over 200 black and white pictures. *Mariner 6* now in solar orbit.[27]

27 March 1969: USA flyby *Mariner 7*, weighing 412kg. Arrives on 5 August 1969 and passes within 3,551 kilometres of Mars' south pole region. Takes measurements of surface and atmospheric temperatures, surface composition and pressure of the atmosphere. Captures over 200 black and white pictures. *Mariner 7* now in solar orbit.[28]

1969: USSR encounter 2 launch failures.[29]

8 May 1971: USA flyby *Mariner 8*, weighing 997.9kg. Fails to leave Earth orbit.[30]

10 May 1971: USSR probe *Kosmos 419,* weighing 4,549kg. Fails to leave Earth orbit.[31]

19 May 1971: USSR orbiter/soft lander *Mars 2,* weighing 4,650kg. Lander released from orbiter on 27 November 1971 but crash lands due to braking rockets failure. No lander data returned but orbiter returns data until 1972.[32]

28 May 1971: USSR orbiter/soft lander *Mars 3,* weighing 4,643kg. Arrives 2 December 1971 and first successful landing on Mars is carried out. Lander fails after relaying 20 seconds of video data. Orbiter returns data until August 1972 making surface temperature and atmospheric composition measurements.[33]

30 May 1971 – 1972: USA orbiter *Mariner 9*, weighing 974kg. Placed into orbit on 24 November 1971. First high resolution images of moons Phobos and Deimos are captured.[34] River and canyon-like features observed by Schiaparelli are confirmed and measured as

[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] Ibid.
[32] Ibid.
[33] Ibid.
[34] Ibid.

three times as deep as the Grand Canyon (up to 7km) and spanning 20% of the entire distance around Mars (4000km).[35] *Mariner 9* still in orbit around Mars.

25 July 1973: USSR orbiter *Mars 5,* weighing 4,650kg. Enters orbit on 12 February 1974 and acquires data for *Mars 6* and *Mars 7* missions.[36]

5 August 1973: USSR orbiter/soft lander *Mars 6*, weighing 4,650kg. Lander fails on descent but returns atmospheric descent data.[37]

9 August 1973: USSR orbiter/soft lander *Mars 7,* weighing 4,650kg. Fails to go into orbit and lander misses the planet.[38]

20 August 1975 – 7 August 1980: USA orbiter/lander *Viking 1,* weighing 3,527kg including fuel (orbiter 883kg, lander 572kg). Launches from Kennedy Space Station on 20 August 1975 and placed into orbit on 19 June 1976. Lander touches down 20 July 1976.[39]

9 September 1975 – 25 July 1978: USA orbiter/lander *Viking 2,* weighing 3,527kg including fuel (orbiter 883kg, lander 572kg). Launches on 9 November 1975 and lands on Mars on 3 September 1976.[40] Both *Viking* landers undertake experiments to search for micro-organisms, provide colour panoramic images of the surface and monitor the weather. They reveal that the colour of the planet's surface is due to iron in the dust oxidising from weathering. The orbiters map the surface acquiring over 52,000 images.[41]

7 July 1988: USSR orbiter/lander *Phobos 1,* weighing 5,000kg. Sent to investigate Martian moon but lost en route.[42]

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[35] Natasha Stephen, "Mars: Exploring the Red Planet" (lecture, City Lit, London, 20 November 2013).
[36] NASA, "A Chronology of Mars Exploration."
[37] Ibid.
[38] Ibid.
[39] Ibid.
[40] Ibid.
[41] Stephen.
[42] NASA, "A Chronology of Mars Exploration."

12 July 1988: USSR flyby/lander *Phobos 2,* weighing 5,000kg. Arrives on 30 January 1989, moves within 800 kilometres of Phobos but fails.[43]

25 September 1992: USA orbiter *Mars Observer,* weighing 2,573kg. Communication lost just before being inserted into orbit.[44]

7 November 1996: USA orbiter *Mars Global Surveyor,* weighing 1,062.1kg. MGS has successfully been mapping the surface since March 1998.[45]

16 November 1996: Russia orbiter/lander *Mars 96,* weighing 6,200kg. Consists of orbiter and two landers. Crashes into ocean after lift-off.[46]

December 1996: USA lander and rover *Mars Pathfinder,* weighing 870kg. Stationary lander arrives on 4 July 1997 and six-wheeled rover *Sojourner* explores the area near the lander. Primary objective of mission to demonstrate feasibility of low-cost landings.[47] *Pathfinder* becomes the first mission to take real colour high resolution images of the surface and to prove it is possible to move a robot about on a planet's surface.[48] Mission ends on 4 November 1997.

3 July 1998: Japan orbiter *Nozomi,* weighing 536kg. Launched to study planet's environment. Communication lost in December 2003. [49]

11 December 1998: USA orbiter *Mars Climate Orbiter,* weighing 629kg. Mission failed.[50]

3 January 1999: USA lander *Mars Polar Lander,* weighing 583kg. Crash landing on Mars due to loss of communication.[51]

[43] Ibid.
[44] Ibid.
[45] Ibid.
[46] Ibid.
[47] Ibid.
[48] Stephen.
[49] NASA, "A Chronology of Mars Exploration."
[50] Ibid.
[51] Ibid.

7 April 2001: USA orbiter and lander/rover *2001 Mars Odyssey*, weighing 376.3kg. Reaches planet on 24 October 2001 and serves as communications relay for future Mars missions.[52]

2 June 2003: European Space Agency orbiter and lander *Mars Express,* weighing 666kg. *Mars Express* successfully arrives on 25 December 2003 but *Beagle 2* is lost, later discovered to have crash landed.[53]

10 June 2003: USA rover *Spirit (MER-A),* weighing 185kg. Arrives on Mars on 3 January 2004. After six and a half years *Spirit's* wheels become stuck and it becomes a permanent monitoring station. Communication lost on 22 March 2010 and JPL end attempts to re-establish contact on 25 May 2011.[54]

7 July 2003: USA rover *Opportunity (MER-B),* weighing 185kg. Arrives on Mars on 24 January 2004. Rover is still operational today. Both *Spirit* and *Opportunity* were flown to Mars in the same launch vehicle and lander with the same design as *Pathfinder.* MER was designed to fit into this space folded. Knowing how something already works shaves off time and money.[55]

12 August 2005: USA orbiter *Mars Reconnaissance Orbiter,* weighing 1,031kg. Arrives on 10 March 2006 and begins scientific mission in November 2006. MRO's mission is to discover if water persisted on Mars long enough to provide a habitat for life. The High Resolution Imaging Science Experiment (HiRISE camera) on MRO continues to capture the surface of Mars in unprecedented detail.[56]

4 August 2007: USA lander *Phoenix,* weighing 350kg. Lands on 25 May 2008. Designed to study history of water and potential to harbour life in the Martian arctic's ice-rich soil. Mission ends after 5 months in May 2010.[57]

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[52] Ibid.

[53] Ibid.

[54] Ibid.

[55] John R. Wright (Rover driver for *Curiosity* and *Opportunity*, Jet Propulsion Laboratory, California), interview by author, Pasadena, CA, 2 November 2015.

[56] NASA, "Mars Reconnaissance Orbiter," 31 July 2015, accessed 4 December 2016, https://www.nasa.gov/mission_pages/MRO/mission/index.html.

[57] NASA, "A Chronology of Mars Exploration."

8 November 2011: Russian lander and Chinese orbital probe *Phobos-Grunt,* weighing 115kg. Designed to land on Phobos. Both craft destroyed on re-entry from Earth orbit in January 2012.[58]

26 November 2011: USA rover *Mars Science Laboratory (Curiosity),* weighing 750kg. Successfully lands in Gale Crater at 1:31 EDT on 6 August 2012.

5 November 2013: India orbiter *Mars Orbiter Mission (Mangalyaan),* weighing 15kg. Successfully reaches Mars orbit on 24 September 2014. Continues to operate, mapping the planet and measuring radiation.[59]

18 November 2013: USA orbiter *MAVEN* (Mars Atmospheric and Volatile EvolutioN), weighing 2,550kg. Assessing Martian atmosphere to further understanding of planet's climate change. [60]

14 March 2016: European Space Agency orbiter and lander *Trace Gas Orbiter* and *Schiaparelli* lander. First stage of *ExoMars* programme 2016-2020. TGO successfully placed into orbit on 19 October 2016. *Schiaparelli* released from TGO on 16 October but crash lands due to its heat shield and parachute being ejected ahead of time and its deceleration thrusters only firing for 3 seconds (as opposed to the planned 30 seconds). On 2 December 2016 ESA confirms funding is secured for the second stage of the mission, the *ExoMars* rover.

<u>Planned future missions:</u>

2018: Launch of NASA's *InSight* mission which will study the deep interior of Mars.
2020: Launch of NASA's *2020* rover.
Launch of ESA's *ExoMars* rover.
Launch of United Arab Nation's *Mars Hope.*
Launch of China's 2020 *Mars Mission*.
Launch of SpaceX's unmanned *Red Dragon* capsule to test low-cost lander mission.

[58] Ibid.
[59] Ibid.
[60] Ibid.

Appendix B

Interview consent form template

For further information:
Luci Eldridge
+44 7825066400
luci.eldridge@gmail.com
Supervisor:
Dr Chantal Faust
+44 (0)20 7590 4483

[Date]

Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images

Interview Consent Form

I *(please print)*…………………………………have read the information on the research project *Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images* which is to be conducted by Luci Eldridge from the Royal College of Art, and all queries have been answered to my satisfaction.

I agree to voluntarily participate in this research and give my consent freely. I understand that the project will be conducted in accordance with the Information Sheet, a copy of which I have retained.

I understand that I can withdraw from the project at any time, without penalty, and do not have to give any reason for withdrawing.

I consent to:

- Be interviewed by Luci Eldridge on the phone, in person or via email

I understand that all information gathered from the interview will be stored securely and my opinions will be accurately represented. Any images in which I can be clearly identified will be used in the public domain only with my consent.

Print Name:…………………………………………………………..

Signature……………………………………………………………

Date: ………………………………………………………………

This project will be conducted in compliance with the Research Ethics Code of the Royal College of Art.

For further information:
Luci Eldridge
+44 7825066400
luci.eldridge@gmail.com
Supervisor:
Dr Chantal Faust
+44 (0)20 7590 4483

[Date]

Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images

Interview Information Sheet

Dear Potential Participant,
I am a research student in the Critical and Historical Studies department. The title of my research is *Mars, Invisible Vision and the Virtual Landscape: Immersive Encounters with Contemporary Rover Images.* You are invited to take part in this research project which explores the contemporary rover imaging of Mars, and how scientists and engineers use the form of the image to explore the planet's surface. The project re-contextualises and re-examines these images within an arts and humanities framework to investigate our quest for knowledge through the machine, and the role of the imaging device as both an extension of vision, imagination and a barrier to truth.

If you consent to participate, this will involve:
- Taking part in an interview either via email, in person or on the phone

Participation is entirely voluntary. All information collected will be confidential. All information gathered from the interview/s will be stored securely. All your statements shall be credited and referenced fully.

If you have any concerns or would like to know the outcome of this project, please contact myself or my supervisor Chantal Faust at the above address.

Thank you for your interest,
Luci Eldridge

Complaints Clause:
This project follows the guidelines laid out by the Research Ethics Code of the Royal College of Art.

If you should have any concerns about your rights as a participant in this research, or you have a complaint about the manner in which this research is conducted, it may be given to the researcher or, if an independent person is preferred, addressed to the Research Ethics Committee of the Royal College of Art.

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