# LOCATIVE INTERACTION IN URBAN SPACE : PROGRAMMATIC FLEXIBILITY

A thesis submitted in partial fulfillment of the requirements of the Royal College of Art for the degree of Doctor of Philosophy

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**2012**

# Copyright Statement

# ACKNOWLEDGEMENT

I would like to thank all the people who supported this work and were to my side throughout the last few years. First and foremost I would like to thank Miles Pennington who largely supports me to develop and finalize my work, Tom Barker who brought me to Royal College of Art and provides me with his enthusiastic support for the start of my work and Paul Ewing who gave me the guidance to think and Bronac Ferran who gave me helpful advice. I would like to thank Richard Harper at Microsoft, Cambridge, who provides inspiring directions and resourceful advice for my work. I thank Raunulph Greenville and Dale Rusell who inspired me with their advice.

I would like thank many supporters, contributors, and collaborators in my work, particularly So-young Roh at Art Center Nabi, Do-young Kim at SK Telecom, Dong-jun Lee at SK Networks, Jun-ki Park and Suk-hyun Sung at Top Nanosis, Soo-in Bahk at GIS Lab, Eunyoung Cha at Gallery I, Jungsun Lee at Samsung SDS, So-young Kim at the Ministry of Culture in Korea and Jae-wook Shin at Korean Broadcasting System. Special thank to Sang-leem Lee at Space Group and Korean Institute of Architects who supports with constant interest and consideration.

I thank my mentor, friends and colleagues for their sympathetic advice and inspiring comments in my work. I am profoundly grateful to Jeremy Ansley for his considerate advice and guidance. Without his sympathetic interest, my work once in unexpected troubles could not have finalized. I thank Meejin Park at Incheon National University for her unconditional supports and interest. I thank Sheila Clark, my friend, colleague and mentor, who encouraged me with her sincere comments. I thank Alison Wright, Urbonas Julijonas, Emila Serra, Chrysostomos Tsimourdagkas, and Matthew Flintham and IDE and RCA research colleagues for sharing their brilliant inspiration and innovative thinking. I thank Neil Taylor, Yoonjeong Han and all IDE staff, particularly Panos Deliabros for his helps. I thank all my friends in RCA for their helps.

I specially thank my parents, my parents in law, and my sisters and brother for their unlimited love, affectionate concerns and patience. I would really love to thank my angelic husband, J.C. Lee, for his tremendous support and love.

# ABSTRACT

Human spatial experience has recently expanded due to the development of location-aware technology. Locative information has become more significant within urban space; as such, related discourses have attempted to focus on the issue as a way in which we acquire locative information when we experience space. Digital location-aware methods enable the demonstration of live densities of telecommunication through which one can infer temporal and spatial factors of live urban situations. When locative telecommunication data is mapped onto urban space, temporal-spatial demographic maps are obtained. Based on these maps, one can infer the correlation between spatial experience and architectural programmes via on site observation and by determining the multi-layered structure of spatial experience via designed data installation. These considerations aim to investigate locative interaction in urban space in order to expand spatial experience.

This research begins with two linked theoretical notions: *rhythm analysis* and *heterotopia*—in other words, temporality as it relates to our everyday life and spatiality as it relates to our search for ideal space. In addition to these positions, the following discourses are specifically developed to investigate locative interaction in urban space. Firstly, the temporal and spatial patterns of urban activities are investigated in an attempt to grasp current urban interactions. The telecommunication data is then mapped geographically. Secondly, the gap between the endowed architectural programmes and the observed activities in urban space is explored in order to examine the multi-layered structure of urban interaction. Thirdly, the above discussions are synthesised using a design project that interprets epistemic aspects of this initiative. Lastly, urban rhythms and locative virtual layers are suggested as the concept for locative interaction in urban space where architectural programmes become more flexible, thus expanding spatial experience. Two projects demonstrate as applicable scenarios of locative interaction in urban space; they involve a heterotopia finder and a floating gallery over London.

This research suggests a new viewpoint from which to consider our world and its digital presence by mapping a ‘live urban space’ using telecommunication data—an initiative that highlights the importance of people as a crucial aspect of our digital surroundings. This research ultimately contributes to expanding urban spatial experience and providing an informative and holistic mapping structure for architecture and urban design, interweaving it with the digital environment.

# CONTENTS

LIST OF FIGURES

LIST OF TABLES

# Chapter 1
# INTRODUCTION

The recent development of location-aware technology has significantly expanded the way we experience space. A proliferation of locative applications, such as map-based telecommunication service programmes, can provide a diverse and informative spatial experience in an urban context. Smart phones can inform us about locative information such as where we are in relation to a destination and how long it takes to reach a meeting place. Many locative applications attempt to incorporate users' individual situations into telecommunication applications. As locative information has become more and more significant in urban space, the relevant discourses have attempted to focus on ways in which we acquire locative information in spatial experience. Spatial experience in urban space is accompanied by information acquisition; therefore, this research aims to investigate locative interaction in urban space in order to expand spatial experience.

Urban space in telecommunication fields tends to be defined as space filled with multifarious urban events and the uncontrollable diversity of individual activities in contradistinction to indoor spaces or limited areas (Danaka et. al., 2006)[1]. This definition indicates the complexity of spatial interaction in urban spaces. However, urban activities tend to be heavily correlated with certain functions and features of buildings, streets, and squares. Spatial experience in urban space tends to be guided by functional and operational factors embedded in the built environment, namely architectural programmes. These architectural programmes are be considered and planned within an urban context, which provides the key principle that shapes the physicality of urban space. Urban locative interaction, therefore, should be discussed with reference to architectural programmes.

Architectural programmes are profoundly related to another factor involving spatial experience, human traffic. Human traffic can reveal the live structure of urban space beyond the static built environment. As digital location-aware methods enable us to demonstrate live densities of telecommunication, we can infer temporal and spatial factors of live urban contexts. The mapping of locative telecommunication data onto urban space yields temporal-spatial demographics. If data visualised maps are analysed by comparing data shifts and architectural programmes in certain spaces, one can infer the correlation between urban activity and architectural programmes. The data maps can reveal the interaction between the endowed architectural programmes and the actual activities of people. This can offer detailed and significant information for locative interaction to expand spatial experience.

On the other hand, it is possible to experience a space beyond its physicality. Spatial experience expands beyond what one perceives in a certain space using sensory organs. Spatial experience can change within a single site as its ambience can shift depending on the time of day; this phenomenon is interpreted by adopting the rhythm of everyday life as put forth by Lefebvre. In addition, a person's memories and experiences can be reflected in and projected upon their spatial experience. This means that spatial experience can be accompanied by a self-customisation of a space. This tendency is explored by the gap between the endowed architectural programmes and observed social activities in the urban space. The gap can reveal multi-layered spatial experiences. Given these subtle aspects of spatial experience, this research adopts Foucault's spatial concept of heterotopia. Heterotopias are reinterpreted as the space generated through occupier-centred expansions of specific architectural programmes reflected in urban space. The notion of heterotopia ultimately provides the theoretical position of multi-layered spatial experience, namely mirror space and its programmatic flexibility, which lie at the core of the discourse advancing key attributes of locative interaction.

In addition to these positions, the following discourses are specifically developed to investigate locative interaction in urban space. Firstly, the temporal and spatial patterns of urban activities are investigated in an attempt to grasp current urban interactions: telecommunication data is mapped geographically. Secondly, the gap between the endowed architectural programmes and the actual activities of people in urban space is explored to examine the multi-layered structure of urban interaction. This is done via on-site exploration and observation. Thirdly, the above discussions are synthesised using design to interpret epistemic aspects of this initiative. Lastly, urban rhythms and locative virtual layers are suggested as a concept for locative interaction in urban space where architectural programmes become more flexible, thus spatial experience is expanded.

## 1.1. Thesis Outline

This thesis is composed of nine Chapters:

Theoretical positions and a framework for locative interaction in urban space will be demonstrated in Chapter 2. The positions involve two linked philosophical themes: rhythm analysis and heterotopias, which in this case refer to temporality and its relation to everyday life and spatiality as it relates to the search for ideal space. Moreover, the three-dimensionality of the production of space is applied to these theories to offer a framework for the methodologies and discourses: the practised, the perceived and the imagined.

Chapter 3 will describe three research methodologies: data visualization, observation and epistemic design. Data visualization will be adopted first to conduct quantitative visualization of urban digital communication through which spatial occupancy will be investigated. Secondly, observation will be conducted to scrutinize the relationship between urban planning programmes and people's activities in urban space via geographical distributions of telecommunication data. Lastly, an epistemic design project will be employed to synthesize findings and develop discourses related to locative interaction reflecting live urban space.

In Chapter 4, telecommunication data collection is described in detail. Retrieved data will be statistically analyzed to find patterns. These will demonstrate how telecommunication data represents an urban rhythm of everyday life. Additionally, the identifiable patterns of data change in individual cell spaces are analyzed statistically, which reveals the pattern of urban activity in respective cell areas—the implication being that urban spatial experience is affected by temporality.

Chapter 5 demonstrates 2D and 3D visualizations, which are created by mapping the spatial and temporal contexts of telecommunication data. The amount of mobile communication from base stations is temporally and spatially represented by juxtaposing it with the coordinates of urban space in order to reveal the territorialization of telecommunication. This process demonstrates the rhythm of spatial occupancy and reveals temporal and spatial shifts of the interaction between people and the built environment.

In Chapter 6, the correlations between actual activities and architectural programmes will be investigated via an in-depth, on-site study of urban interactions. This observation will be conducted using temporal trajectories generated by connecting the areas with the highest data levels from temporally arrayed 2D maps.

Chapter 7 develops the design project to synthesize findings from the above investigations (statistical analyses, data visualization and observation) and develops the discourse of locative interaction in urban space. The design semiotics of this LED installation will also be reviewed with respect to epistemological design.

In Chapter 8, urban rhythm and locative virtual layers will be demonstrated as concepts of locative interaction in urban space. More specifically, the design factors of urban rhythm are temporal-spatial coordinates and live data considerations. The locative virtual layer is embodied by mirroring and layering as design factors.

Chapter 9 demonstrates two relevant projects of applicable scenarios with value scenario, which reflect the concept of locative interaction to expand spatial experience: one being a heterotopia finder that guides one's spatial experience (wandering, arranging meeting points and/or browsing locative information) as an individually tailored informative map; a second being floating galleries in London using a hypothetical plan of cell spaces superimposed on the urban structure of the West End. An architectonically structuralised digital presence will be generated to contain location-based, time-related, and even user-tailored programmes that reflect architectural programmes in a physical urban space. The urban space, therefore, obtains programmable flexibility thus enabling expansion of spatial experience.

Chapter 10 includes concluding remarks including summary, contribution, limitations and future work.

This research provides several contributions towards a new way of perceiving the world where physical and virtual space are interwoven, the understanding of the interaction between people and the built environment, and the ways of information acquisition and communication in urban space.

## 1.2. Glossary

**Architectural Programme**: A plan of anticipated activities to be carried out in an architectural context, which is generated by information management in architecture[2].

**Base Station**: A signal transmitter in a telecommunication field.

**Cell Space:** The area covered by electronic waves of the base station

**Design Epistemology**: 'Design epistemology is distinct from analytic methodologies, which is crucial to develop scientific initiatives. Compared to the analytic methodology of science, design as epistemology relates to the synthetic methodologies of implementation'[3].

**Design Semiotics**: The semiotics of design is a study of the symbolic qualities of man-made forms in the cognitive and social contexts of our use and the application of the knowledge gained to objects of industrial design[4]

**Heterotopias**: Heterotopias can be reinterpreted as the space generated through occupier-centred expansions of specific architectural programmes reflected in urban space.

**Live Urban Context**: This term is used to stress continuously changing human traffic in urban space which is a key component in spatial experience.

**Location**: In this research, the informative positioning node of the urban context.

**Locative Interaction:** The direction of applicable research in ubiquitous computing. In information and communication, location is considered as one of the more significant contexts. Recently, location-aware technology has become important to accessing hand-on information through a map on a mobile phone. Locative interaction in this research is the way that people's communication and information acquisition is based on locative information in the urban context. (See more in Section 2.3)

**Mirror Space**: This analogy was adopted by Foucault to describe heterotopias. The image that you see in a mirror does not exist. Foucault argues that this image in a mirror is a metaphor for utopia. It is also a heterotopia because the mirror exists as part of real objects[5]. (See more in Sub-section 2.2.1)

**Mode 1 and Mode 2**: Gibbons (1994) used the terms Mode 1 and 2 to describe the process of knowledge acquisition and its evolution. The old paradigm of scientific discovery (he called it 'Mode 1') is characterized by the hegemony of theoretical or, at any rate, experimental science; by an internally-driven taxonomy of disciplines; and by the autonomy of scientists and their host institutions, the universities. The old paradigm ('Mode 1') has been being superseded by a new paradigm of knowledge production ('Mode 2'), which was socially distributed, application-oriented, trans-disciplinary, and subject to multiple accountabilities[6].

**Programmatic Flexibility**: the flexibility of architectural programs in urban space.

**Spatial Experience:** the way that we experience space.

**Spatial Occupancy**: the act of using a building or a certain type of urban space.

**Technological Intervention**: technological involvement in order to improve the spatial experience.

**Ubiquitous Computing:** 'ubiquitous computing'. Since Mark Weiser coined the concept of ubiquitous computing in 1991[7], a prescient view of the future of the silicon-based information society, it has inspired diverse fields ranging from sociology to architectural design.

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1 Danaka et. al., (2006) 'A framework for Spatial Interaction in Locative Media' In: Nobert Shunell, (eds), *NIME06 International Conference on New Interfaces for Musical Expression*, 04-04 June 2006, Paris, France: IRCAM, 26-30

2 Duerk, Donna P. (1993) Architectural programming: Information management of design, New York, Wiley, pp.8

3 Mahdjoubi, Darius (2003) *Epistemology of Design*, Integrated Design and Process Technology, IDPT-2003, The Society for Design and Process Science, Printed in the United States of America, June 2003. pp. 1-5.

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[5] Foucault, Michel (1967) 'Of other space' In: Dehaene, Mitchel et.al., (eds) *Heterotopia and the City: Public Space in a Post-civil Society*, London: Routledge,p13-30
[6] Nowotny, Helga, et al. (2003) Mode 2 Revisited: The New Production of Knowledge, *Minerva* 41, pp. 179
[7] Weiser M. (1991) The computer for the 21st century, *Scientific American*, 265(3): p94-104

## Chapter 2
# POSITIONS AND CONTEXT

The subject of locative interaction, particularly when reflecting the live urban context, should be investigated at the intersection of time and space: spatiality is inseparable from temporality, particularly in the live context of the built environment. Our city is not static like city images seen in a well-presented photograph. Urban space is alive as the stage of our everyday lives and as the realization of our desires and dreams. Urban spatial experience occurs in the practice of everyday life in these spaces, and this results in the pursuit of an ideal of our own adjustable space. Urban spatial experience is performed in 'lived time[1]', which is beyond calculable time. On top of 'lived time', we tend to seek our own 'other (individually desirable) space[2]' in real urban space. This research, therefore, adopts rhythm analysis and heterotopias as philosophical positions regarding temporality and spatiality in our everyday life.

The two philosophical positions provide the viewpoint regarding how to interpret urban telecommunication data as a digital technological intervention. The statistical analyses and visualization of telecommunication data will be conducted as 'rhythm analyses'. The rhythm analysis in Section 2.1 is not a kind of scientific analysis but an attitude and an orientation of understanding of the interrelations between space and time[3]. Heterotopia, as an experiential spatiality in Section 2.2, offers a theoretical model of a final destination of this research, a concept of locative interaction reflecting live urban space. The dual logic of mirroring one's dreams and desires in relation to physical space and the ambiguity of spatial experience in heterotopias will produce a specific discourse (programmatic flexibility) allowing the expansion of spatial experience discussions via example projects. In Section 2.3, the framework to generate a concept of locative interaction through expanding spatial experience will be adopted from the production of space and will include experience, perception and imagination.[4] These three processes explain the way we develop discourses (by heterotopias) via methodologies (by rhythm analysis).

## 2.1. Rhythm as Live Context

We generally understand time as chronological time represented by hours, minutes, and seconds. This numerical representation of time seems to provide accurate structure for events. However, time is a human notion, which reflects our everyday life. It cannot, therefore, be demonstrated merely by a linear and numerical method.

Time is a crucial philosophical subject with diverse viewpoints. Amongst these is that of Henri Lefebvre who has portrayed the temporality of repetition and cycle as ‘rhythm analysis’. His notion of temporality has been influential in contemporary academic thought. A number of David Harvey’s writings are representative examples of this. Harvey, a widely influential geographer and social theorist, adopted Lefebvre’s notion of temporality to demonstrate the contemporary experience of space and time[5]. This notion of time is primarily derived from rhythm rather than numerical time.

Contrary to chronological time, rhythm is lived time that is not simply linear but cyclical (Lefebvre 2004)[6]. The temporality of rhythm reflects our biological time (heartbeat, sleeping and hunger) and social time (working and education) in everyday life. Biological time is increasingly conditioned by the social environment and working lives. This means that the rhythm of our bodies tends to be increasingly subject to social time. Furthermore, social time is connected with spatial occupancy. Most social time is enacted in certain function-given spaces. For example, factory and office buildings are used for working time. Therefore, the rhythm of social time can be revealed by people’s spatial occupancy. This kind of notion of time is important in perceiving the temporality of urban telecommunication since communication is connected with the rhythm of everyday life. This research takes note of the mechanism between time and space mediated by (people’s) occupancy. It can be traced by telecommunication data collected from locative references (base stations).

Urban space as a stage for urban issues is comprised of everyday events that include ‘rhythm’, with repetitions of day followed by night. This everyday rhythm is one of the main positions in this research. Lefebvre’s narrative of space and time, the production of space, indicates that space is generated and regenerated as a complex social construction (Lefebvre 1991)[7]. My viewpoint throughout this thesis has been shaped by these philosophical contemplations, which interweave space, time and communication by demonstrating that our city space carries the attributes of media.

Lefebvre’s concept of rhythm is strongly related to the frequency of repetition of an action (Lefebvre 2004)[8]. There are two kinds of rhythms: cyclical rhythms and linear rhythms. An example of a cyclical rhythm would be day fading into night, and night brightening into day; a linear rhythm can be seen in the accumulation of knowledge, development of culture and in news broadcasting[9]. The two rhythms can be complementary to each other. For example, the broadcast of the local news is set by time intervals throughout the day and the week. This means that news is being released (linear time) every morning or night (cyclical time). In this research, telecommunication data is collected by a cyclical rhythm, 24 times every day of the week. Additionally, telecommunication data itself is generated by a linear rhythm. This representative figure of everyday practice will be visualized and interpreted under the position of rhythm analysis.

## 2.2. Heterotopias and Spatial Experience

Once the rhythms of everyday life in urban space are revealed via telecommunication use, we can question the meanings of these rhythms, namely the patterns of temporal and spatial shifts of telecommunication data. Rhythms can become temporal and spatial indicators of how people occupy urban space, a kind of representation of spatial experience.

However, spatial experience does not simply mean that we perceive a certain space with sensory organs. Our previous memories can be reflected upon spatial experience as we are able to experience a space beyond its physicality. This means another position to interpret the meanings of rhythm is needed; this research adopts a spatial notion to explain multi-layered spatial experience; this is Foucault's concept of heterotopias.

### *2.2.1. Mirror Space*

Foucault (1967) describes heterotopias as the space where we experience heterogeneous functions at once via reinterpreting them in an individualized way. Contrary to the traditional viewpoint of architecture creating the physicality of the built environment, Foucault adopts the concept of the mirror to depict his notion of heterotopia. The image that one sees in a mirror does not exist. Foucault argues that this image in a mirror is a metaphor for utopia. It is also a heterotopia because the mirror exists as part of a canon of real objects[10]. It is a metaphor of the contradiction inherent in utopia and of the symbiotic relationship between utopias and heterotopias due to the mirror's potential to provide a virtual world behind the surface. In Foucault's original discussion of utopias and heterotopias in the essay 'Les Mots et les Choses' (1966), the spatial trope of heterotopias is demonstrated by describing a range of disparate space-times in terms of a mirror, a brothel, a vacation resort, a library or a museum. All of these share the characteristic aspect of revealing that 'I am there and yet I am not', as in the reflection of a mirror. Heterotopias are compensatory 'other spaces' and contesting counter-sites where both real and illusory spatiality can coexist (Boyer 2008)[11]. The 'other space' thus has a dual logic. It is a 'space of contestation and reverberation, never closed nor completed but open to constant reinterpretation and invention' (Boyer 2008)[12].

Foucault specifically articulates six kinds of heterotopias. Firstly, a ‘crisis heterotopia’: a separate space such as a boarding school or a hotel room where activities such as coming-of-age or a honeymoon take place, out of sight. Secondly, ‘heterotopia of deviation’: an institution where we place individuals whose behaviour is outside the norm (hospitals, asylums, prisons, rest homes, and tombs). Thirdly, the heterotopia that has the power of juxtaposing several different spaces and locations that are incompatible with each other in a real place: the theatre alternates as a series of places that are alien to each other. Fourthly, heterotopias are mostly connected to segments of time. They open up through what we might define as a pure symmetry of ‘hetero-chronisms’[13]. Examples of this are a museum or library, where time is accumulated constantly. Fifthly, the heterotopia of ritual or purification is a space that is isolated and penetrable yet not freely accessible, like a public place: examples of this include the sauna or hammam. Sixthly, heterotopia has a function in relation to all of the remaining spaces. A heterotopia of illusion creates a space of illusion that exposes every real space. In addition, the heterotopia of compensation creates another real space (Leachy 1997)[14].

| **Type** | **Space in reality** |
|---|---|
| Crisis heterotopias | a boarding school<br>a hotel room |
| Heterotopias of deviation | hospitals, asylums, prisons, rest homes, and tombs |
| The heterotopias juxtaposing a few different spaces and locations | a theatre<br>a garden |
| Segments of time | a museum or library |
| The heterotopias of ritual or purification | a sauna |
| All of the remaining spaces | |

Table 2- 1. The principles of heterotopias

From these six characteristic heterotopic contexts, this research primarily focuses on the third (heterotopias juxtaposing a few different spaces and locations) and the fourth (the heterotopia of time).

The third attribute of heterotopias can provide a key concept to design locative interaction. Real sites juxtaposing incompatible and different spaces and locations (the third principle of heterotopias) can reveal multi-faceted spatiality in our everyday life. It hints at what and how locative interaction should follow. This is because the built environment tends to focus on certain functions rather than reflect spatiality derived from individual experience related to heterotopias. Physicality of the built environment endowed by functions or programmes can affect (precisely guide) and at the same time limit our spatial experience. In this respect, if we consider the third principle of heterotopias as multifaceted spatiality in designing locative interaction, we can design more effective and efficient interaction based on location that will provide better communication and information acquisition.

As temporality should be considered in terms of the live urban context for locative interaction, it can be investigated through the notion of ‘heterotopias of time’ which is connected with ‘slices of time’ (Soja 1996)[15]. This explains why the temporal factor is adopted as a key chronological calibration to trace changes of digital footprints through visualizing telecommunication data in urban space. As in museums or libraries, two representative examples of heterotopias of time, accumulated time within a day will be represented by data relating to telecommunicative uses. In addition to this, the density of data visualizations calibrated from the hourly time-layers will be analyzed to identify temporal trajectories that will provide a way within urban practice to observe human activities in the space of the city. Time layers will therefore provide the design intervention of an epistemic design project and will be used to develop discourses of locative interaction.

### 2.2.2. Architectural Reflections

- ***Ambiguity and Programmatic Flexibility***

It has been suggested that the notion of heterotopia may not be relevant in designing the built environment. This is because of an ambiguity relating to heterotopias: namely, that their meanings and functions can be altered over time (Soja 1996)[16], while architectural processes tend towards making abstract information into concrete forms and shapes through architectonic language. This ambiguity conflicts with the ‘compositional totalization’ characteristic of architectural practice: i.e. to arrange specific architectural programmes and then actualize their diverse tectonics in urban space.

This conflict can be interpreted as the confrontation (or gap) between the nature of spatial experience and the static physicality of the built environment. Although the built environment is statically located, spatial experience is dynamic and somewhat arbitrary. The static space can be interpreted depending on an individual’s spatial experience. This is one of the primary attributes of heterotopia.

We experience heterotopias in urban space; in particular, public space tends to function as individual heterotopias for people. For example, vibrant and busy streets in a commercial district become individual heterotopias when we want to shop. Small civic parks near workplaces become heterotopias when we need a break. The urban theme park becomes a heterotopia when we want to enjoy family time. All these examples are related to spatial experience beyond the physicality of urban space. This means that there can be a gap between architectural programmes in the built environment and the actual spatial experience. Although architectural programmes tend to guide people's activities in urban space, an individual's spatial experience can vary. Therefore, heterotopias can be reinterpreted as the space generated through occupier-centred expansions of specific architectural programmes reflected in urban space. If architectural programmes become flexible, our spatial experience can be enhanced, and urban space can provide a more user-focussed and tailored environment. In this respect, the ambiguity of the heterotopia can be developed to advance the idea of a 'programmatic flexibility' in the built environment.

- ***Architectural Examples of Programmatic Flexibility***

Programmatic flexibility can be seen in a kind of void space, such as squares or plazas in front of cathedrals or monumental buildings. These grand anterior areas were positioned as symbolic spaces to reveal nearby buildings distinctively and to present the dignity of the buildings from their conception. However, as urban structure and society has changed, the functions and meanings of these void spaces have shifted. This 'absence' (void) in architecture facilitates shifts in their architectural programmes, in contrast to a presence, which would be filled with buildings and settings. Figure 2-1 is an example of how an urban void reveals programmatic flexibility in the built environment. The front courtyard of Somerset House, London, has been used for different architectural programmes depending on the time and situation. Marquees have been placed there for diverse exhibitions. An ice-skating rink and fountain support seasonal event programmes. Here, programmatic flexibility in the void of the front courtyard complements the solidity of specific programmes in the current building, endowing it with the possibilities of expanding spatial experience beyond the constraints of time and space.

Figure 2- 1. Fountain[17] and Ice-skating rink[18] in Somerset House, London

However, absence in architecture does not always embrace the issue of programmatic flexibility due to the limitation of physicality. Programmatic flexibility, being beyond physicality, has played an important part in contemporary architectural discourses. The attempt to be free of physicality has produced architecturally imaginative scenarios in the manner of 'paper architecture'. *Exodus, or Voluntary Prisoners of Architecture, Exhausted Fugitives Led to Reception* by Elia Zenghelis and Rem Koolhaas (1972) (Figure 2-2) is a representative work of this kind of architectural scenario. This project demonstrates an 'architectural oasis in the behavioural sink of London' (Kipnis 2002)[19] through a programmatic strip cutting through the centre of London. This titanic strip void between the walls contained 11 squares offering narrative architectural programs[20]. The walls running through London are metaphors of elimination as they symbolize the protection of 11 squares including flexible (and imaginative) architectural programmes that can be removed and reused from the old city. These protected squares represent 'a mirror of architectural mythology' (Boyer 2008) according to a dual logic: a mirrored discourse between urban utopia and architectural divergence. Paradoxically, this project mirrors narratives of desires and dreams of contemporary architecture through the extreme strip plan divided by the walls. This can be seen as a fictive scenario of programmatic flexibility to expand spatial experience, which can enhance the interaction between people and the built environment. In this project, architectural imagination liberates the limitation of physicality by way of programmatic flexibility.

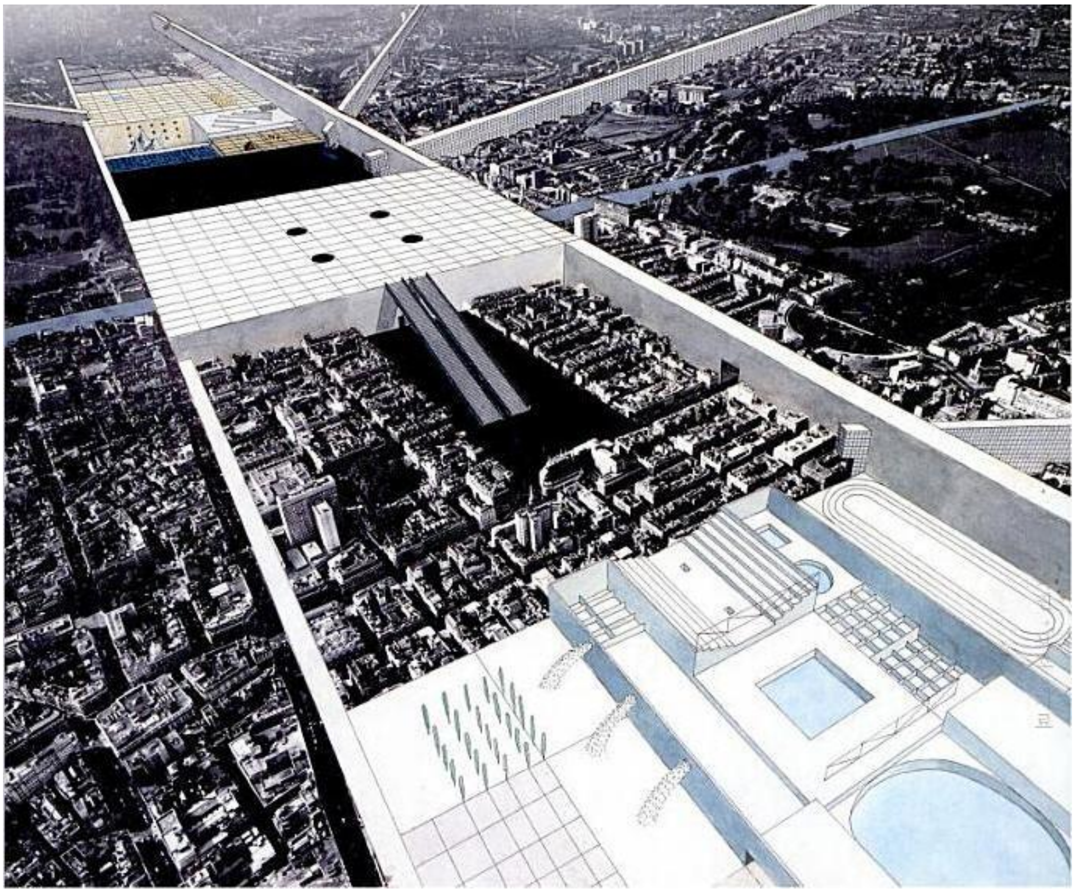

Figure 2- 2. 'Exodus, or Voluntary Prisoners of Architecture, Exhausted Fugitives Led to Reception', Rem Koolhaas and Elia Jenghelis (1972)[21]

Moving on from this, we can adopt another, stronger intervention to obtain programmatic flexibility in order to expand spatial experience beyond the limitation of physicality. This is through technological intervention such as telecommunicative devices, digital presence and digital communication applications that enable the expansion of the built environment via an invisible electronic presence. This enables a programmatic flexibility, one that is strongly connected with expanding spatial experience using communication and information acquisition. If the attributes of this invisible electronic presence are revealed, particularly in real time, we will be able to recognize a way to obtain more programmatic flexibility and expand spatial experience for locative interaction.

## 2.3. Locative Interaction

### *2.3.1. A Definition of Locative Interaction*

The framework for this research follows the dual logic of heterotopias. This duality provides the concept of a mirror structure as well as programmatic flexibility; both factors are generated by contextual approaches. Although we experience spatiality at a certain location, this location cannot be separated from others. The matter of locative interaction and locative information should be interpreted with this in mind.

Location in communication and information technology can be understood as ‘geographical embedding including positioning and diverse information’ (Edwardes, 2009).[22] Location-based interaction in this research means the interaction between people and locations, including information. A different kind of information in certain locations is likely to be linked with an urban context. Communication and information acquisition based on location should be considered within people’s spatial experience, as influenced by a live, urban context. This is because locative communication is inevitably accompanied by people’s spatial experience. In accordance with this, locative communication and information acquisition should be considered in an urban context related to spatial experience rather than solely focusing on a locative position. Context in the built environment includes human traffic and human spatial occupancy. Therefore, location in this research means the informative positioning node of the urban context. Locative interaction is the way that we experience space based on locative information in an urban context, which can yield high levels of communication and information acquisition.

### *2.3.2. A Framework for Location Interaction*

Generating the concept of locative interaction in urban space involves producing a new digital space and the possibilities of expanding spatial experience by technological intervention. This includes how to design the digital spatiality enhancing locative interaction in urban space, which is the core discourse in this research. As discussed above, the theoretical model of this digital spatiality is heterotopias reflecting the rhythm of everyday life. The rhythm is traced using telecommunication data collected in urban space. The spatial attribute of heterotopias (ambiguity) conveys the attribute of this digital spatiality (programmable flexibility) for locative interaction. More precisely, this project addresses how the physical urban space can obtain programmatic flexibility for better locative interaction through telecommunication intervention.

This discussion begins with the current situation of interaction between people and the built environment. It develops through the framework of the production of space suggested by Lefebvre and readopted by Harvey (Lefebvre 1991; Harvey 1990). The production of space has the three dimensions, namely the experienced, the perceived and the imagined, which have dialectic relationships and demonstrate the production of space experienced in everyday life.[23] This framework of three dimensions indicates the phases of space production with which we should develop the digital spatiality for locative interaction (Table 2-1). Each phase of space production is discussed in detail below.

| **Production of space**[24] | | A.<br>Spatial practice<br>(The Practised) | B.<br>Representations of space<br>(The Perceived) | C.<br>Space of Representation<br>(The Imagined) |
|---|---|---|---|---|
| | | Physical Infrastructure | New system of mapping; Architectural discourses | Imaginary landscape; Science fiction ontologies and space; Artists' sketches |
| **Digital Space** | | Cell spaces;<br>Base stations | Geography of Telecommunication | Location of Representation |
| **Methodology** | Rhythm analysis | Data Collection<br>Statistics | Data Visualization<br>Observation | Epistemic Design |
| **Discourses** | Heterotopias: Programmatic Flexibility | The temporal and spatial patterns of telecommunication: | Geography of spatial experience:<br>Altering spatial occupancy and heterotopic attributes:<br>Existing programmes and programmatic flexibility | The mechanism of Programmatic Flexibility for expanding Spatial Experience |
| **Design Works** | | | - 2, 3 and 4D visualized data maps | - Data installation<br>-Applicable scenarios |

Table 2- 2. A Framework for designing locative interaction in urban space

- ***Spatial Practice: Cell Space (Table 2-1, Row A)***

Firstly, spatial practice is conducted on the level of physical infrastructure such as transport and communication-related infrastructure and the built environment. This dimension encompasses the physicality of spatial experience. From a digital communicative viewpoint, one's spatial experience can be affected by an array of electronic apparatus in the urban space. When making a mobile phone call, one must be within a certain radius of cell space generated by base stations (electronic wave emitters). On this level, data collection from cell spaces and statistical analysis will both be discussed to identify the temporal and spatial patterns of telecommunication data. These patterns can be a factor for architectural programmes that affect spatial experience. This will provide fundamental research for temporal and spatial interaction between people and urban space, which is traced using telecommunication data.

- ***Representations of space: Representational Geographies of Telecommunication (Table 2-1, Row B)***

Secondly, on the level of ‘perception’, we can generate representations of space. Examples of this level include new systems of mapping, visual presentation, new artistic and architectural discourses and semiotics. The dimension of perception in the production of space will provide methodologies to decode and interpret telecommunication data related to spatial experience in this research. Three relevant methodologies positioned within rhythm analysis include data visualization, observation and epistemic design. Data visualization is adopted to produce geography of spatial occupancy as an indicator of spatial experience and interaction between people and urban space. The interaction will be scrutinized in detail using on-site observation and will then be reinterpreted as having heterotopic attributes by comparing given architectural programmes and actual patterns of activity in urban space.

- ***Spaces of Representation: Locative Interaction (Table 2-1, Row C)***

Thirdly, on the level of ‘imagination’, we can produce the spaces of representation, such as imaginary landscape, science fiction ontology, mythologies of space and place, and space of desire[25]. In fact, this research is to suggest a production of new space where our spatial experience can be expanded.

Visual representations of urban telecommunication space will be developed into a concept at an imaginative level using an epistemic design project. The project will synthesize discourses of locative interaction through inspirational images of data installation and will provide a background of programmatic flexibility through which we can locatively interact with urban space. The correlations between given architectural programmes and actual patterns of activity will convey the possibilities of programmatic flexibility in urban space through technological intervention, which comes from the ambiguity of heterotopia, will provide a concept of locative interaction reflecting telecommunication traffic. This concept may effect what kind of space we can perceive and experience and will be demonstrated via applicable scenarios.

Bearing all these in mind, the following specific research questions arise:

- How are the temporal and spatial patterns of urban activities traced by telecommunication data?

- What is the correlation between urban activity and architectural programmes on site?
- How can a design project synthesize urban rhythm and heterotopias?
- What is the concept of locative interaction that expands spatial experience and its applicable scenarios?

## 2.4. Related Works

Coined in 1991, Mark Weiser's concept of ubiquitous computing[26] (the penetrating view for the future of a silicon-based information society) has inspired diverse fields of inquiry, ranging from sociology to architectural design. Weiser hoped that the concept of ubiquitous computing would allow computers to vanish into the background like writing, the first information technology (Weiser 1991) [27]. Under this influential direction for information technology, its applications have researched while trying to trans-discipline with diverse fields. The ideas surrounding information communication technology bring together the heterogeneous fields under the topic of interaction between human and computer, which are exemplified with the name of interactive art, interaction design, new media works and so on.

### *2.4.1. Location Related Works*

The advent of location-aware technology has been expanded to telecommunication projects in the level of urban space. This also started to be developed by lab-based projects such as *Urban Tapestry* and *Wiki City.* Although these were not released as a telecommunication service programme to the general public, these commonly show highly specific locative applications through connecting the digital environment and urban space.

Urban Tapestry has been developed by 'Proboscis[28]' as a research project and an experimental software platform for knowledge mapping and sharing (Figure 2-3). It combines sociological approaches and cultural production, which have been developing a prototype system for accessing and publishing location-related content digitally. In addition, it creates sound maps of environments and journeys that can be shared remotely (Lane et.al. 2003 and Angus 2008)[29].


Figure 2- 3. Urban Tapestry: Wireless networking, public authoring and social knowledge

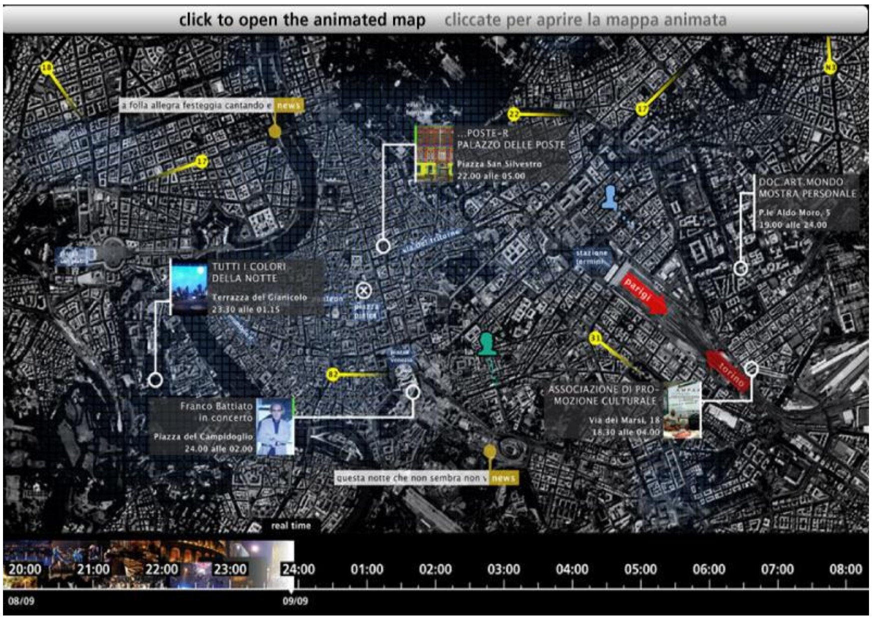


Figure 2- 4. Wiki City being conducted by Sensible City Lab in MIT media lab

However, urban tapestry is based primarily on communication in a community rather than universal areas of a city although the research team argued that it can be applied to urban space. On the other hand, the Wiki City in the image above focuses on urban space rather than a certain specific community area (Figure 2-4). Wiki City[30], which is being conducted by Sensible City Lab at MIT, demonstrates one of the potential uses of location-based applications. This project focuses on creating a location and time-sensitive platform for storing and exchanging data, making it accessible to users through mobile devices, web interfaces and physical interface objects. This communication platform enables people to obtain location-based information in real time.

The subject of locative interaction led by creative labs has been developing via approaches interconnecting locative information and real space. In the workshop on Mobile

Spatial Interaction at CHI 2007, Fröhlich and his colleagues categorised relevant application projects as the belows[31];

- Navigation and Way finding
- Adding content to physical places or objects
- Accessing information attached to physical places
- Mobile virtual and augmented reality

In the recent trend of locative service applications, we can search location-based information matched with a map in mobile phone. The prevalence of revolutionary smart mobile phone*, for example, i-phone* released in 2007*,* has brought diverse locative applications. Touch-screens, intuitive input system, high resolution camera, ubiquitous connectivity such as 3G and WiFi networks enable us to continuously produce and share geospatial contents (Bilandzic and Foth, 2012)[32].

Location-based applications for navigation and way finding popularly combine with tagging and sharing individual geospatial experience (Espinoza, 2001;Lane 2003)[33] [34]. Social networking tends to be added on top of these applications (Nakayama et. al., 2006)[35] (Figure 2-5). Specific information about restaurants and various shops can be tagged, rated, and shared via mobile applications. Locative matchmaking programmes can organise instant meetings in real space, which were previously enabled primarily only in virtual communities, such as 'Second Life'.


Figure 2- 5. Left two images: 'Locmarker', right two images: 'Location Manager'. 'Locmarker[36]' released by Cindy Xintong in 2010 and 'Location manager[37]' released by Sepia Apps in 2012 show a type of individually customized navigation through putting marks on a map to record of spatial experience.

### 2.4.2. *Augmented reality*

At present, locative information is an important and growing trend in communications. More diverse locative applications are being released and developed, which are commonly augmented by communicative themes, location-aware technology and maps. By adopting a map in addition to GPS, locative applications have revolutionised our communication and information environments.

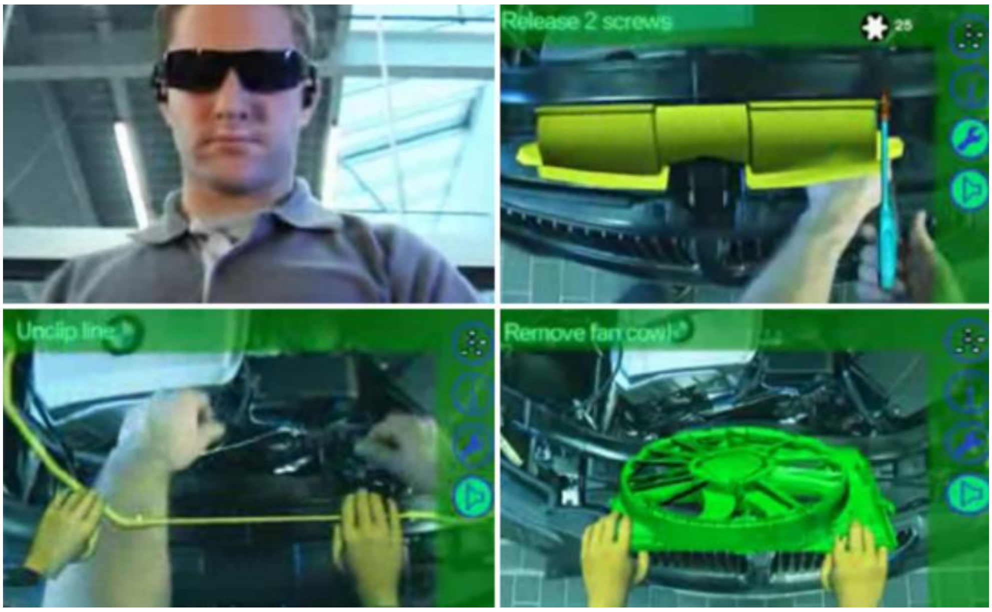


Figure 2- 6. A concept of augmented reality glasses applied in car maintenance has been developed by BMW[38].

With the help of a GPS receiver, digital compass, and accelerometer, geospatial communication is likely to provide us with more immediate information through augmented reality for example. It can be created by integrating virtual objects into 3D real time environments, as a variation of the virtual environment. The different applications for augmented reality have been investigated in at least six areas: medical visualisation, maintenance and repair, annotation, robot path planning, entertainment, and military aircraft navigation and targeting (Azuma, 1997)[39], each of which focus on enhancing specific performances. This trend in applications can be extended to design and architecture. If augmented reality technologies are applied to architectural space this can affect the perception of space and is called 'spatiality' (Korgh 2000).[40] Spatial experience does not solely depend on a few specific criteria, but also on ambience. Augmented reality can change the feel of certain architectural spaces; in fact, we tend to obtain information while experiencing space. As well as specific functionalities that relate to information acquisition and communication, augmented reality can be used to create an aesthetic atmosphere. Adapting augmented reality to architectural space can provide a new way to experience space beyond the purely physical. Furthermore, if it is applied to urban space, our spatial experience can be extended, so transforming information acquisition and communication in urban space.

A number of projects in CASA (Centre of Advanced Spatial Analysis)[41] demonstrate a productive future for geospatial communication in urban planning using augmented reality. Mobile Augmented Reality Navigation Systems for Pedestrians, developed by Sung-Hyun Jang, deliver hand-held accessibility maps of specific visual information related to urban infrastructure (Figure 2-7). It introduces augmented reality and uses it to show the various infrastructures that are imbedded in buildings or buried underground. Infrastructure maintenance workers, for example, can easily get access to these infrastructures[42].

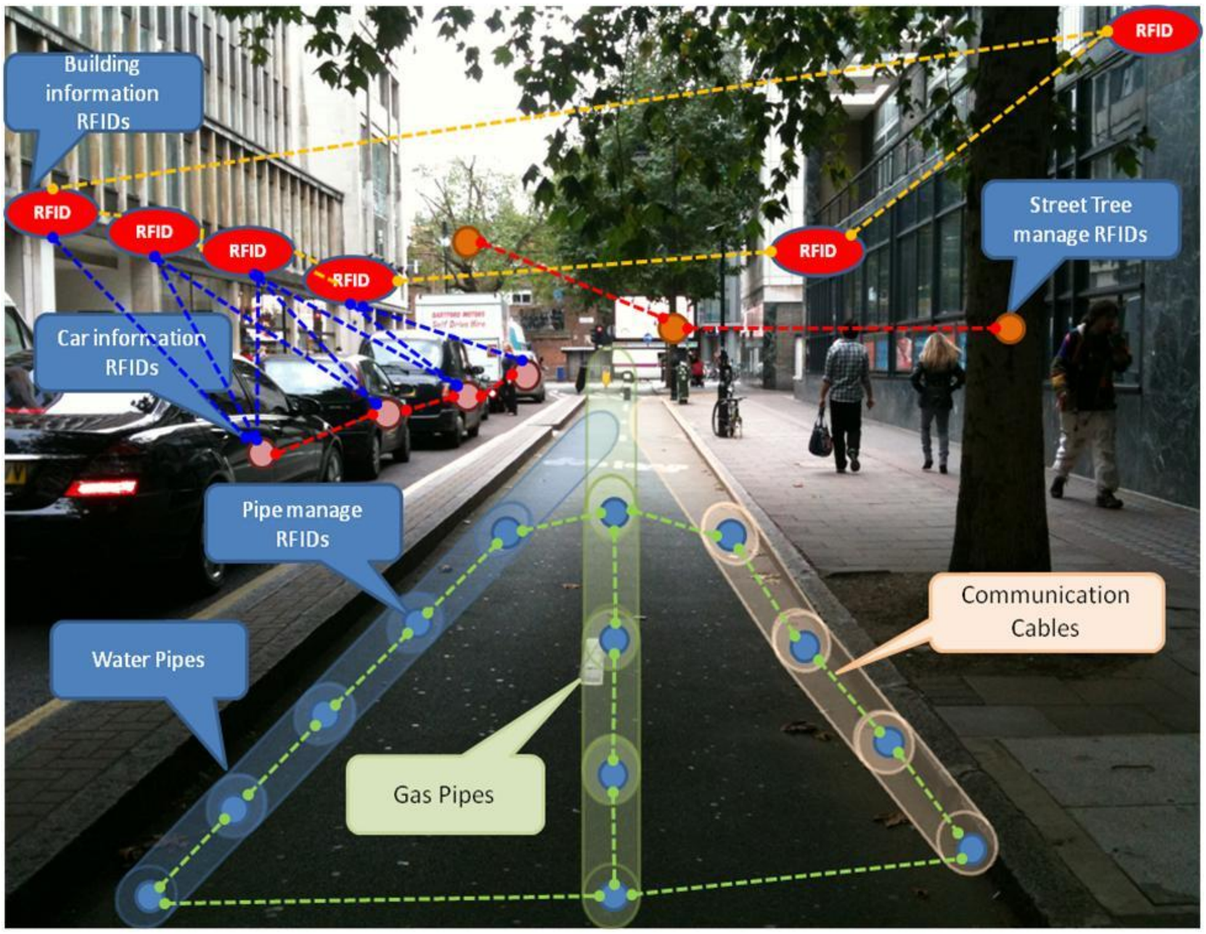


Figure 2-7. Mobile Augmented Reality Navigation System for Pedestrians by Sung-Hyun Jang

Figure 2-8. Audi project (2011), BIG architects: Based on research into inefficiency of land use as car use increases, this road-free system was proposed[43]. Blue arrows in a media floor indicate where cars can go; brown circles show the safe areas for people.

Figure 2-7 shows an urban scenario using a road-free system created by BIG, a group of Danish architects. This scenario demonstrates the possibility for information acquisition and communication in urban space: the blue arrows indicate where cars can go, while the brown circles show the safe areas for people. Without the use of roads, pedestrians and cars can safely negotiate urban space if the direction in which they both move is known in advance via graphically represented information. We do not need to allocate more land to roads as car use increases if we can use the land more efficiently. Although this project does not mention the adoption of augmented reality, this urban scenario can be more easily understood using augmented reality without the construction of additional facilities.

If we adopt augmented reality in urban space, we can experience multiple spaces at once. Also, the spaces generated in augmented reality should be considered within the context of physical space, particularly in the urban environment. In fact, we already experience dual spatiality in the built environment, through physical space and the digital presence provided by maps on our mobile phones. Our spatial experiences traverse physical reality, virtual reality, and mixed reality through ubiquitous connectivity. This ‘hybrid space’ has brought diverse new social interaction and communication patterns that are referred to as ‘net locality’. (De Souza e Silva, 2006; Gordon and de Souza, 2011)[44,45].

Unlike the virtual space represented on personal computer screens, maps (represented on a mobile phone) of locative service programmes express the physicality of our built environment. Most of locative applications related to urban space tend to overlook or less importantly to deal with this fact. Although the physical attribute of the built environment is important in our activity, the current locative works tend to incline to a virtual ground updated by a new technology. However, as the role of the built environment in communication technologies becomes ever more significant, these locative applications become more relevant. Although, as mentioned above, we can experience dual spatiality in the physical environment through mobile devices and digital connectivity, a key component of spatial experience comes from space programmes that are embedded in the built environment, which can guide our activities in urban space. Thus, we will see the correlation between urban activity and architectural programmes through urban activity patterns that can be traced by telecommunication data. This investigation will see programmable flexibility reflecting urban rhythms and heterotopias, which can ultimately expand our spatial experience for new forms of communication and information acquisition.

## 2.5. Summary

Rhythm analysis and heterotopias are adopted as philosophical positions and offer a theoretical model connected with spatial experience beyond physical urban space. The notion of heterotopias (mirror and ambiguity), in particular, indicates the flexibility of spatial experience in specifically programmed urban spaces. This produces the articulation of sub-questions in this research that will provide part of the framework of this project with reference to three dimensions of the production of space: experience, perception, and imagination.

Also, locative-interaction-related works tend to be in four categories (navigation and way finding, adding content to physical places or objects, accessing information attached to physical places, and mobile virtual and augmented reality). Recent works on locative interaction, particularly in urban space, focus on how we can interweave physical and virtual space. Augmented reality is adopted as a tool to actualise this in urban space, which is expected to bring about further innovations in urban communication and information acquisition.

Fundamentally, the matter of spatial experience is related to what kinds of space programmes are provided by the built environment. However, there is a gap (ambiguity) between given programs and actual activities. Actual activities can be traced through the interpretation of spatial occupancy, which reveals the interaction between people and urban space when it is temporally presented. One should investigate the gap by analyzing a rhythmical traffic map. Also, a conceptual terrain (such as digital heterotopias) emerges by representing rhythmical traffic maps as a data installation. This will be further developed into a concept of locative interaction to expand spatial experience.

Bearing all these in mind, the following research questions arise:

- How are the patterns of urban activities traced by telecommunication data?
- What is the correlation between urban activity and architectural programmes on site?
- How can programmable flexibility be represented reflecting urban rhythm and heterotopias?
- What is the concept of locative interaction that expands spatial experience and its applicable scenarios?

The above research questions will be investigated in the following chapters, according to the diagram in the next page (Figure 2-7).

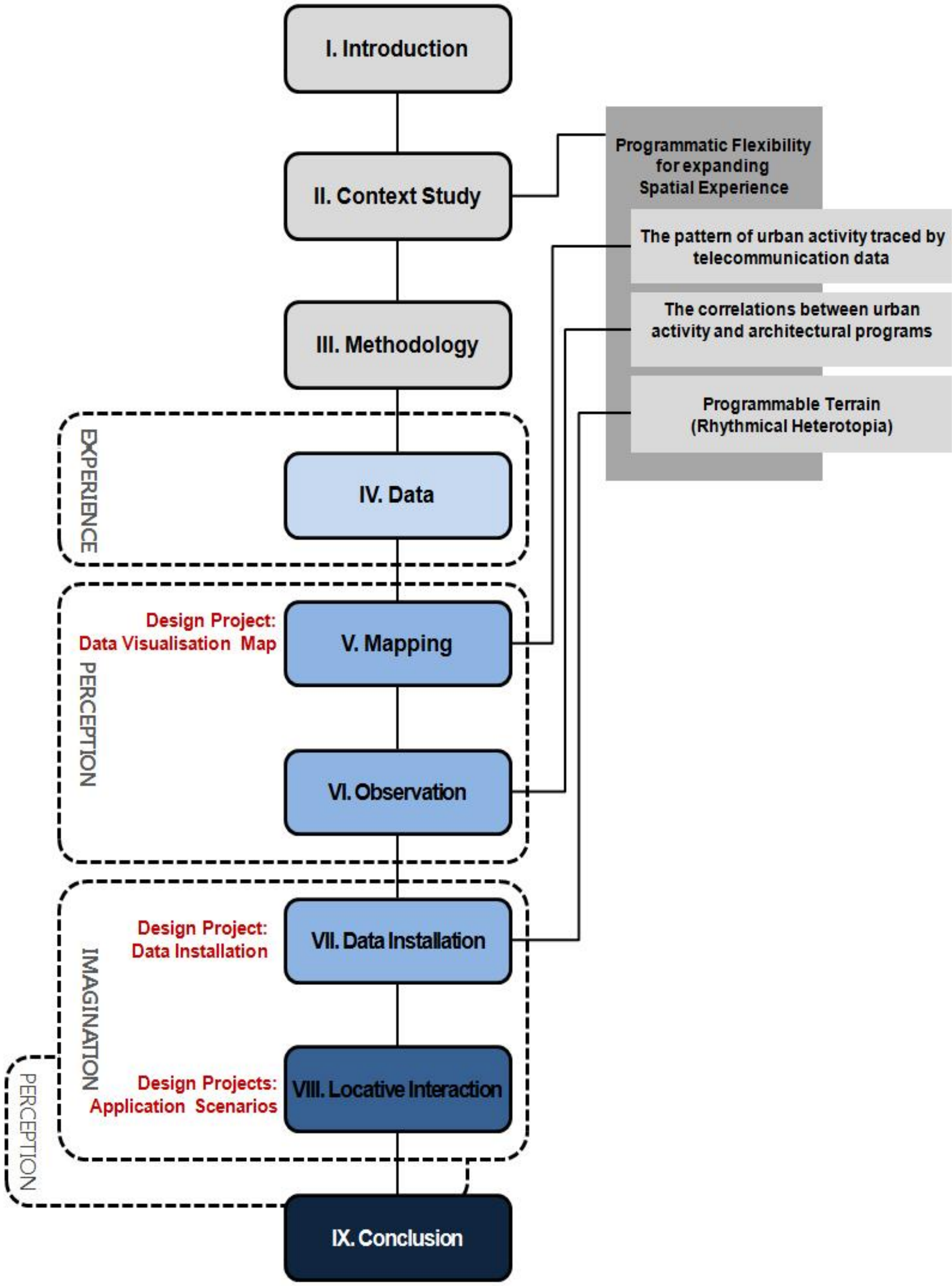


Figure 2- 9. The flow and framework of research

[1]This term is adopted from 'Rhythmanalysis' by Lefebvre: Lefebvre, Henry (2004) Rhythmanalysis, London: Continuum, pp.xi.

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# Chapter 3
# METHODOLOGIES

This chapter demonstrates methodologies employed to design locative interaction in urban space (as outlined in Chapter 2) and discusses how an urban space can obtain the flexibility of architectural programmes in order to enhance spatial experiences via telecommunication intervention.

As mentioned in 2.3, this research deals with locative interaction in ‘hybrid space’ where physical reality, mixed reality and even virtual reality are combined at once. For example, if we use mobile phones to browse for a nearby restaurant, in a certain spot in urban space, using a digital map with preference tags and relevant websites, this can be interpreted as a multi-layered spatial experience, which includes: physical spot reality; digital map with tags; mixed reality and websites; virtual reality.

These different kinds of space are connected via ‘cell space’ generated by a base station. Telecommunication use is enabled under digital presence generated by technological apparatus such as base stations, receivers, and transmitters. Although it is not visible, our everyday life is substantially dominated by this digitalized zone. In fact, we live in a dual structure, comprised of the physical built environment and our digital surroundings. Although both have very different attributes (particularly, in terms of physicality), both can be compatible with each other because they are juxtaposed as if reflecting the mirror structure of heterotopias. Digital presence locatively mirrors our communicative behaviour conducted in the built environment. The behaviour can be traced as data temporally and locatively. When the data is visualized, we can identify the mirror structure between digital presence and the built environment.

Data visualization enables us to identify spatial occupancy by tracing telecommunication data, which can be considered a map of urban interaction. On-site observation is adopted to scrutinize the correlation between urban activity and architectural programmes as an in-depth study of urban interaction revealed by data visualization. Furthermore, design epistemology will be applied to synthesize findings from previously conducted research and to develop the discourse of programmatic flexibility.

## 3.1. Data Visualisation

### *3.1.1. Visualising Data*

The need for data visualisation takes root in the fact that numbers, particularly data sets, are frequently too abstract to be useful. According to *Understanding Media*, by Marshall McLuhan, numbers have been conceived as the language of science, in comparison to letters, which are seen as the symbol of civilisation. Throughout western history, we have traditionally held letters in high regard and looked to our literatures as the hallmark of civilised attainment. Yet all along, the shadow of numbers has haunted us. In isolation, numbers are as mysterious as writing[1]. Numbers, shown as the result of scientific research, are treated as another type of language that is more complicated. There has always been the need to illustrate numerical information with pictorial elements such as graphs and diagrams, to make its content clearer. This is a stable research trend formalised over a period when computing technology has been generating more elaborate and complex data.

The history of data visualisation began with the scientific revolution, although some early pre-17th century maps and diagrams show various types of pictorial information. Friendly (2008) tried to establish milestones in data visualisation developments, as shown in Graph 3-1. The milestone events have been classified by the following questions: What triggered this development? What was the communication goal? How does it relate to other developments? Using these milestones and the development of key elements in graphic methodology, the 17th century is considered the origin of visual thinking. During the 18th and the 19th centuries, numbers relating to people, such as social, moral, medical, and economic statistics, were collected widely and regularly. The usefulness of this visualised data for city planning and government administration were recognised. From this period onwards, the field of data visualisation was considered to be a subject worthy of study in its own right[2,3]. In the early half of the 1900s, there was little development of data visualisation. This trend reversed during the 1950s and the 1970s, a period in which significant research in this field, such as *The Future of Data Analysis* (Tukey, 1962), was published and computer processing of statistical data began. During this period, an archetype of the GIS (geographical information system) and an interactive system for 2- and 3-dimensional statistical graphs appeared, thus providing a foundation for the future development and extension of visual thinking.

Data visualisation research has developed significantly, and the subject has blossomed into a vibrant and a multi-disciplinary research field. This, according to Michael Friendly's "*A Brief History of Data Visualization*", is due to the development of relevant software programmes, a new paradigm of visual data analysis (linking, focusing, and selecting) and increased attentions paid to the cognitive and perceptual aspects of data representation[4]. Taking the afore-described historical background into consideration, we can achieve a definition of data visualisation. It is 'the study of data representation by an abstract schematic form reflecting attributes of information' (Friendly, 2006)[5]. According to Vitaly Friedman (2008), 'data visualisation is a graphical representation [used] to transmit information obviously and efficiently'[6].

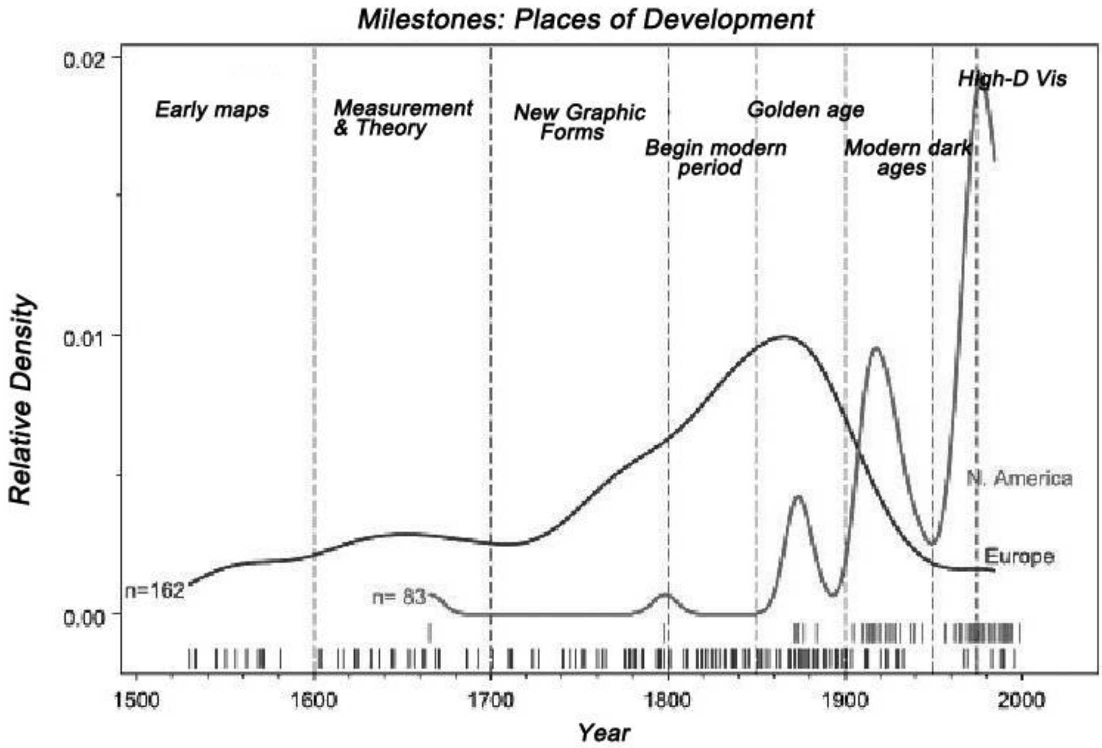


Figure 3- 1. Time distribution of milestone events in the history of data visualisation shown using a rug plot and density estimate (Chen et. al. 2008)[7].

Not all researchers agree with this discipline. Frits H. Post (2002), for instance, argues that the origin of this field was in the early days of computer graphics in the 1950s, when the first graphs and figures were generated by computers. This means that Post locates data visualisation as part of computer science while Friendly (2006) and Friedman (2008) define it as statistical graphics and thematic cartography. A significant boost was given to the field with the appearance of the NSF report *Visualization in Scientific Computing* (1987), edited by Bruce H. McCormick, Thomas A. DeFanti and Maxine D. Brown[8]. In this report, the need for new computer-based visualisation techniques was stressed by the authors.

With recent rapid diffusion rates of computing technology, more complex mathematical visualisation models have been developed. Larger data sets have been generated via advanced and diverse data acquisition devices such as weather forecasting systems and telecommunication data wherein a variety of data sets must be processed and visualised using graphic techniques. Visualised data also contributes to a new level of perception in interpreting the world. Data visualisation in research, for example, is significant when analysing the rhythm of everyday life. Geographically visualised data can be particularly useful as a foundation for programmatic flexibility. Accordingly, the next sub-section will focus on the geographical mapping of digital data.

### 3.1.2. Digital Data Mapping

Two aspects of data visualisation, theme-oriented and technology-oriented data, have developed complementarily. A substantial number of data visualisations utilising GIS provide a representative example and offer one of the most powerful software programmes for spatial analyses. Although GIS is based on powerful computing technology and has not been developed for data visualisation, diverse themes juxtaposed with geographical coordinates can be displayed and visualised using numerous GIS tools. In addition, the interest in GIS has been augmented by the development of GPS (geographical positioning system), which is currently diverging into LBS (location based service)—a trend in application-driven research in the ubiquitous computing field. Thematic cartography operated by technological tools is becoming a useful aspect of telecommunication convergences because locative work is a significant context for actualising ubiquitous media in the built environment. In this respect, both a theme and appropriate technology have merged to create an informative map.

With increased interest in map-based services in the web and telecommunications, there has been new research conducted on the visualisation of geo-data and digital infrastructures in order to examine the potential for electronic geography. Cai, Hirtle, and Williams (1999) attempted to reveal the relationship between locations and virtual space by visualising distributions of telecommunication data with geographical information including location and the radius of base stations[9] (Figure 3-2). It has been considered a window towards magically informative and communicative worlds beyond limitations of space. However, a study conducted by Jonathan Reads, Francesco Carabrese and Carlo Ratti (2007)[10] again demonstrated the relationships between the real and the virtual world by rendering different graphic versions for distributions of telecommunication data with the help of a more advanced GIS programme. Consequently, these two studies contribute to the corroboration of correlations between real sites and virtual reality affected by digital communication infrastructures.

Despite the important contribution of these two studies, both have their limitations. This is because they do not go beyond providing a better understanding of our invisible electronic environment. In fact, the results of the above research overlooked meanings in the relationship between electronic surroundings and physical space. This means that location-based visualisations of telecommunication data include a spatial attribute of respective locations connected with the social aspects of urban space. In addition, these studies tend to focus on a visualisation of locative telecom data rather than relations between the data and undiscovered urban spatial layers. Location-based telecom data should, therefore, be considered along with urban spatial factors, such as the urban fabric and building use, because variations of locative telecom data can already reveal demographic flows reflecting the spatial sociology of urban life.

Data visualisation in this research is utilised to establish the concept of new communicative territory through interpreting data variations of digital atmospheres rather than by analysing physical environments. Geographically visualised data maps will provide a perceptual framework in order to observe physical urban spaces and develop discourses of locative interaction.

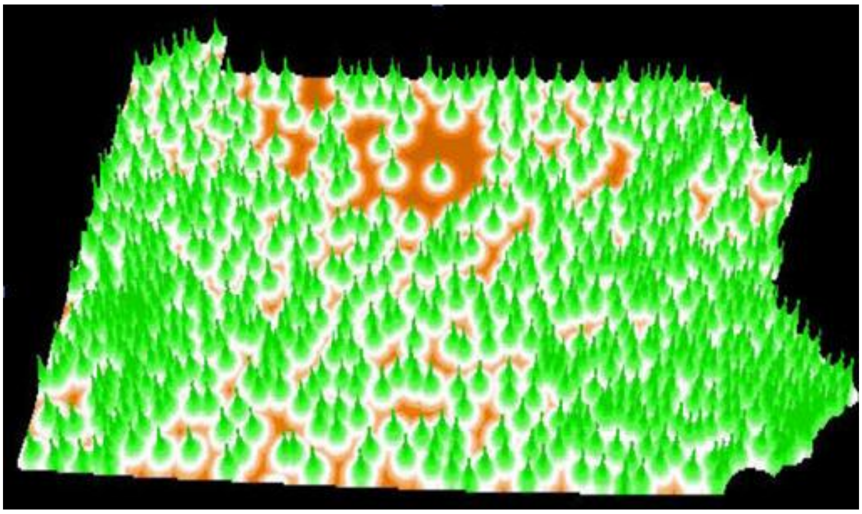

Figure 3- 2. Surface Model of Access Bandwidth deliverable from Wire Centers by Cai, G., Hirtle, S., C., and Williams, J.

## 3.2. Observation

Observation is conducted to investigate the relationship between the density of telecommunication data and people's activities in urban space, which is one of the important contextual factors for spatial experience.

Observing one's activities in connection with urban settings is an important methodology, particularly in the field of architecture and urban design. The observational research of pedestrian behavior and city dynamics by William H. Whyte is a representative example: he published a number of influential books including his findings drawn via his methodology of observation that required direct surveillance of urban spaces recorded using film and photographs.

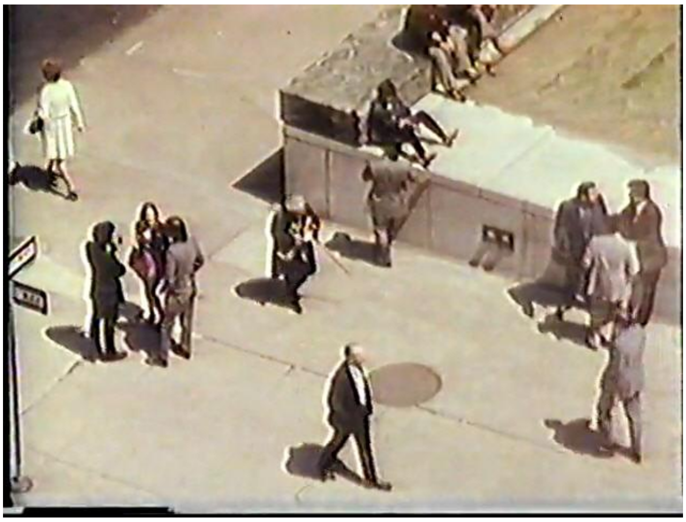

Figure 3- 3.William H. Whyte (1980) The social life of small urban spaces[11]

The method of observation in the following research adopts Whyte's process. However, the objectives and specific method of observation should be clarified.

The geographical distributions of quantitative data maps will be demonstrated using data visualisation. Depending on the geographical distributions of data, the density of traffic will vary. The connection of areas with the highest data levels will reflect time intervals and generate temporal trajectories for observation (see Figure 6-1). This process will be discussed in further detail in Chapter 6.

In addition, the relationship between people's activities and the urban fabric (building use, public space and streets) will be observed in order to compare density in visualised maps and in real urban space. This is important when identifying people's activities with relation to heterotopias in spatial rhythms in which the levels of density of telecommunications traffic changes depending on the time variation. This demonstrates interactivity between people and urban spaces as reflected in a live context. The discourse regarding these factors will be holistically developed as a concept of locative interaction reflecting live urban space and realized in an epistemic design project.

## 3.3. Design Epistemology

There are wide-ranging discussions on the deficiencies of the production of knowledge using analytic methodology (Gibbons et. al, 1994)[12]. Gibbons used the terms Mode 1 and 2 to describe the shift of the process of knowledge acquisition and its evolution. In the old paradigm, scientific discovery (referred to as Mode 1) is primarily produced by theoretical or experimental methods and can be characterised using classified disciplines and the autonomy of scientists (Nowotny 2003)[13]. The Mode 1 has been replaced by a new paradigm of knowledge production (Mode 2), which operates within the context of application rather than within a set framework. Mode 2 is also trans-disciplinary and not institutionalized within a university structure (Gibbons et al, 1994)[14].

A recent trend of research in information technology with relation to ubiquitous computing demonstrates a representative example supporting a new paradigm of knowledge production (Mode 2). This is due to the application-driven nature of research in the information technology field, one that pursues trans-disciplinary approaches ranging from design to sociology. This research adheres to Mode 2.

Along with new modes in knowledge production, a number of studies within design fields have been conducted in contexts similar to Mode 2.

Donald Schon (1989) advocates the epistemology of design practice as a reflective conversation with the situation[15]. In ‘The reflective practitioner’ written by him, he indicates that practitioners should not function as a user of research outcomes and that researchers should not maintain distance from the experience of practice for reflection-in-action. This kind of position is significant in the era when the new production of knowledge is needed. In addition, according to Mahdjoubi (2003), design can be divided into three categories: design as activity, design as planning and design as epistemology[16]. ‘Design as activity’ is connected with the conceptualisation of making new products of certain forms or functions. ‘Design as planning’ focuses on the processes of systemization prior to execution and conceptualization stages. Design as planning is considered as a schematic design or a plan. Moreover, ‘design as epistemology’ is related to synthetic rather than analytic methodologies of science, which can be ‘envisioned as a method of expression and change’ (Mahdjoubi 2003)[17].

Furthermore, research based on the observation of the process of a specific architectural design project demonstrates that visual presentations shown in the process of design can play a role in developing knowledge (Ewenstein et.al., 2009). Ewenstein and Whyte argue that visual presentations as an epistemic object are ‘central artifacts of knowing, expressing a wide range of knowledge forms'[18]. This suggests one can produce and develop knowledge using epistemic objects in design. Also, the deficiencies of the production of knowledge using analytic methodologies can be complemented by synthetic methodologies.

This research adopts a design epistemology as a method of integrating various discourses and bridging the perception and imagination of telecommunication data by designing an epistemic object. Data gathered using analytic methodologies, such as statistical studies, data visualisation, and observation, will be synthesised and developed into the core discourse using this method.

## 3.4. Summary

Data visualisation has been adopted to communicate information obviously and efficiently via graphical representation. It is increasingly important in an age of 'information overload'. This research adopts data visualisation to interpret the meaning of telecommunication data as a live urban context beyond the clear communication of information. It is used as a methodology to analyse the temporal and spatial rhythms of telecommunication use in urban space. Moreover, observation is adopted as a methodology to investigate the correlation between urban activity and architectural programmes. Data visualisation, in particular, provides maps of data distribution for the schedules and venues of observation. The two methodologies are merged in the design project described in Chapter 7, which is created to synthesise findings and develop discourses related to locative interaction reflected within a live urban space. Prior to applying data visualisation, the general attributes of telecommunication data will be enumerated in the next chapter.

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# Chapter 4
# DATA

## 4.1. Introduction for Data

### *4.1.1. Research Site*

The research area is part of central Seoul (approximately 3 km by 3 km), the capital of Korea for the past 500 years. It is a city of enduring traditions mixed with cutting-edge technology, which makes it an ideal case study for investigating telecommunications


Figure 4- 1. The map of the research site, in the center of Seoul, South Korea[1]

The information technology industry and technology-related consumption is vibrant and diverse in Korea. According to the Korean Information Technology Industry Statistics Year Book (2008), the number of telecommunication subscribers is approximately 45,000,000 and is gradually increasing, which means that nearly all the population of Korea uses mobile phones (the population of Korea is approximately 49,000,000 in 2010[2]). The number of subscribers in SK Telecom (52,000,000) exceeds the Korean population, which demonstrates an enthusiastic consumer approach towards information technology service programmes. Cyworld[3] exemplifies the unique Internet culture of Korea. It has been a popular social networking website in Korea since 1999, and is similar to Facebook, a world-wide contemporary popular social networking web-based service. Korean users' attitudes towards other types of online services based on information communication technology are similar to those relating to Cyworld. This is one reason why Seoul is an ideal site in which to investigate the relationship between new mobile technology and urban structure.

Seoul is particularly rich as it offers a number of diverse urban paradigms within a relatively small area. For example, both private and public national head office buildings are located in this research site making it a collage—mixed and reorganised with chronological traces of distinct time-layers representing more than half a millennium. As such, the city centre demonstrates the physical evidence of the rapid industrialisation and modernisation of Korea. That is to say, 500-year-old palaces located in an urban structure (road systems and building groupings) have remained in tact. The urban fabric (building sites and alleys) has been rapidly but minimally changed due to urban development led by industrialisation. This has resulted in an organic collage of urban fabric reflecting various periods rather than the well-planned urban space of the Euclidean grid. This means the research site is suitable for investigating telecommunication territorialisation and patterns of urban occupancy that depend upon time intervals amidst diverse building uses and contexts.

### *4.1.2. Data Collection*

A few key points should be considered with regards to the collection of telecommunication data. Surveillance issues, for example, must be discussed in advance of collecting data because collected telecommunication data can include information relating to individual privacy. The attributes of data to be collected must be carefully selected. Data access is limited because of another reason: data can reveal confidential telecommunication business information. Undeniably, we have no choice but to rely on technological cooperation from a telecommunications company that has the right to access relevant data from base stations. Certain data required for research cannot be obtained because it is considered as classified business information. Finally, one should establish a timescale for collecting data. The amount of data generated and accumulated from individual mobile usage is too large to be stored for a long period of time; it is expensive and cumbersome. In the case of SK Telecom, for example, data expires after 3 months. Accordingly, if more than 3 months' data is needed, a data collection time schedule is required.

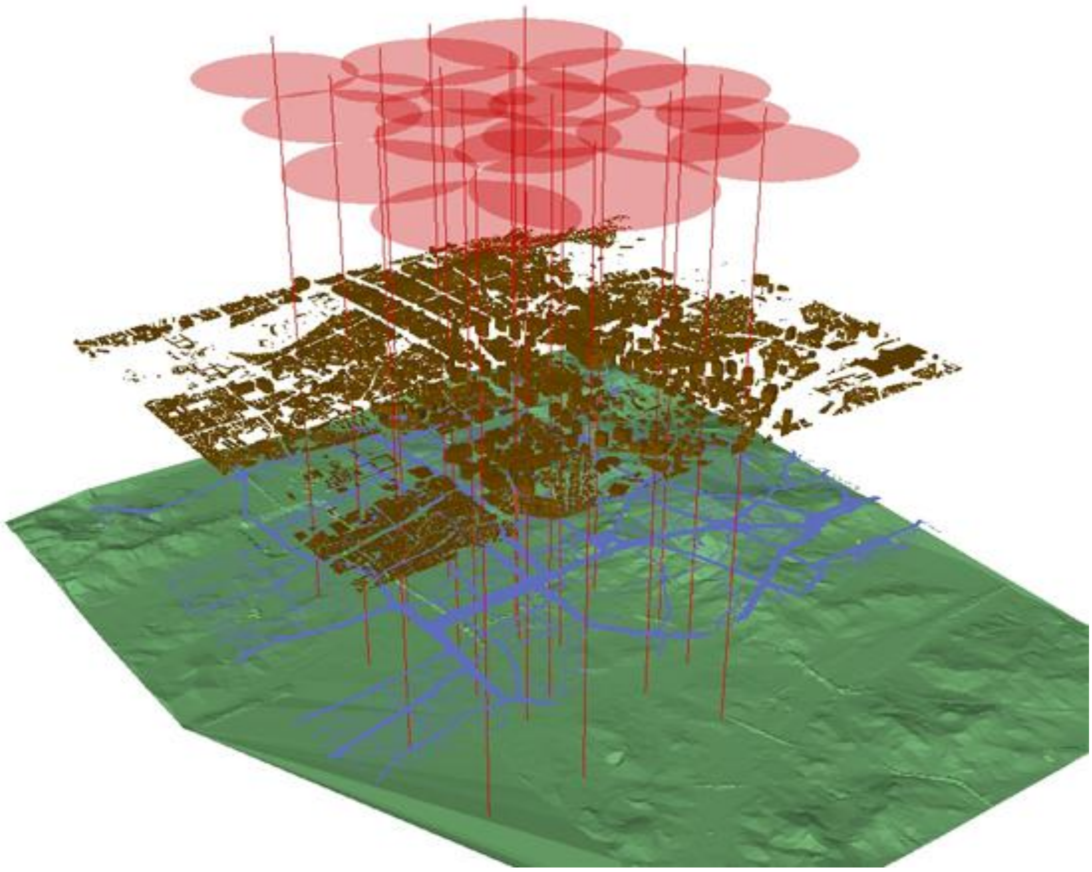

Figure 4- 2. Deconstructed image of multi-layered urban structure juxtaposed with the location of base stations and a radius of cell spaces. From the top: cell spaces, building shape and height, network of roads, and geographical contours

Taking these three aspects into consideration (privacy, classified business information, and data expiry), this research utilises a designated amount of mobile phone calls made in certain cell spaces. The number of calls demonstrates the extent to which users are willing to communicate in the area covered by base stations.

This data is based on the number of mobile phone calls that are counted “once”, when subscribers start to make a mobile phone call regardless of movement between areas covered by one base station into another area. Accordingly, a data value of a certain base station at a certain time will be used as a baseline. This reference point allows values in the remaining base stations to be represented as percentages of relative value.

- ***Time of Data Collection***

Although the philosophical position of time in this research is related to the rhythm of repetition and cycle, chronological time is adopted here as the users’ biological time has been adjusted to engage with social time and working hours. These hours are significant in calculating labour in the modern age and framing leisure time[4]. Working hours are a disputed topic that creates social conflicts. To be thorough, telecommunication data was collected hourly over a one-week period in September 2008.

- ***Cell Space***

The term 'cell space', coined in 1998 by David S. Bennahum, originally referred to the then new ability to access e-mail or Internet wirelessly. Cell spaces are defined as the areas covered by the signal from respective base stations. The distance between base stations ranges from just less than 200M to 600M. Generally, one base station is able to cover an area of a diameter of one kilometre. This radius can be changed depending on use (phone calls), which is a key aspect of creating urban media. This area, characterised by a mobile-related signal, is called 'cell space'[5].

Cell space is a unit that aids in the design of locative media by considering the overlap with urban physical structures (Figure 4-2). Its capability as an urban design factor was previously mentioned. In addition, cell spaces are allocated and located by technical workers rather than architects, regardless of the urban fabric, and their locations are significant when constructing locative media as a crucial factor in an everyday electronic environment. This is because these spaces are nodes which generate psycho-geographical information through which we can scrutinise everyday telecommunication behaviour. Informative data configurations provide topography reflecting everyday rhythms. The resulting 'maps' are fundamental for actualising architecture as a medium of communication and information beyond the current understanding of architecture, which is focused on physicality.


Figure 4- 3. The radius of cell spaces in the research site

Most of the cell spaces (Figure 4-3) in the site have dual or triple spatial attributes and are likely to be crowded and busy. This means that dynamic variations of urban telecommunication data can be expected. If a residential district had been chosen as the research site, topologically dynamic changes of data would not be expected because obvious daily routines and a clear spatial zone would show a homogeneous pattern of typical data flows. On the other hand, mixed and overlapping attributes of urban space, such as the one chosen for this research, will demonstrate diverse topological hierarchies depending on time variation. Therefore, the contextually heterogeneous site is ideal for the extraction of telecommunication behaviour represented by diverse data contours with intersecting concepts of time and space.

| | Name of Base Station | Main Facilities |
|---|---|---|
| A | Gwanghawmun | The Center Post Office, Gwanghawmun Plaza |
| B | Namsan-dong | Schools, Offices |
| C | Naesu | Seoul Metropolitan City Hall, Palace, Embassies, Seoul Plaza |
| D | Dansungsa | Shopping district, Park, |
| E | Dangju-dong | Palace, Embassies, Headquarter offices |
| F | Seolin-dong | Headquarter offices, River park, |
| G | Supyo | Shopping district, River park |
| H | Sunhaw-dong | Palace, Park, Art center, Hotels, Embassies, Office buildings of Seoul Metropolitan, Police station |
| I | Sungrea-mun | Large wholesale markets |

| | | |
|---|---|---|
| J | Ankuk station | Palaces, Embassies, Museums, Art galleries, Office headquarters, Police station, Offices, Residential areas, Gwanghawmun plaza |
| K | Ulgee 4 | A few wholesale markets |
| L | Ulgee station | Company headquarters, Shopping centers, |
| M | Ulgee Ypgu | Shopping district, Office headquarters, |
| N | Insa-dong | Shopping district, Office headquarters, |
| O | Juksun-dong | Seoul Metropolitan Police Station, The Government Central buildings, Palace, Concert hall (Sejong Center), Museums, Art galleries, Embassies, |
| P | Jongro5 | Palace, Embassies, Wholesale markets |
| Q | Jungang | Department Stores, Wholesale markets, Seoul Post Tower, Bank of Korea, Bank headquarters |
| R | Chungmuro | Shopping district, Wholesale markets, Radio and TV stations |
| S | Taepyungro | Press center, Company headquarters, Seoul Metropolitan, Seoul Plaza |

Table 4- 1. Cell spaces of base stations

## 4.2. Statistical Analysis

Before geographical visualisation, the character of numerical information in urban telecommunication must be investigated; in particular, the pattern of data variation dependent on time intervals must be revealed to examine the relationship between everyday life and urban space.

### *4.2.1. Indicators of the Rhythm in Everyday life*

The pattern of data variation is generally constant during weekdays: Monday's data was adopted as a random weekday example. The multi-curved line graph below demonstrates data changes over 24 hours in respective cell spaces on a weekday, Saturday and Sunday (Figure 4-4, 5 and 6, respectively).

In general, the average amount of data dramatically drops on Saturday and drops further on Sunday compared to that on Monday. Additionally, the pattern of data variation on Monday is different from the data pattern seen in the other two days. The data pattern on Monday shows a number of fluctuating spots with the two distinctive humps at 12.00 and 19.00 as the highest. However, the pattern on Saturday and Sunday is somewhat constant (more calls are seen in daytime than at night). The number of calls on Monday ranges from a few hundred to approximately 22,000 and those on Saturday and Sunday from about 300 and 100 to 12,000 and approximately 8,500 respectively. To summarise briefly, relatively higher numbers of calls are shown in daytime in the three graphs.

In the graph for Monday (Figure 4-4), a notable pattern is seen: the number of calls increases between 7 AM to 12 PM then decreases for one hour before increasing again until 7 PM. This pattern is repeated from all base stations, regardless of their respective data levels. This is an appropriate representation of everyday life of people who live in urban areas.

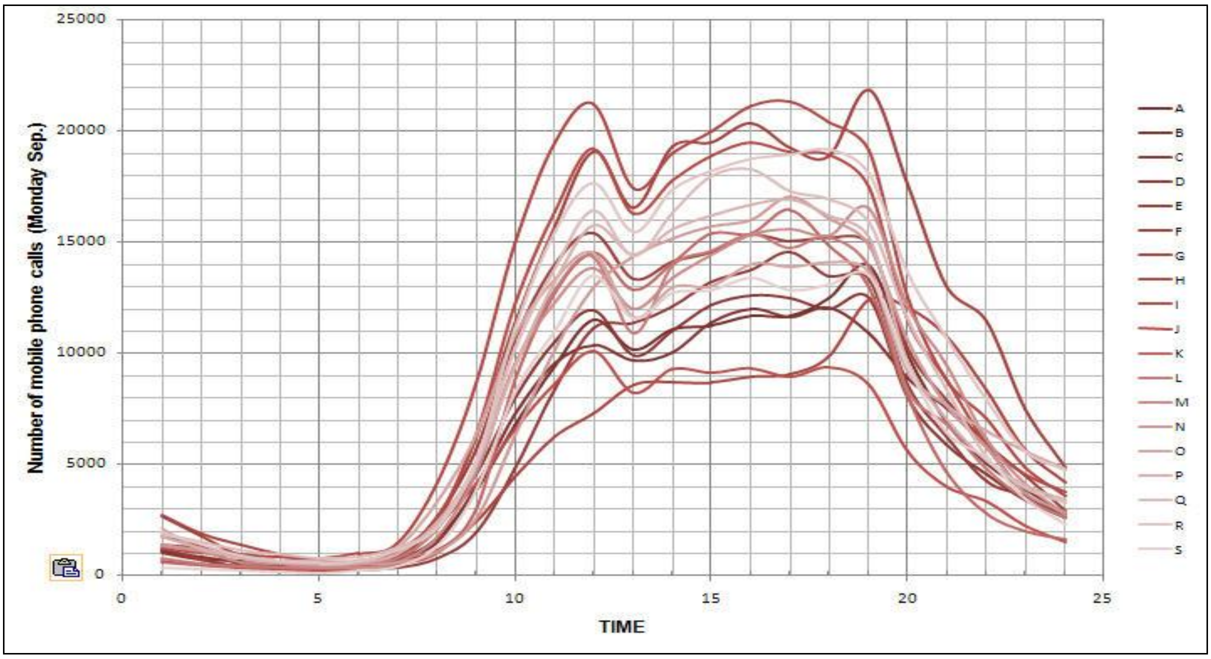


Figure 4- 4. The number of mobile phone calls (Monday, September, 2008)

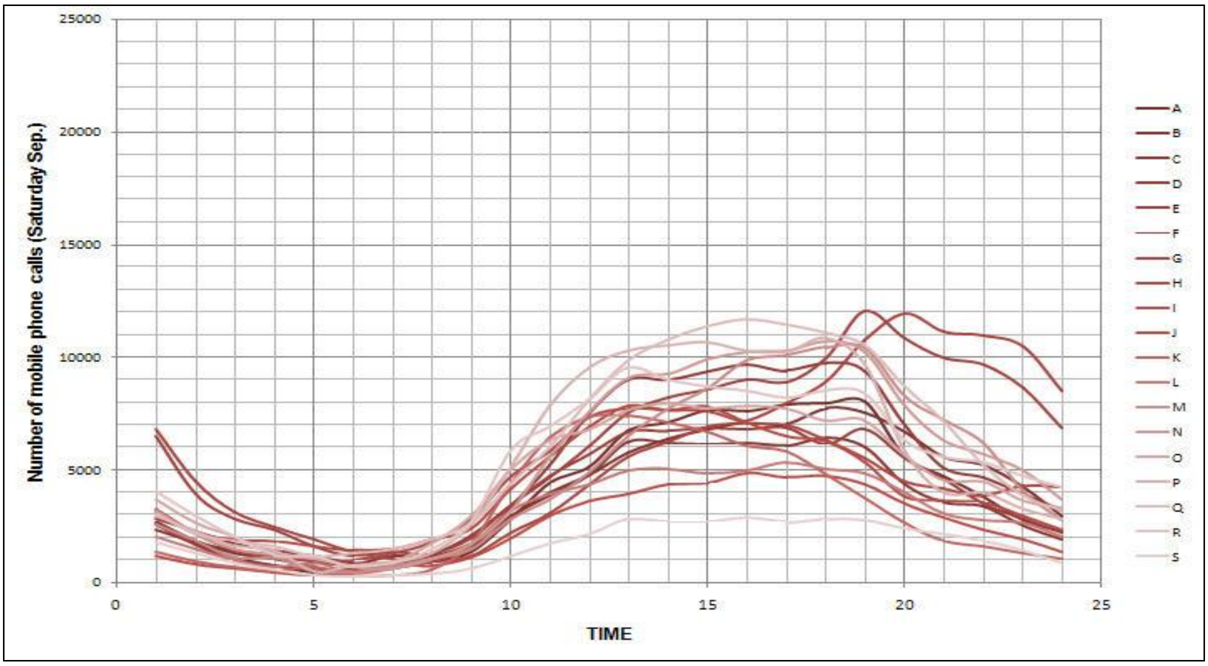

Figure 4- 5. The number of mobile phone calls (Saturday, September, 2008)

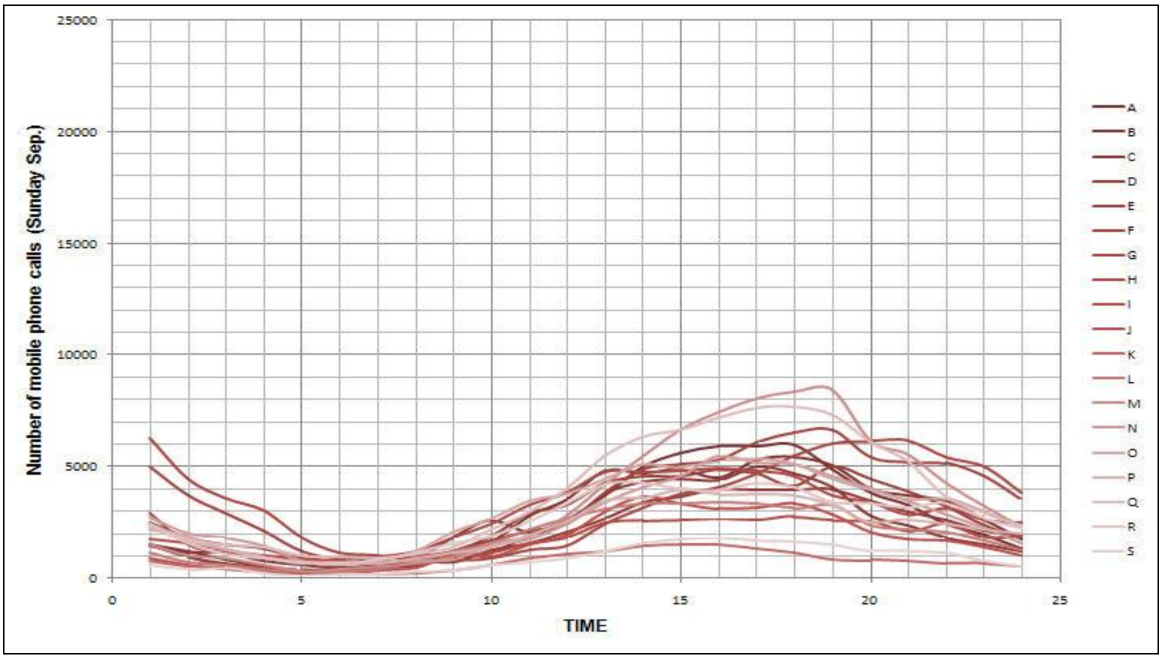

Figure 4- 6. The number of mobile phone calls (Sunday, September, 2008)

### *4.2.2. Patterns of individual spots*

Taking a macroscopic view perspective, the average data in all base stations was compared, dependent on the day of week, as shown in Figure 4-7. From 8.00 to 18.00, the pattern of days of the week is very distinctive. The number of mobile phone calls on Saturday is almost half that of weekdays and double that from Sunday. The pattern from 19.00 is somewhat irregular due to the bar graph relating to Friday, which is constant to the end. As time passes, particularly at night, deviations between weekdays and others are lessened. Telecommunication at night time decreases sharply during weekdays while telecommunication data decreases gradually on Saturday and Sunday.

Specific data analysis depending on individual cell space was conducted as seen in Figure 4-8 and 9. This pictorial graphs show daily data changes within a week in September 2008 according to respective base stations. The horizontal axis is the time of day, from 1.00 to 24.00, and the vertical axis is the weekday, from Monday to Sunday. Classification is represented using 5 colours differentiating every 5000 calls; 0-5000 is blue; 5000-10000 is red; 10000-15000 is yellow; 15000-20000 is violet; 20000-25000 is sky blue.

Generally speaking most locations of base stations are activated from 9.00 when most companies and shops start work. Levels decrease after 18.00 when working hours finish and workers go home or travel to appointments. Most base stations have peak uses at 19.00.

After 19.00 or 20.00, the number of phone calls gradually decreases until 23.00 or 24.00. It is worth noting that some base stations (F, G, H, O, R) are busy until 22.00: these areas have many shops and bars.

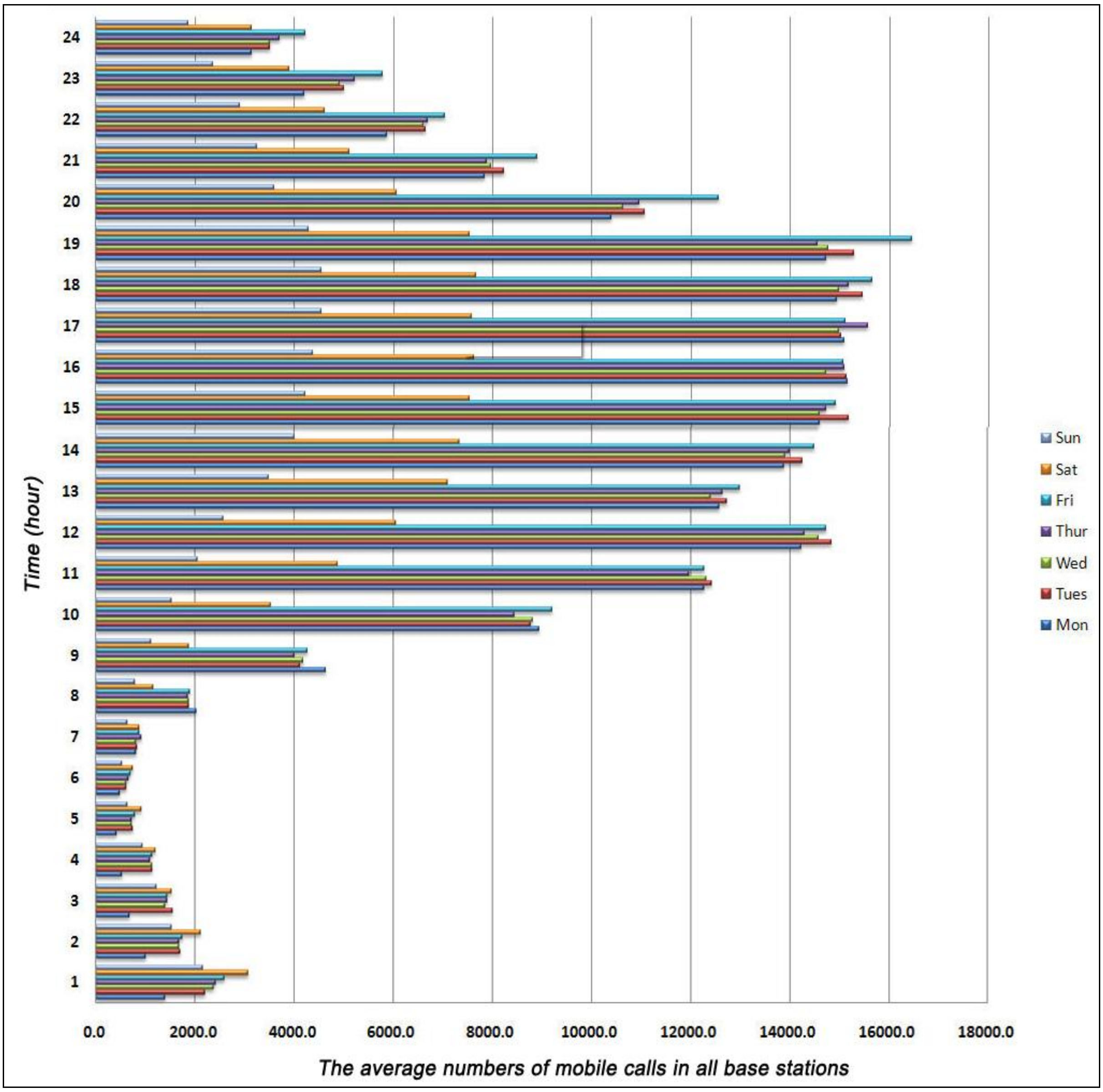


Figure 4- 7. Pattern analysis of average numbers of calls in all base stations depending on days of the week (From Monday 22nd September 2008 to Sunday 28th of September 2008)

As seen along the vertical axis, the trend is for the amount of data traffic on Saturday and Sunday to differ from that of weekdays. A substantial number of spaces (C, D, E, I, J, K, L, P, and R) are considerably less crowded on Sunday (0-5000 calls). Although other cell spaces (A, B, F, G, H, M, N, and O) are busy on Sunday, the number of phone calls ranges from 5000 to 10 000, which does not reach the level of Saturday or weekdays. Accordingly, telecommunication data considerably decreases from Saturday to Sunday. As a general rule for weekdays, if the coloured parts in respective graphs are nearly rectangular, the pattern of phone calls is somewhat constant during weekdays: this is generally the case, which means that variation in data patterns is not presented. This is contrary to the fact that, as expected, Mondays or Fridays have different patterns from other days of the week because of the influence of Saturdays or Sundays.

Interestingly, data in the morning changes more quickly in most spaces while night-time data changes vary as the width of colour changes; this is especially seen from 19.00 or 20.00. In the case of J, K, and L, the times of data changes in the morning and evening are very similar, which means that the influx and efflux of the population in this base station tends to be mainly affected by the schedule of office workers. On the other hand, for a considerable number of base stations, data decreases during the night are more gradual than subsequent increases in the morning. The slower night-time decrease in data is the result of two factors: the working population spends more time in the base stations during the evening, and the derivation of data is from an area with amenities for leisure after work such as pubs, restaurants, shops and other entertainment facilities.

Specifically, data distributions in respective spaces are patterned as below:

- ***Pattern I, Location of base station A, B, C, D, K, L, O and S: Weekday Routine Type I***

A typical type of data distribution appears in these cells. During weekdays, the number of phone calls gradually increases from 8.00 and continues until 19.00, after which point levels decrease moderately. The slightly differing factor amongst these base stations is the time when the colour categories change (blue, red, yellow, violet, and sky blue). Most of them have their first inflection point at 12.00, when most employees are on their lunch break. The second inflection point is at 19.00, where some spaces change color from yellow to red at 20.00. The time of red to blue varies, ranging from 21.00 to 23.00. On Saturdays and Sundays, the weekday pattern is broken and the time-span of the red category (5000 – 10 000 calls) is rapidly shortened, as is shown in other cells. Characteristically, the daily rhythm of data change is constant.

- ***Pattern II, Location of base station E, H, I, P, Q and R: Weekday Routine Type II***

The pattern of these cells is similar to that of the previous cell group (A, B, C, D, K, L, O and S) regardless of a higher volume of calls, indicated by the violet colour section. The slope of the data increase at 8.00 or 9.00 is steeper than that of the former group until 12.00, after which point the number of calls slightly decreases at 13.00 only to recover and gradually increase or plateau until 19.00. The pattern after this is similar to that of the location of base station groups in pattern I. The difference between pattern I and II is that pattern II is more vibrant and has a distinctive inflection point at lunch time. This means that more office facilities are located and/or more office workers are in the areas of pattern II, because it reflects an ordinary routine of working hours.

- ***Pattern III, Location of base station M and N: Afternoon Type***

Cells M and N demonstrate a pattern based on pattern I and have a band of higher data from 13.00 to 19.00 during weekdays. Base station M is part of the Myung-dong area, and N is in Insa-dong. Both are famous tourist spots and consist of a number of districts of diverse entertaining, shopping, and eating facilities. Despite the attributes of facilities in the two areas, higher data does not continue until 24.00. This means that telecommunication in these areas are not constantly activated up to midnight. In this respect, pattern III is differentiated from pattern IV, where a higher level of data continues until 24.00.

- ***Pattern IV, Location of base station F, and G: Evening Type***

The data distribution pattern for individual days is shown to vary only slightly while the location of base stations in patterns I, II, and III shows an even data distribution. These are distinctive as higher data is seen after lunch through to midnight on Fridays, after which the number of calls decreases steadily. Colour bands as an indicator of data changes, however, are wider than in patterned locations of base stations at nighttime. Accordingly, telecommunication increases at night compared to other base station locations. In general, the two cells record the largest number of mobile phone calls in the day and night.

Even though cells O and R belong to patterns I and II, respectively, more active telecommunications are shown later in the evening when compared to base stations of the same pattern groups—red reaches the 24.00 mark. Data for the two cells starts to decrease by 20.00 and gradually dwindles. Data slips back to red from yellow by 20.00 and 21.00 when F and G still maintain a higher level of data, which explains the violet and yellow colouring.

- ***Random I, Location of Base station G***

The number of calls in base station C surpasses the 5 000 level (the point of change from blue to red) not at 9.00 but at 10.00. The level remains constant until 18.00 when data begins to rise to more than 10 000, while that of other base stations decreases. The number of calls falls steadily from 21.00 and is somewhat constant up to midnight, a level that is higher than data from other cells during the same hours. Most facilities in this area are commercial, such as retail and bars, rather than offices. There is a large amount of influx and efflux of population within a day. Accordingly, data variation is not similar to the patterns of other locations of base stations reflecting the working hours of office workers. Even though the total level of data is lower, the numbers of calls at night are the highest. Saturdays and Sundays show relatively larger numbers of calls due to leisure potential in the area.

- ***Random II, Location of Base station J***

A considerable part of base station J is the residential area designated by the government as a conservation district. The remaining part of this cell is composed of palaces, embassies, museums, art galleries, company headquarters, a police station, and office buildings. The telecommunication use, however, is much less than in other cells. Generally, these types of buildings tend to give rise to a great number of consumer facilities such as bars, restaurants, cafes, and various retail or entertainment shops. Due to Korean zoning regulations, such commercial facilities are banned in residential areas. The data flow of this cell is affected by the attributes of a residential area rather than museums and office buildings. This explains why data is somewhat higher during the daytime on weekdays and lower than other cells on Saturdays and Sundays.

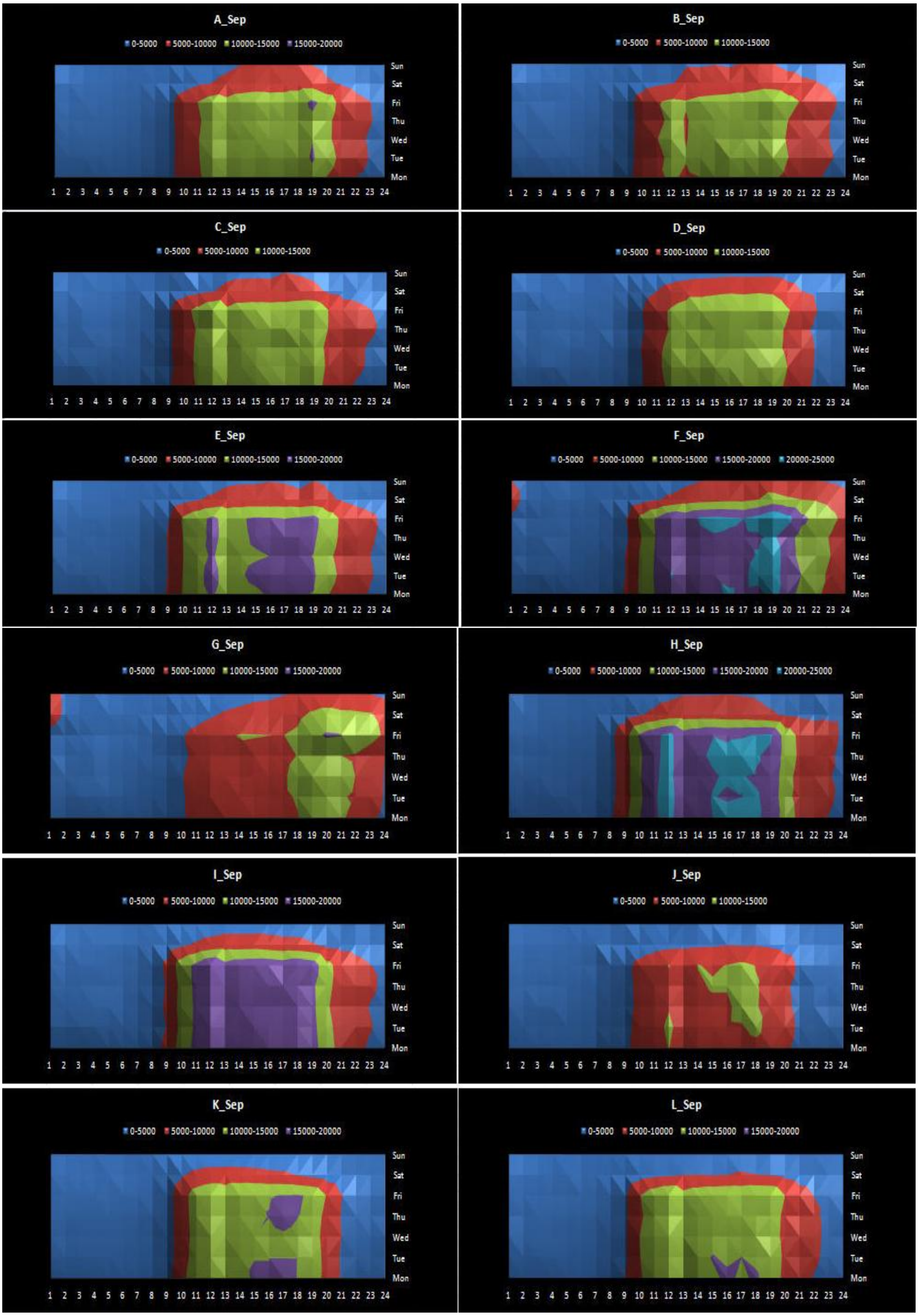


Figure 4- 8. Data analysis depending on individual cell spaces (A, B, C, D, F, G, H, I, J, K and L)

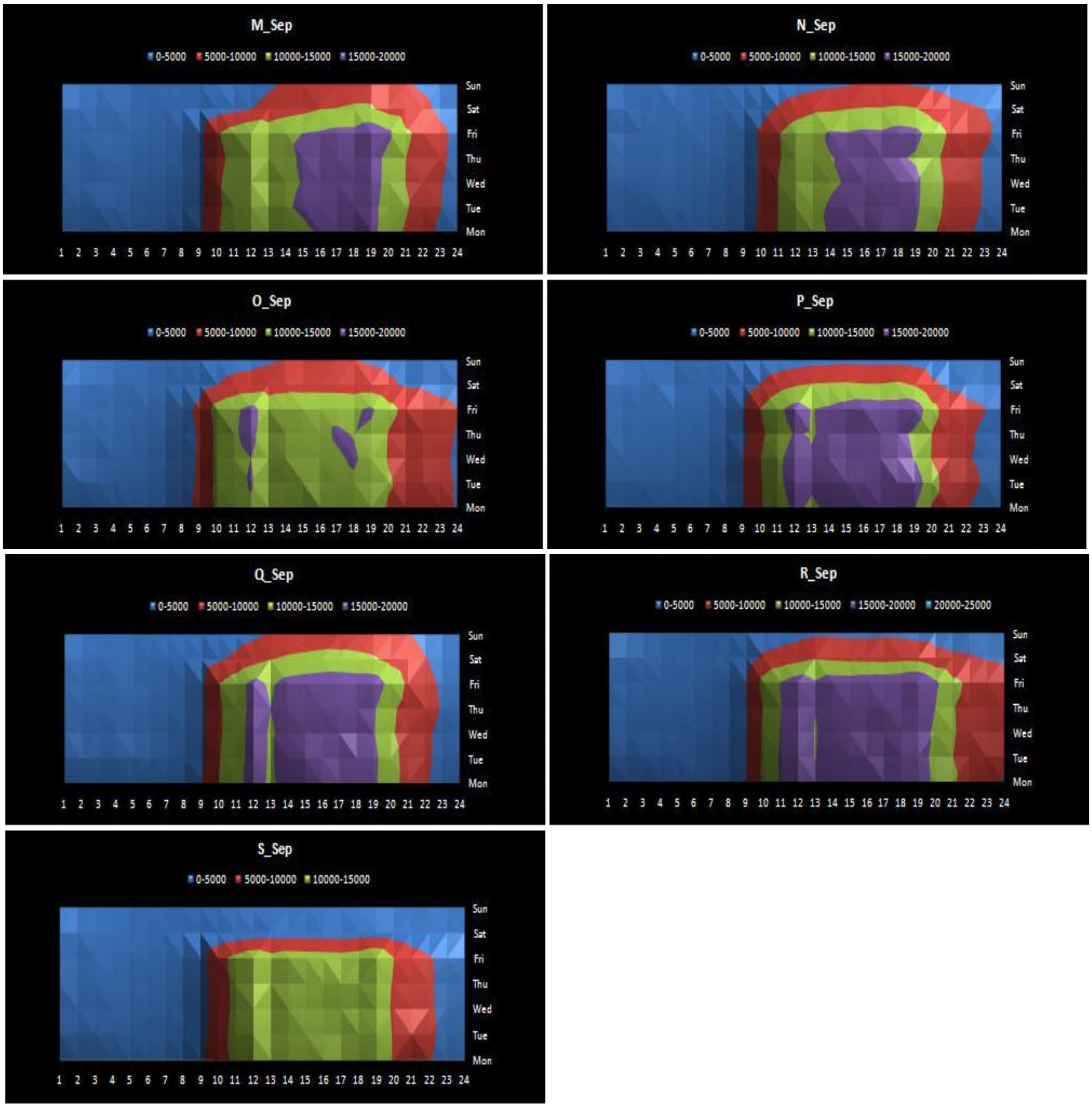


Figure 4- 9. Data analysis depending on individual cell spaces (M, N, O, P, Q, R, and S)

Telecommunication in urban space is patterned with four classifications (*Weekday routine type I, II, Afternoon type and Evening type)* depending on the time-line within a week.

A rhythm of weekdays is reflected as *Weekday routine type I* and *type II*. *Weekday routine type II* has a higher data level and represents a more distinctive inflection point at lunchtime than *weekday routine type I* although the two types, at the same time, show a clear pattern centered around normal office hours (9.00 to 6.00). The areas shown as *weekday routine type I and II* are composed of mainly office buildings and public offices.

The third pattern is the *Afternoon type* in which higher telecommunication data is shown from approximately 14.00 to 19.00. Mainly commercial complexes, such as retail shops, department stores, restaurants, bookshops and theatres are located in this area (cells M and N). These amenities tend to be preferred by the younger generation and tourists.

The fourth pattern is the *Evening type*, shown in one of the busiest areas (cells F and G) and located in the central part of the research site. Building use ranges from office headquarters to amenities such as retail outlets and restaurants. A concentration of amusement facilities such as bars, pubs, and karaoke bars causes the highest level of telecommunication data during the evenings. In addition, the nightlife context, involving taxis and social coordination, yields the highest data levels

## 4.3. Summary

Telecommunication data that records the number of mobile phone calls from cell spaces covered by radiuses of base stations in a central area of Seoul was collected. Calls generated can be interpreted as the number of people at a certain time and in a certain location. In particular, the calls can be considered as the representation of a communicative activity of the persons who make mobile calls in a given urban situation (time and location). This is a method of analysing patterns of urban telecommunication (locative interaction).

In light of statistical study, it is clearly found that the trajectories of telecommunication reveal a rhythm of everyday life as well as a relationship between said rhythm and spatial occupancy. Furthermore, the study of telecommunication patterns in individual unit spaces created by base stations shows temporal digital footprints. These can be used as a foundation of spatial programmes in architecture and urban design because it reveals the true nature of temporal-spatial occupancy. If these statistically based graphs are locatively and visually regenerated, this kind of telecommunication map can be fundamental in scrutinising locative interactions in an urban environment. Mathematical graphs of statistical analyses, however, are not enough to identify the geographical distribution of data, which is important when scrutinising interactivity between people and urban space. Geographical and topographical visualisations will be conducted in the next chapter.

[1] http://maps.google.co.kr/maps?hl=ko&rlz=1T4RNTN_koGB356KR360&q=seoul&um=1&ie=UTF-8&hq=&hnear=%EC%84%9C%EC%9A%B8%ED%8A%B9%EB%B3%84%EC%8B%9C&gl=kr&ei=PXl6TPfFPJm8jAepjpGqBg&sa=X&oi=geocode_result&ct=image&resnum=1&ved=0CCYQ8gEwAA
[2] http://kostat.go.kr/portal/korea/index.action Retrieved 28 March 2011

[3] Cyworld is a social networking website launched in September 1999 by SK Communications. Today, Cyworld has extended its operation to the United States, China, Japan, Taiwan, and Vietnam. And the Swedish version of the site, called bilddagboken.se, has already gained nearly six million users.

[4] Rossum, Gerhard Dohrn-van., (1996) *History of the hour: clocks and modern temporal orde*rs, Chicago: University of Chicago Press, p. 289-291

[5] Manovitch, Lev. (2002) *The Poetics of Augmented Spaces*: Learning from Prada [online], available from:http://www.noemalab.org/sections/ideas/ideas_articles/pdf/manovich_augmented_space.pdf [Retrieved as of 15 April 2012]

## Chapter 5
# DATA VISUALISATION

The objective of data visualisation is an analysis of the geographical pattern of interaction between people and urban space. In other words, interaction in the context of this research means spatial occupancy within a rhythm of everyday life. Urban telecommunication data and its geographical and topographical visualisation are expected to act as a diagnostic reagent to reveal a live urban context (physical movement). The patterns of urban interaction will be shown as live patterns of spatial occupancy.

## 5.1. Data Processing

- ***Visualisation Tools and Data Processing***

The tool used for visualisation is ArcGIS[1], chosen from a number of GIS (Geographical Information System) programmes for geographical visualisation. Above all, it enables geospatial analyses by geographically distributing data.

The processing work involved in using ArcGIS must be preceded by a number of tasks, which include a statistical table of numerical information that demonstrates the following: telecommunication data and geographical information of a given research site, CAD files of the site, including shapes of buildings and locations of base stations, and information such as the height, age, and use.

The process of data visualisation begins with converting a variety of information to variables compatible with ArcGIS. CAD files can then be converted to SHP[2] (ESRI Shapefile) files in order to make a connection with numerical data. Then, the GIS programme can be applied. Thirdly, geographical data linked with telecommunication data should be processed from point-based information to raster-based files, which changes points to an assembly of 2D pixels. Fourthly, pictorial contours, including topological distributions of data, are generated by IDW (inverse distance weighted) in GIS spatial analysis. Lastly, 2D data visualisation was completed by the classification of data visualising and colour controls.

- ***The Four Hypothetical Points***

Before the above processes, the boundary for visualising must be limited not only by the radii of cell spaces but also by the borders as shown in the Figure 5-1 and 2. Accordingly, in order for the given research site to be visualised, the marginal points should be rearranged, otherwise, the polygonal connecting points O, P, R, Q, and H would be the border of the visualising data. To do so, a rectangle of four points was made to surround the whole research site: ranging from P1 to P4, these points have an average value of respective time layers[3]. Figure 5-2 describes the reason why the four points are needed and where the four points are.

Specifically, this border region is based on the individual temporal layers in which the telecommunication data was measured: it has 15 classes with equal intervals of data distribution with layered properties to make the variation of data distinguishable. Each class is represented by colour variations from red, for the highest data level, to blue, for the lowest data level. In addition, telecom data is juxtaposed with real locations and the signal radii of base stations: the resulting telecom data map is shown as a translucent overlay on the urban map below, which includes urban information such as the height and shape of buildings, road systems and geographical contours.

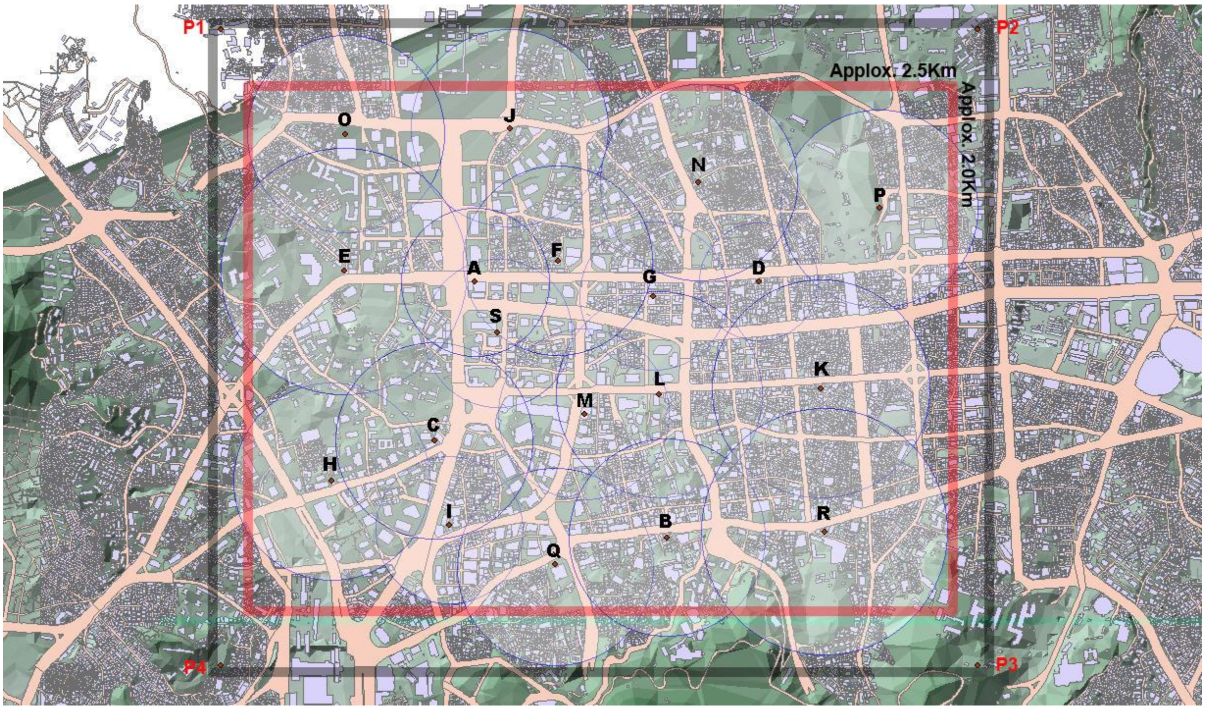

Figure 5- 1. Cell spaces and the four hypothetical points

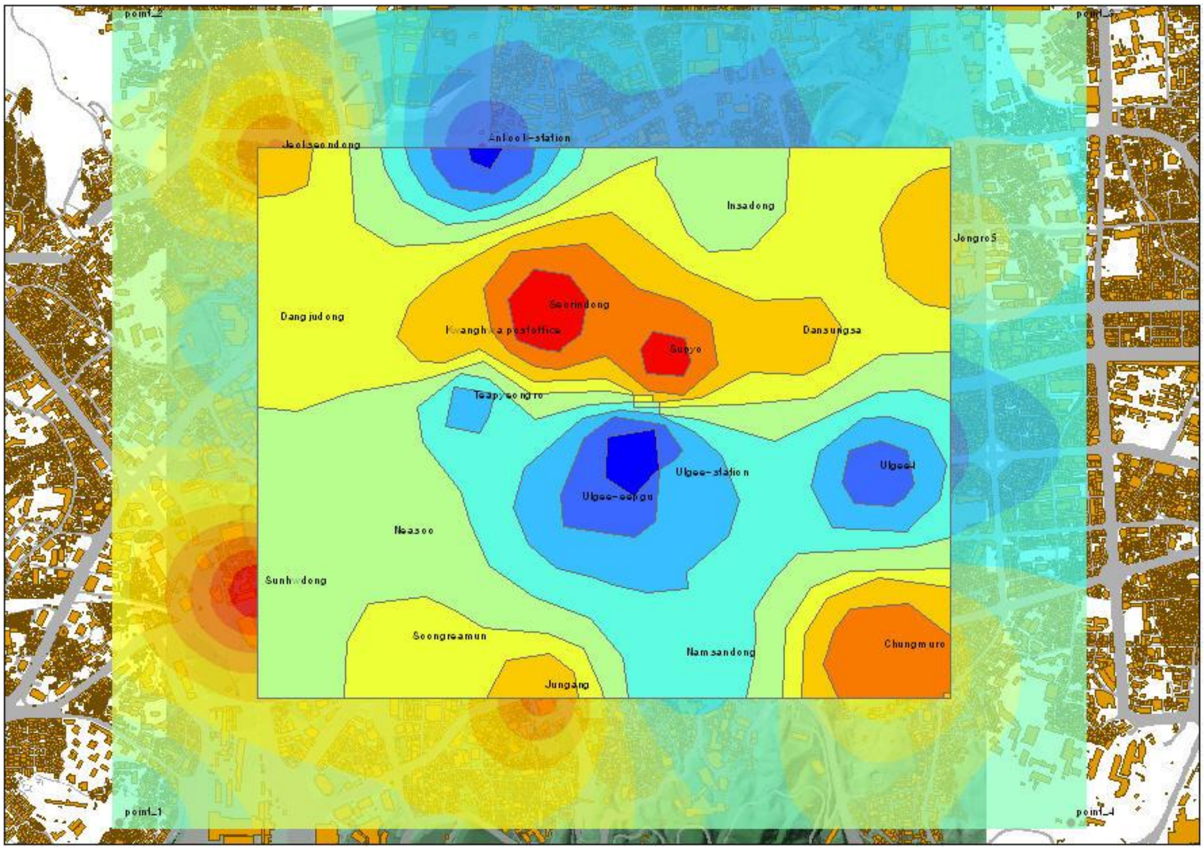

Figure 5- 2. When not applying the 4 hypothetical points, the area analysed will be shrunk; the inner Square is shown before applying the 4 points while the outer coloured square is the current area.

## 5.2. 2D and 3D Mapping

Data distribution for a certain time shows a level of spatial occupancy and telecommunication use, which represents a different density of urban space depending on time variation. Sequences of telecommunication territorialisation are obtained when serial maps are visualised and consulted (From Table 5-1 to 5-6).

- ***2D Visualisation of Data***

The 2D visualisation of data demonstrates how the geographical distribution of telecommunication density changes depending on the variation of time within a day despite beliefs in the static nature of urban settings such as road systems and buildings. City planning and urban design tend to focus on programmes and functions rather than temporal occupations of certain spaces. This does not mean, however, that urban planners and urban designers have not considered temporal factors. As Bernard Tschumi (1994) demonstrates in *Event Cities*, unlike programmes in urban space, events are highly connected with the behaviour and flow of people in a city. In other words, temporal factors are inherent in urban events, and the 2D visual analysis conducted here reveals how the spatial occupancy of people in urban space is more fluid and dependent on time intervals.

We believe, in a sense, that architectural programmes such as building use include a certain number of populations predicted by the purpose of the building. For example, we naturally consider that an area including a busy square is likely to be much busier on a Saturday or Sunday afternoon. However, according to the visualisation research shown below, we tend to overlook the fact that the seemingly busy area of a symbolic square hosting a big event can be less busy than other adjacent areas. When looking at the 2D picture below, the most famous Seoul plaza known nationally for its frequent events programmes is located in the area of C. A historic venue favoured by inhabitants as well as tourists is also placed in C. However, the area C on Saturday and Sunday afternoon is less busy than other neighbouring cell spaces, Q and M. This is because Seoul Plaza is just open space while cell space Q and M is full of commercial buildings and high-rise offices. In other words, the capacity of the space is architecturally programmed. We can anticipate the density of certain areas by considering building use or operations in the respective areas.

| WEEKDAY (MON) | | |
|---|---|---|
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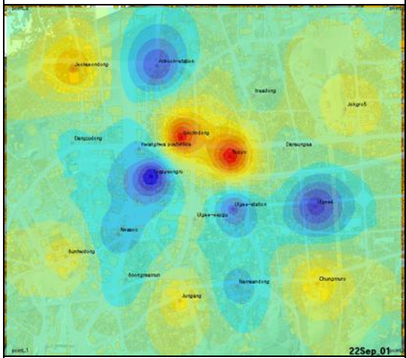
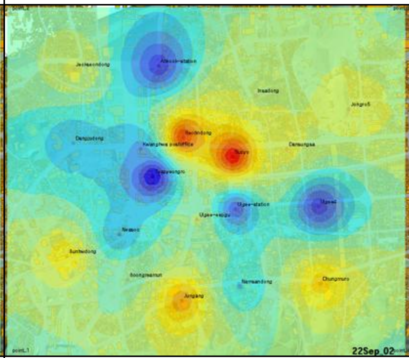
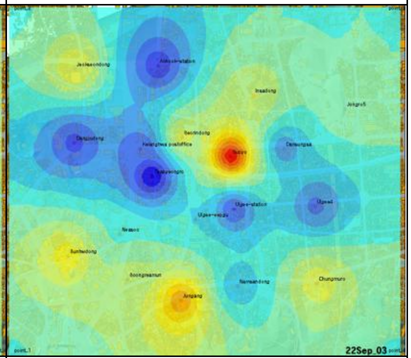
|  |  |  |
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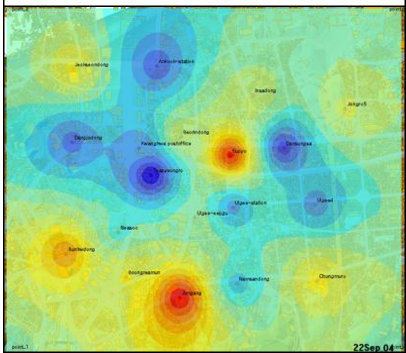
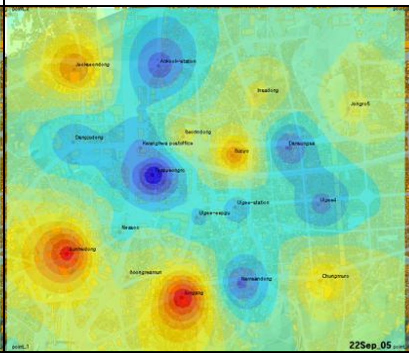
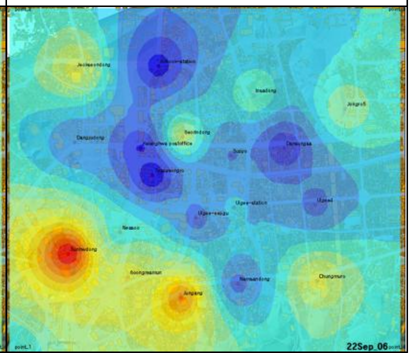
|  |  |  |
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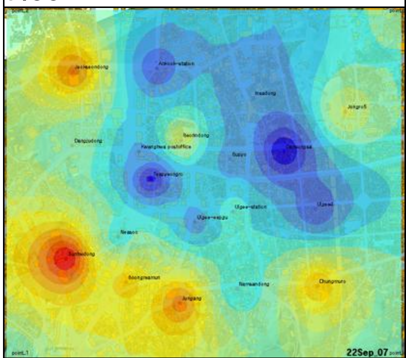
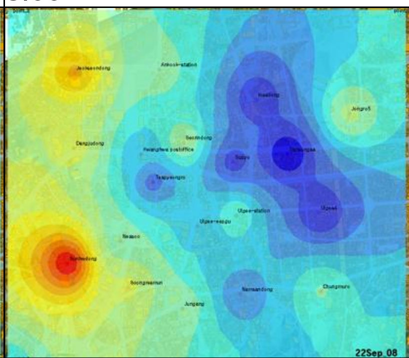
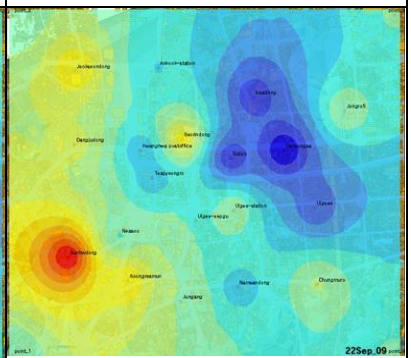
|  |  |  |
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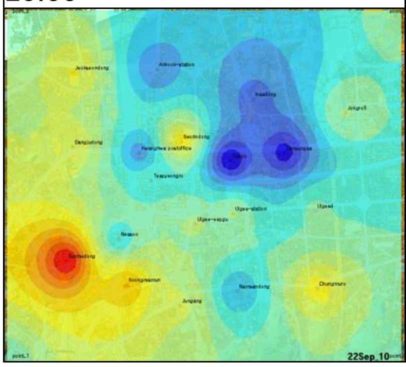
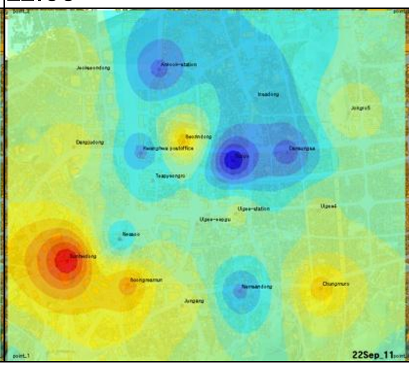
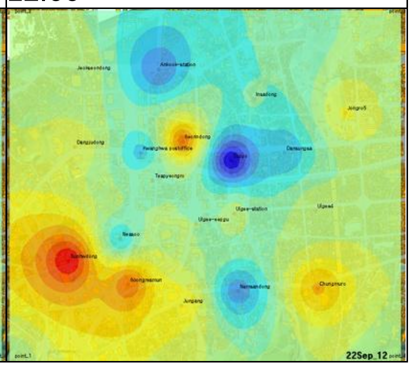
|  |  |  |

Table 5- 1. 2D data visualisation from 1.00 to 12.00 on Monday

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|---|---|---|
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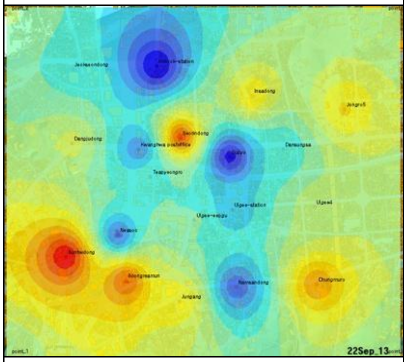
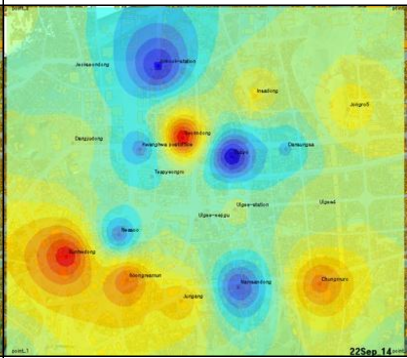
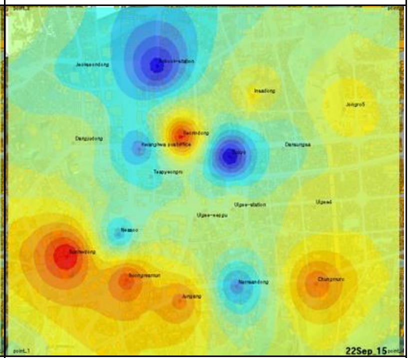
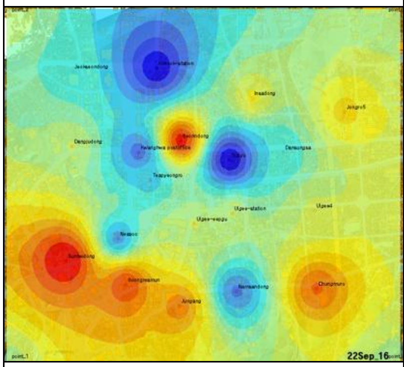
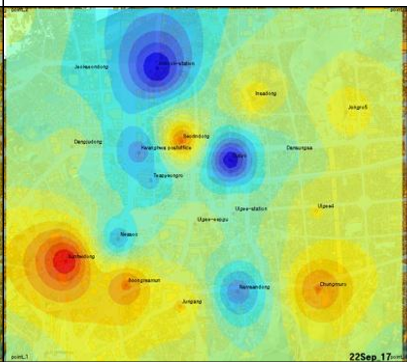
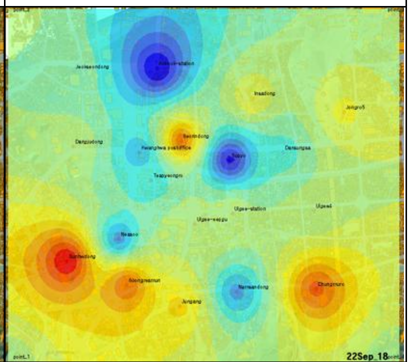
|  |  |  |
| 16.00 | 17.00 | 18.00 |
|  |  |  |
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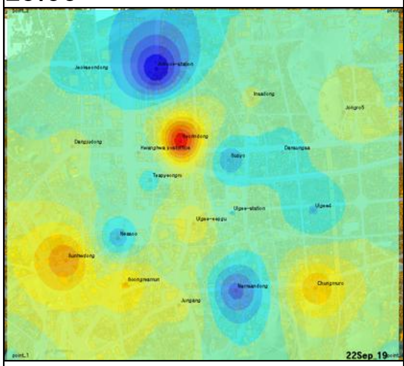
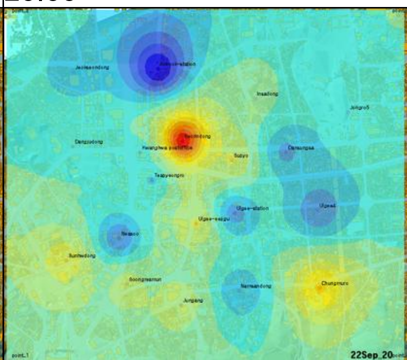
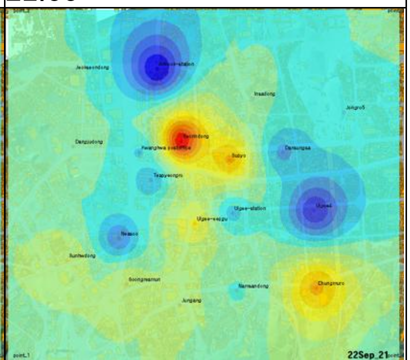
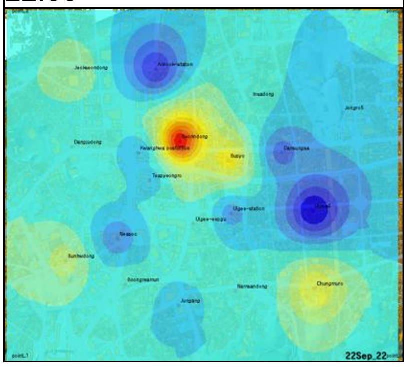
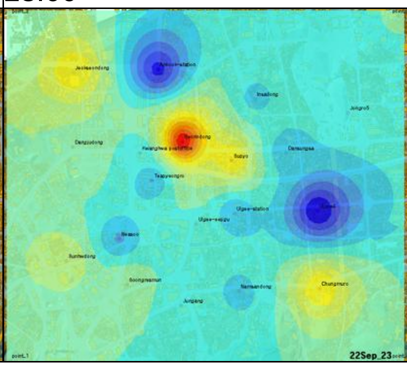
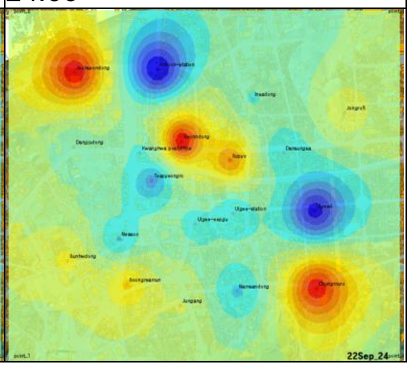
|  |  |  |
| 22.00 | 23.00 | 24.00 |
|  |  |  |

Table 5- 2. 2D data visualisation from 13.00 to 24.00 on Monday

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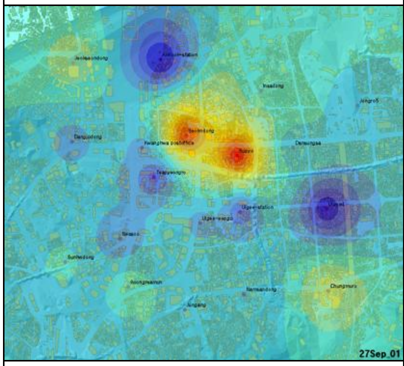
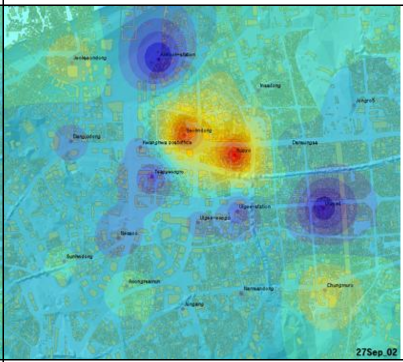
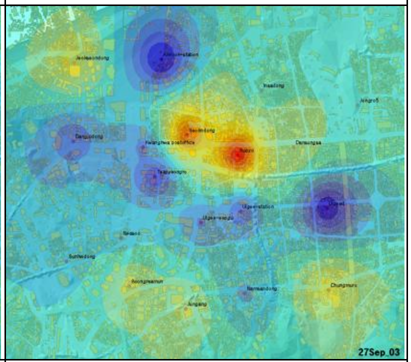
|  |  |  |
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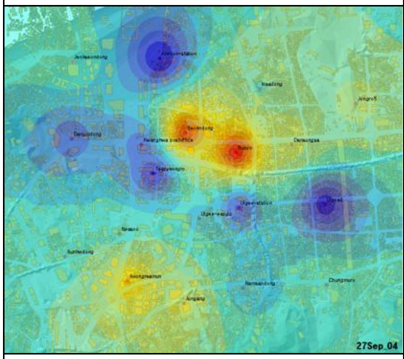
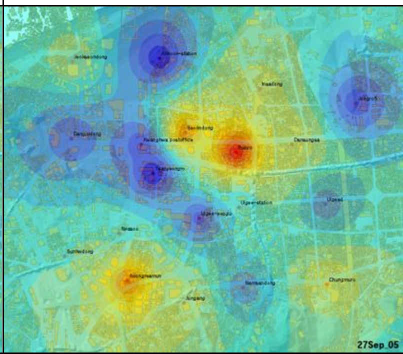
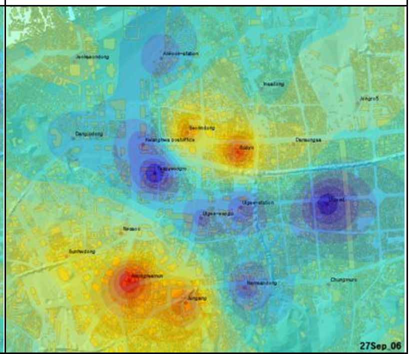
|  |  |  |
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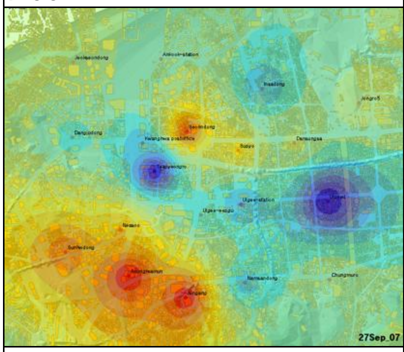
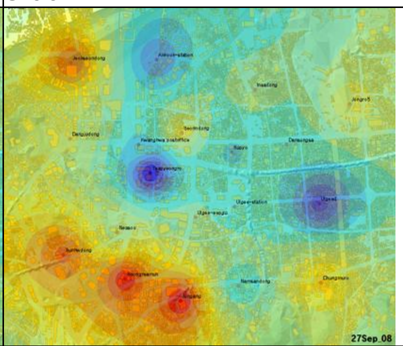
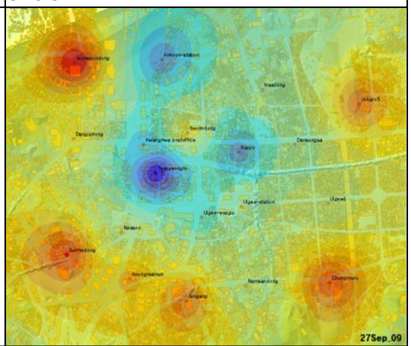
|  |  |  |
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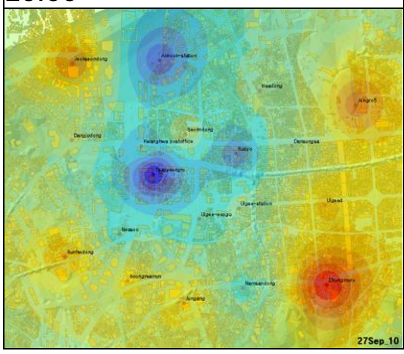
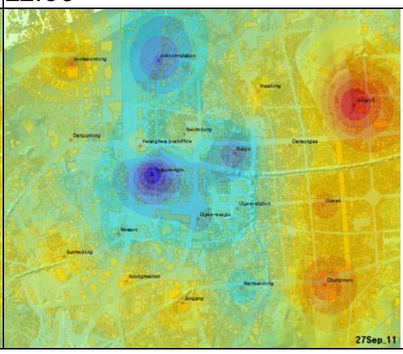
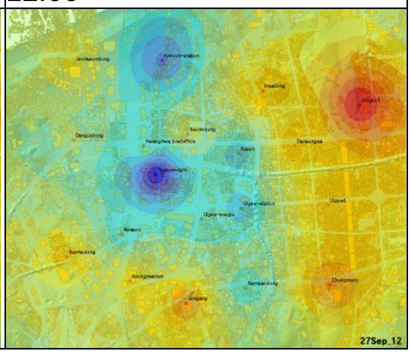
|  |  |  |

Table 5- 3. 2D data visualisation from 1.00 to 12.00 on Saturday

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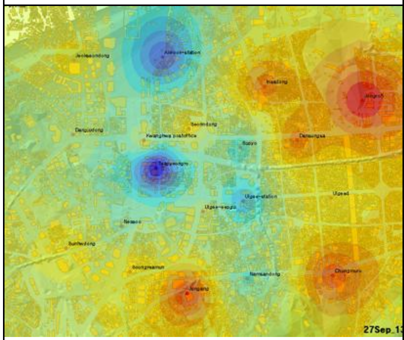
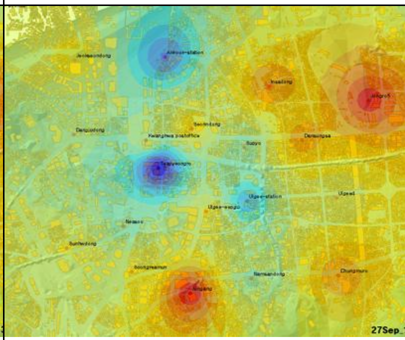
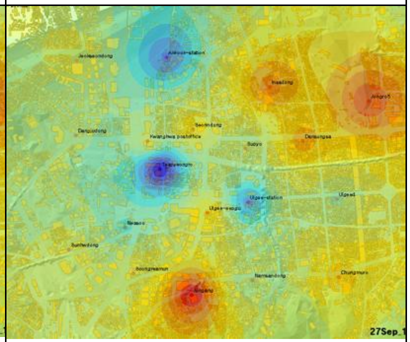
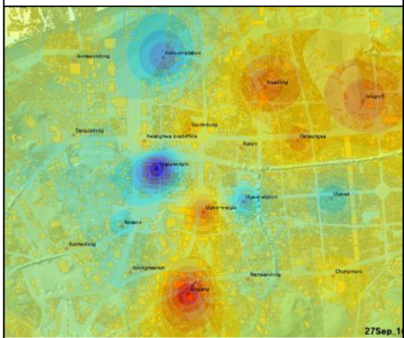
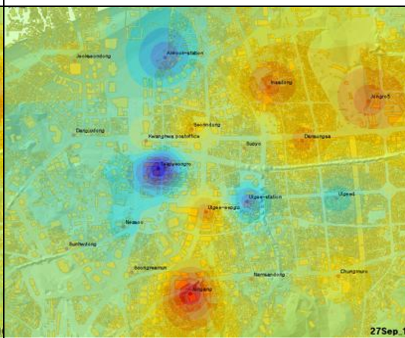
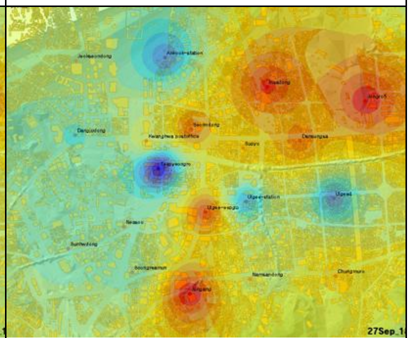
|  |  |  |
| 16.00 | 17.00 | 18.00 |
|  |  |  |
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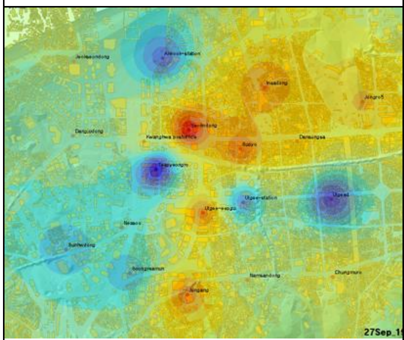
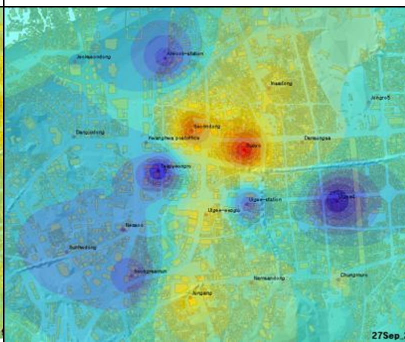
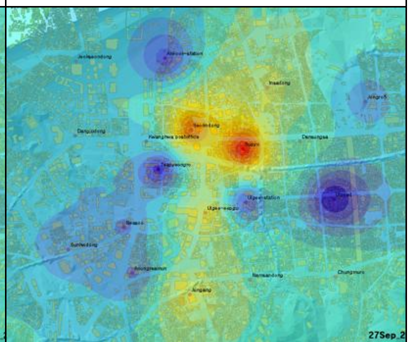
|  |  |  |
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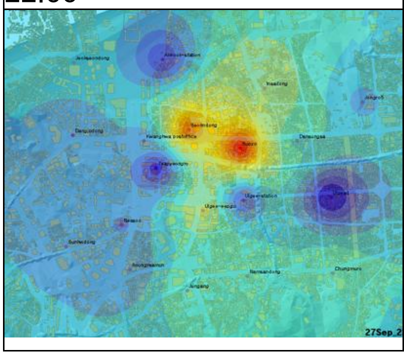
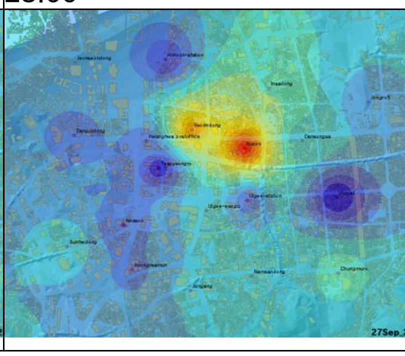
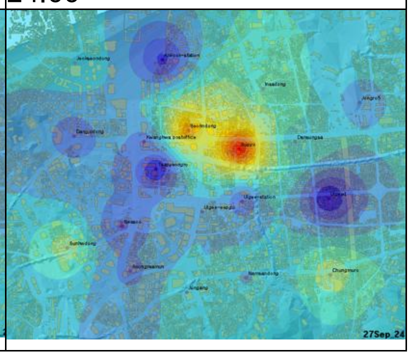
|  |  |  |

Table 5- 4. 2D data visualisation from 13.00 to 24.00 on Saturday

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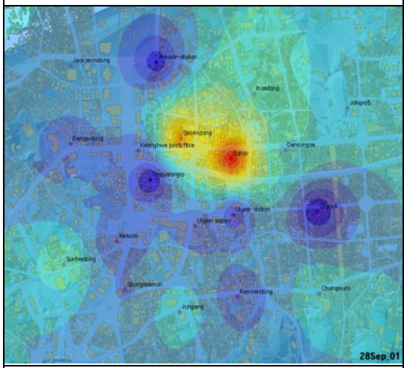
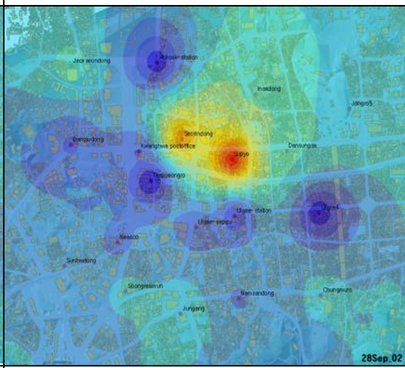
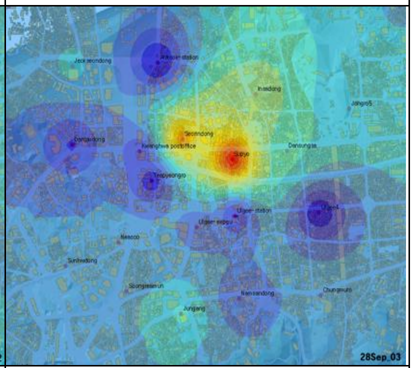
<tr><td></td><td></td><td></td></tr>
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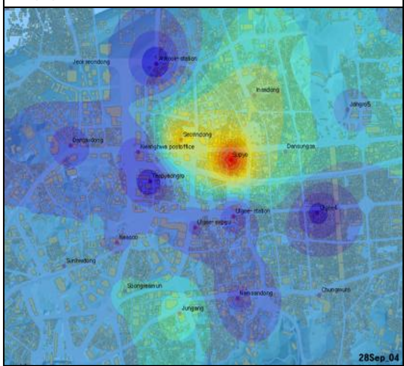
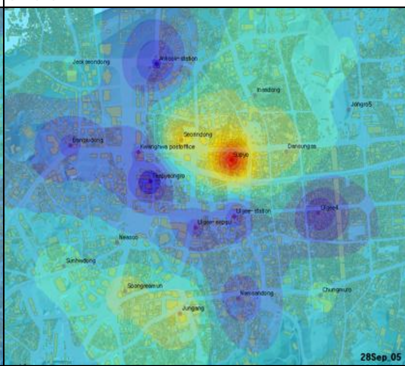
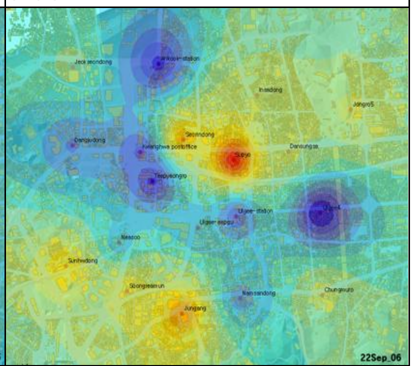
<tr><td></td><td></td><td></td></tr>
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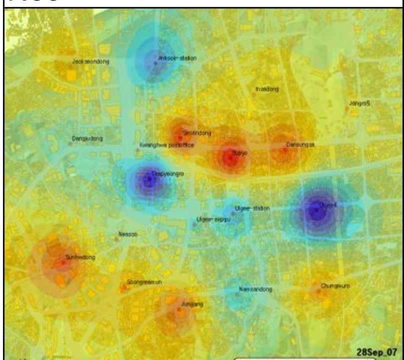
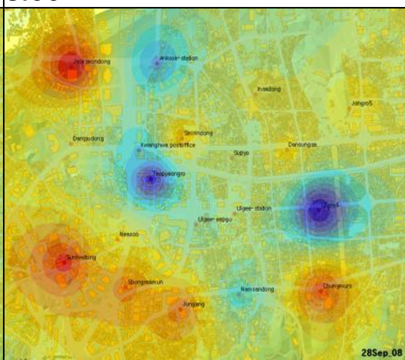
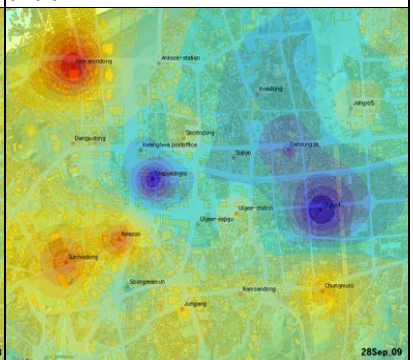
<tr><td></td><td></td><td></td></tr>
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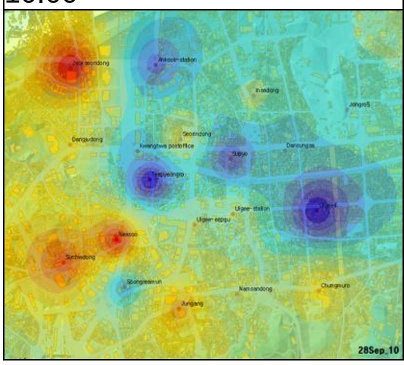
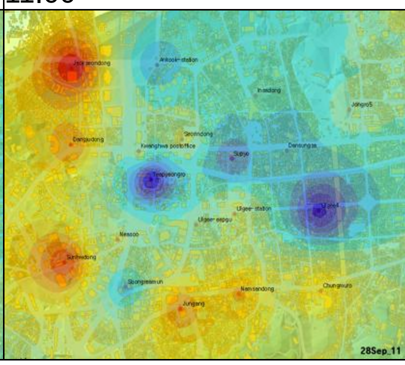
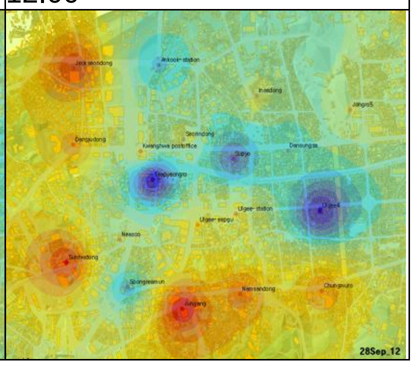
<tr><td></td><td></td><td></td></tr>
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Table 5- 5. 2D data visualisation from 1.00 to 12.00 on Sunday

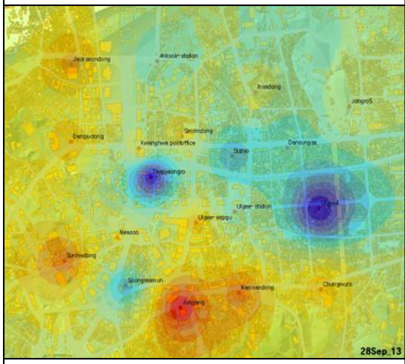
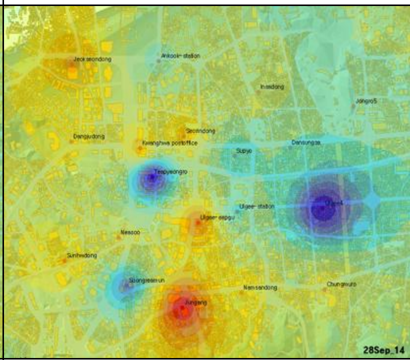
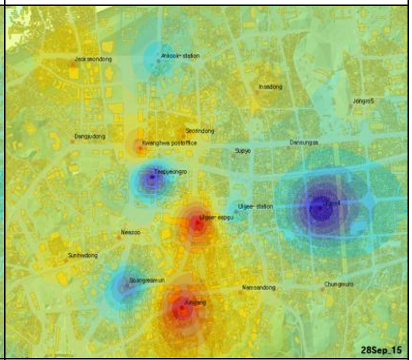
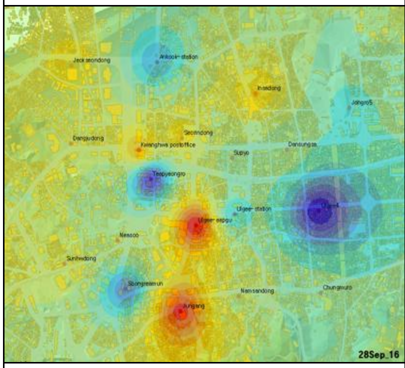
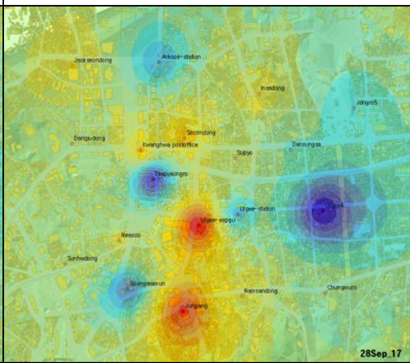
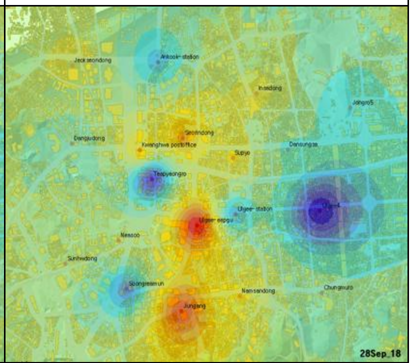
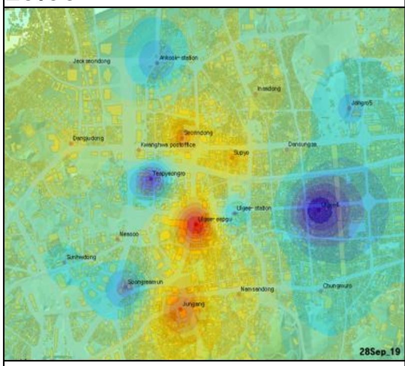
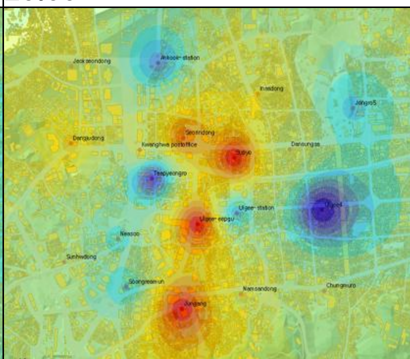
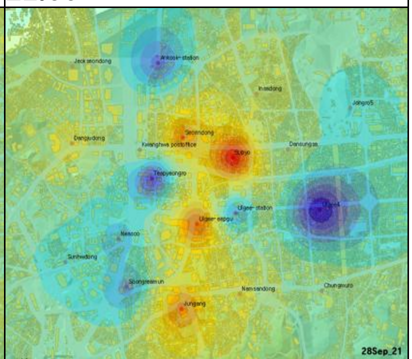
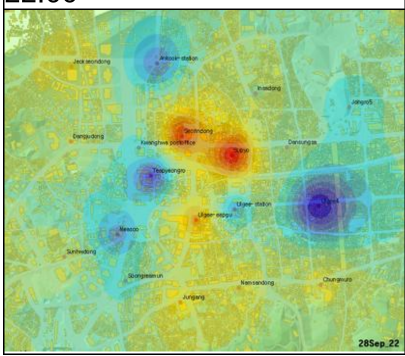
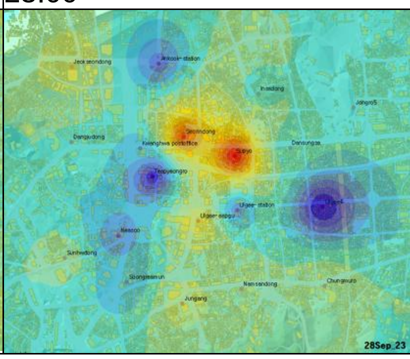
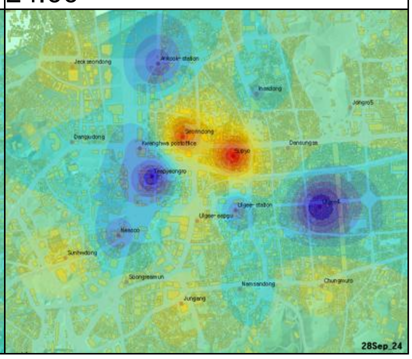
| SUNDAY | | |
|---|---|---|
| 13.00 | 14.00 | 15.00 |
|  |  |  |
| 16.00 | 17.00 | 18.00 |
|  |  |  |
| 19.00 | 20.00 | 21.00 |
|  |  |  |
| 22.00 | 23.00 | 24.00 |
|  |  |  |

Table 5- 6. 2D data visualisation from 13.00 to 24.00 on Monday

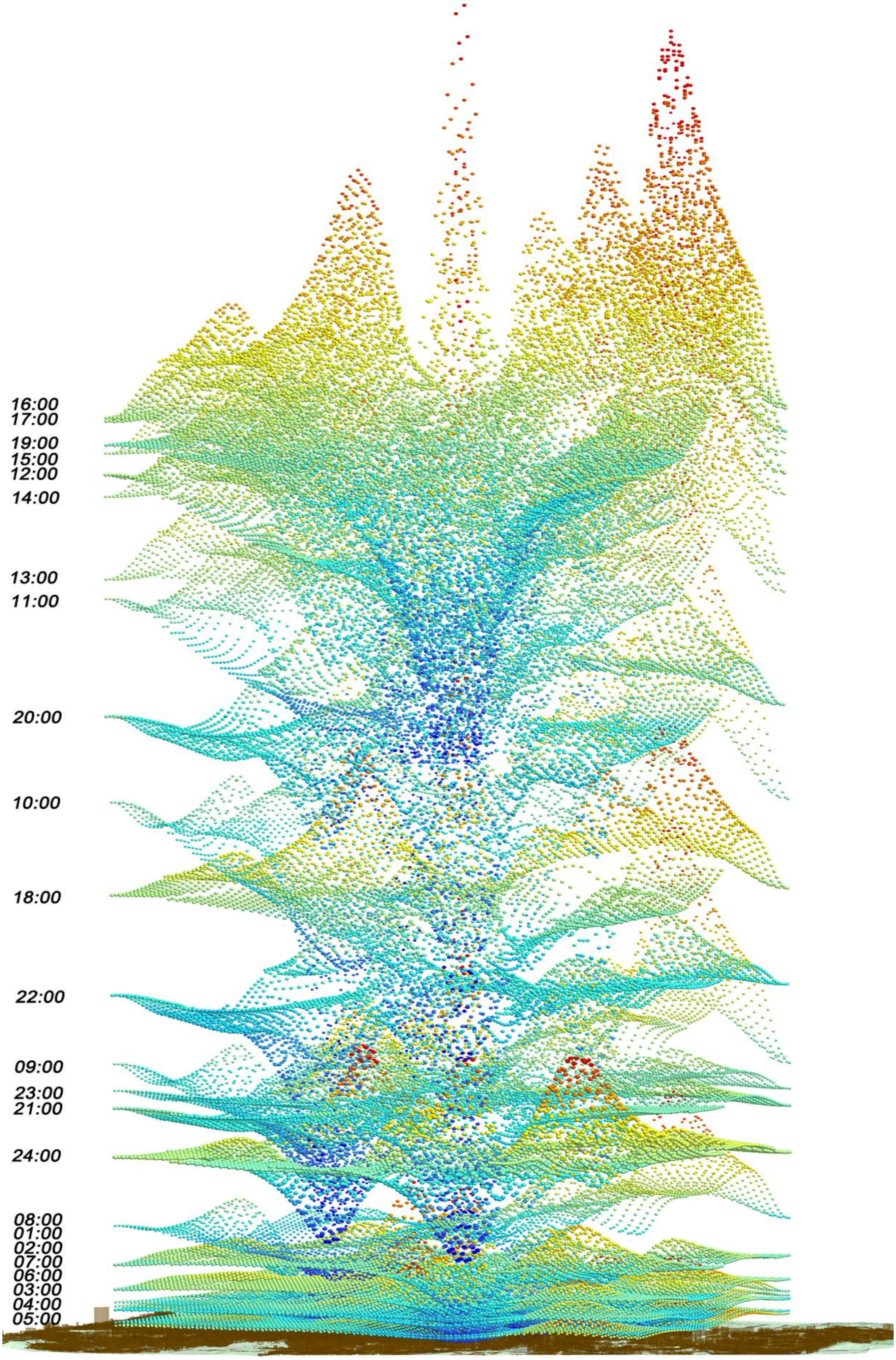


Figure 5- 3. 3D data visualisation created by hourly overlapping data of a weekday, the times in the left side is when respective data topographies come

- ***3D Visualisation of Data***

3D visualisation is generated using spatial analysis in Arc Scene, version 9.2 of ArcGIS (Figure 5-3). The framework for the visualisation is the same in 2D. Through the change of Layer Properties, 15 colour classifications were set to show a changed data distribution at every hour.

The attributes of data distributions in certain cells can be thoroughly visualised using by 2D schemas. From an analytic point of view, 2D visualised maps can be more informative because the resulting data distribution is translucently juxtaposed with geographical data (see tables 5-1 to 5-6), which is more helpful when analysing data shifts geographically. In addition, the pattern of data changes in a different timeline for respective cell spaces can be easily discerned using graphs of the statistics in Section 4.2. 3D visualisation, however, reveals the holistic form of data changes in an urban scale, which can expand our perception of the spatiality of a digital presence. Figure 5-3 shows the 3D data visualisation representing the fluidic shift of spatial occupancy via urban telecommunication.

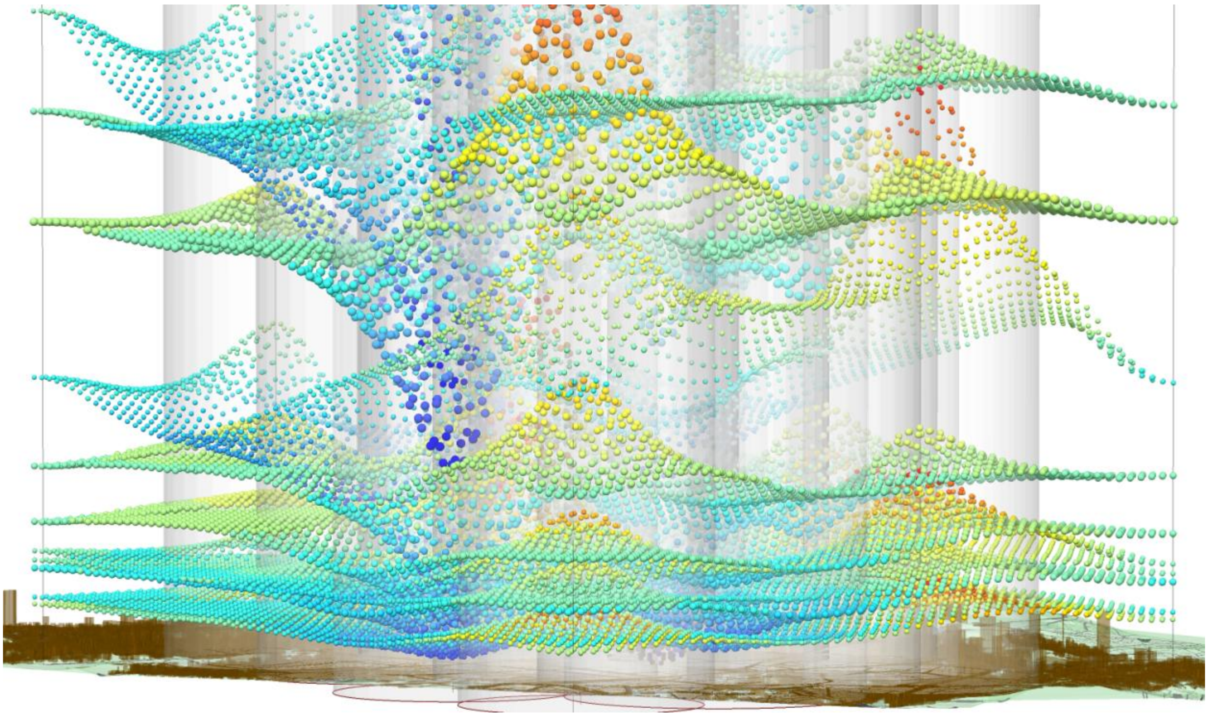


Figure 5- 4. 3D data visualisation juxtaposed with the volumetric structure of cell spaces

## 5.3. Analysis on Visualized Data Maps

Geographical and topographical visualization (2D and 3D) reveal that the pattern of spatial occupancy shown by data distributions varies depending on time intervals. The attributes of respective cell spaces are patterned. Most cell spaces show distinguishable differences between weekdays and weekends. For example, cell H (primarily an office zone) has a much higher data level at certain time during weekdays than it does at the weekend. Cell P (the area of a number of large wholesale markets) is relatively more vibrant in daytime on Saturday than on weekdays and Sunday. This kind of cell space tends to have a singular-use.

However, unlike most cell spaces, which have their own time line for more activation (higher level of data), a few cell spaces represent higher data level regardless of day of the week. They are patterned with the two types: ‘Intensive-use space’ and ‘Mixed-use space’. Intensive-use spaces are close to singular-use spaces. However, they are differentiated from singular-use spaces because of the intensive formation of a certain use. Entertainment districts are an example of this. Cell P (mixed-use area focusing on entertainment venues and restaurants) shows a higher level of data at night throughout the whole week. In the case of cell P, the dense distribution of bars and entertaining facilities is the reason for it to be higher at night every day. On the other hand, although cell Q (mixed-use area: office buildings, wholesale markets, department stores, and historic venues) has the same type as cell P at first glance, diverse uses are activated alternately when it is analyzed by matching urban space. Through telecommunication data visualization in urban space, the specific attributes of the space can be acquired, visualized and analyzed. Also, time-based informative maps deliver more really situational information of live urban space. This kind of spatial information is beyond geographical information based on the static built environment, and is more informative for a spatial experience.

In addition, the topological visualization of urban telecommunication is revealed by colour changes and relative height of 2D and 3D maps respectively. This is important in scrutinizing the relationship between people flow and the urban context in terms of telecommunication use. In fact, in architectural design and most plans related to the built environment, the flow of people provides a fundamental design intervention which can be referred to as a kind of ‘people traffic’. In particular, the telecommunication flow of people conveys more specific numerical information than the people traffic being currently used in architectural practice. This is because more specific numbers can be collected and predicted using telecommunication data while the existing practice tends to rely primarily on observation. In addition, the pattern of temporal occupancy is read through overlapping data topography (3D visualization), which also provides a more specific informative number of ‘people flow’ while the existing architectural and planning practice that needs to refer to people flow has tended to adopt observation. Furthermore, if both spatial and temporal information of people traffic are visualized, interventions for designing certain works regarding the built environment can be generated from holistic viewpoints.

The 2D and 3D maps can also be interpreted as maps of interaction between people and urban space. The interaction between people and urban space means that architecturally people occupy a certain space, which can be called as locative interaction in the computing field. In the interaction, time can be a crucial catalyst to make it possible to trace the sequence of the spatial occupancy of people. In this respect, the 2D and 3D maps show the temporal alternations of spatial interaction of people, which can be seen as an alternating territorialization of urban telecommunication. Spatial occupancy can be structured by temporal overlaps, as seen in Figure 5-4.

The characteristic of this data visualization is chronological calibration. Hourly visualized telecommunication data is the process of decoding live urban space through capturing telecommunication situations at certain times. 3D visualization can be seen as temporally deconstructed images of live urban space, which constitutes the telecommunication rhythm of time-space. In the visualized rhythm, we can conceive the heterotopias mechanism reflecting live situations in urban space. This is because heterotopias can be interpreted as individually adjustable spaces and a live urban context can be more informative in finding more adjustable space as human traffic can be a crucial factor of spatial experience. However, quantitatively visualized maps have limited information regarding urban space. Therefore, the discussion of heterotopias attributes is needed to investigate the real urban situation by comparing visualized data maps. This discussion will be conducted by observing the real urban space in the next chapter.

## 5.4. Summary

Telecommunication data collected from base stations were visualized by juxtaposing it with urban space hour by hour. Spatial Analysis in a GIS programme was used as the tool for the process and visualization of the data. Through visualized maps, the temporal attributes of urban space are revealed in a number of patterns: singular-use space, intensive-use space, and mixed-use space. Time-based visualized maps deliver more situational information about urban space. This kind of spatial information is beyond geographical information based on the static built environment, and is more informative about the spatial experience.

Furthermore, the 2D and 3D maps are interpreted as maps of the interaction between people and urban space. In the data maps, time acts as a crucial catalyst to trace the sequence of people's spatial occupancy, which demonstrates the telecommunication rhythm of time and space. In this respect, the 2D and 3D maps show the temporal altering of spatial interaction, which can be seen as an alternating territorialization of urban telecommunication. These temporal shifts of spatial interaction demonstrate the ambiguity of spatial programmes in urban space. This is because spatial occupancy is altering, although spatial programmes in the built environment are given and determined. This means that certain spatial programmes can be more, or less, influential on one's spatial experience. Moreover, actual spatial experience might not be synchronized with certain spatial programs in urban space. This can be interpreted as the ambiguity between spatial experience and programmes in urban space. In the visualized rhythm, the heterotopias attribute (ambiguity) of live urban space will be discussed in the next chapter through observation of real urban space compared with visualized data maps.

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[1] ArcGIS is an integrated collection of GIS software products that provides a standards-based platform for spatial analysis, data management, and mapping. ArcGIS is scalable and can be integrated with other enterprise systems such as work order management, business intelligence, and executive dashboards. (http://www.esri.com/software/arcgis/index.html).

[2] a popular geospatial vector data format for geographic information systems software.

[3] Inverse distance weighting models work on the premise that observations further away should have their contributions diminished according to distance. The simplest model involves dividing each of the observations by the distance it is from the target point, http://www.spatialanalysisonline.com/OUTPUT/html/InversedistanceweightingIDW.html. [Retrieved as of 15 April 2012]

# Chapter 6
# OBSERVATION

Chapter 5 demonstrated the temporal and spatial map of telecommunication territorialisation in urban space, which was created using simple numerical information related to spatial and temporal factors. These 2D and 3D data visualisations were interpreted as interaction maps between people and urban spaces.

In this chapter, the correlations between actual activities and architectural programmes are investigated and incorporated in an in-depth study of urban interactions gathered using on-site observation. Observations were conducted following temporal trajectories generated by connecting areas with the highest data levels from temporally arrayed 2D maps.

## 6.1. Temporal Trajectory

Observational research was conducted in urban public spaces demonstrating the highest data levels amongst cell spaces. Although the areas of dense use are represented by the same colour (red), the highest data areas for different times can be observed for activities prescribed by architectural programs. Adaptive use can reveal the gap between actual activities and programmes in the built environment, which may be a key feature in locative interaction; the action prescribed by architectural programmes versus actual activities can produce a significant context for locative information.

Observation routes (temporal trajectories) were arranged by overlapping 2D visualised maps gathered at one-hour time intervals and by connecting the highest data level cell spaces (Figure 6-1). This provides a time schedule for observation as well as areas of interest. Figure 6-2 demonstrates these locations and a time schedule for a weekday, Saturday and Sunday. Photographs and video recordings were made according to these schedules.

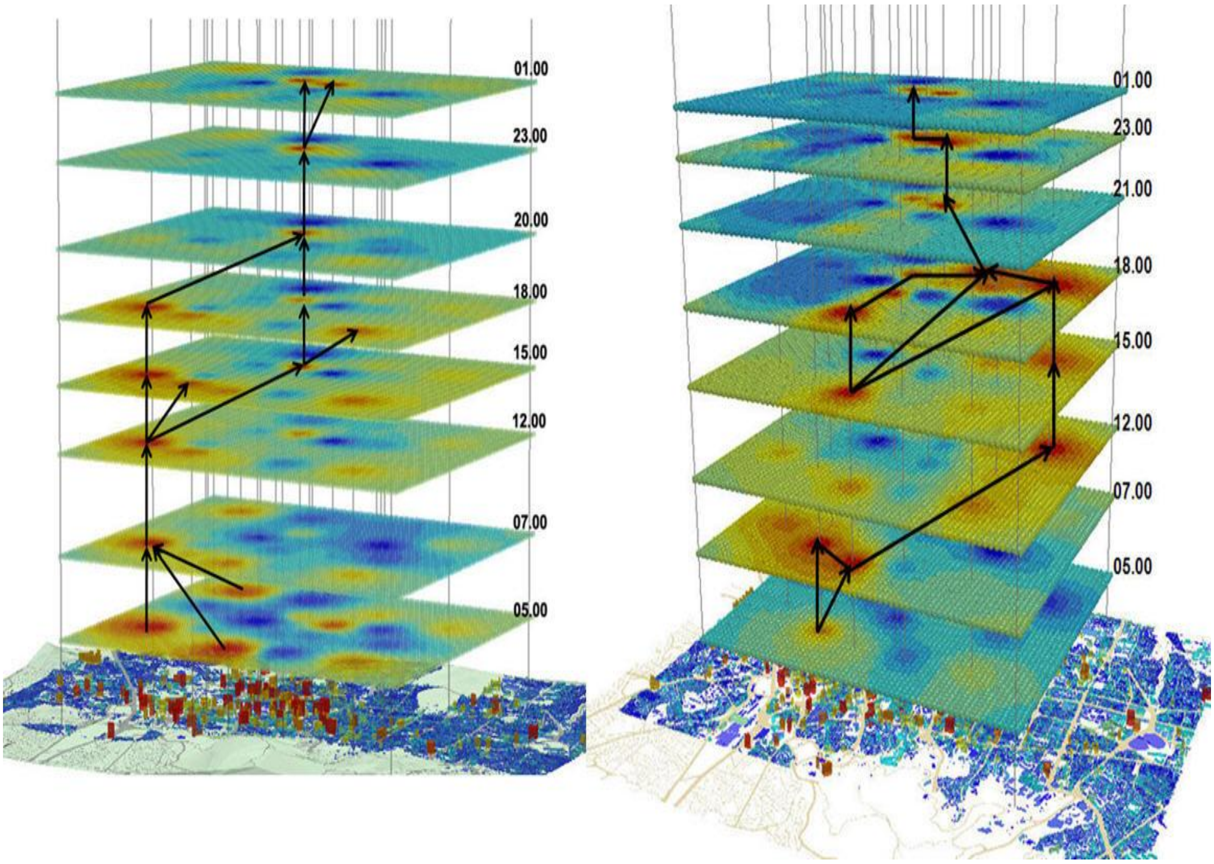


Figure 6 - 1. Temporal trajectories: connecting telecommunication focal points where data reaches the highest level (right: A weekday, left: Saturday)

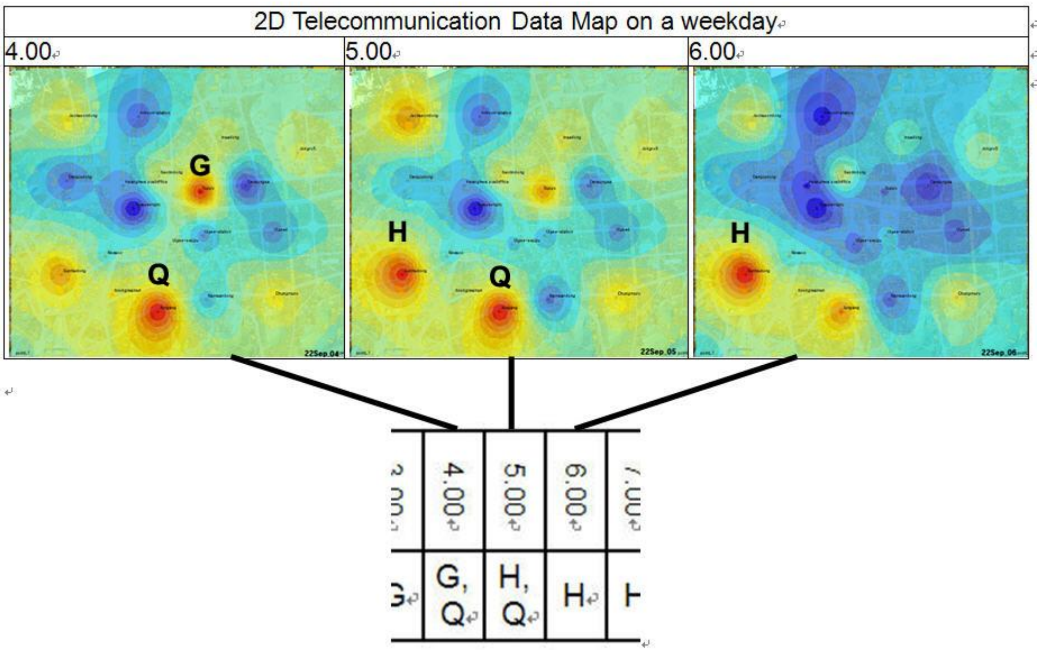


Figure 6 - 2. Observation spots & Time schedule

| Temporal trajectory of a week day | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 | 13.00 | 14.00 | 15.00 | 16.00 | 17.00 | 18.00 | 19.00 | 20.00 | 21.00 | 22.00 | 23.00 | 24.00 |
| , G | , G | | , Q | , Q | | | | | | | | | , H | , H | , H | | | | | | | | , P, R |

Table 6- 1. Observation spots & time schedule of on weekday

| Temporal trajectory of Saturday | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 | 13.00 | 14.00 | 15.00 | 16.00 | 17.00 | 18.00 | 19.00 | 20.00 | 21.00 | 22.00 | 23.00 | 24.00 |
| , G | , G | , G | , G | | | , Q | , Q | | | | | | , Q | | | | , P, Q | | | | | | |

Table 6- 2. Observation spots & time schedule on Saturday

| Temporal trajectory of Sunday | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.00 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 | 7.00 | 8.00 | 9.00 | 10.00 | 11.00 | 12.00 | 13.00 | 14.00 | 15.00 | 16.00 | 17.00 | 18.00 | 19.00 | 20.00 | 21.00 | 22.00 | 23.00 | 24.00 |
| | | | | | | | , O | | , O | | | | | , Q | | | | | Q | | | | |

Table 6- 3. Observation spots & time schedule on Sunday

## 6.2. Observation

### *6.2.1. Weekdays*

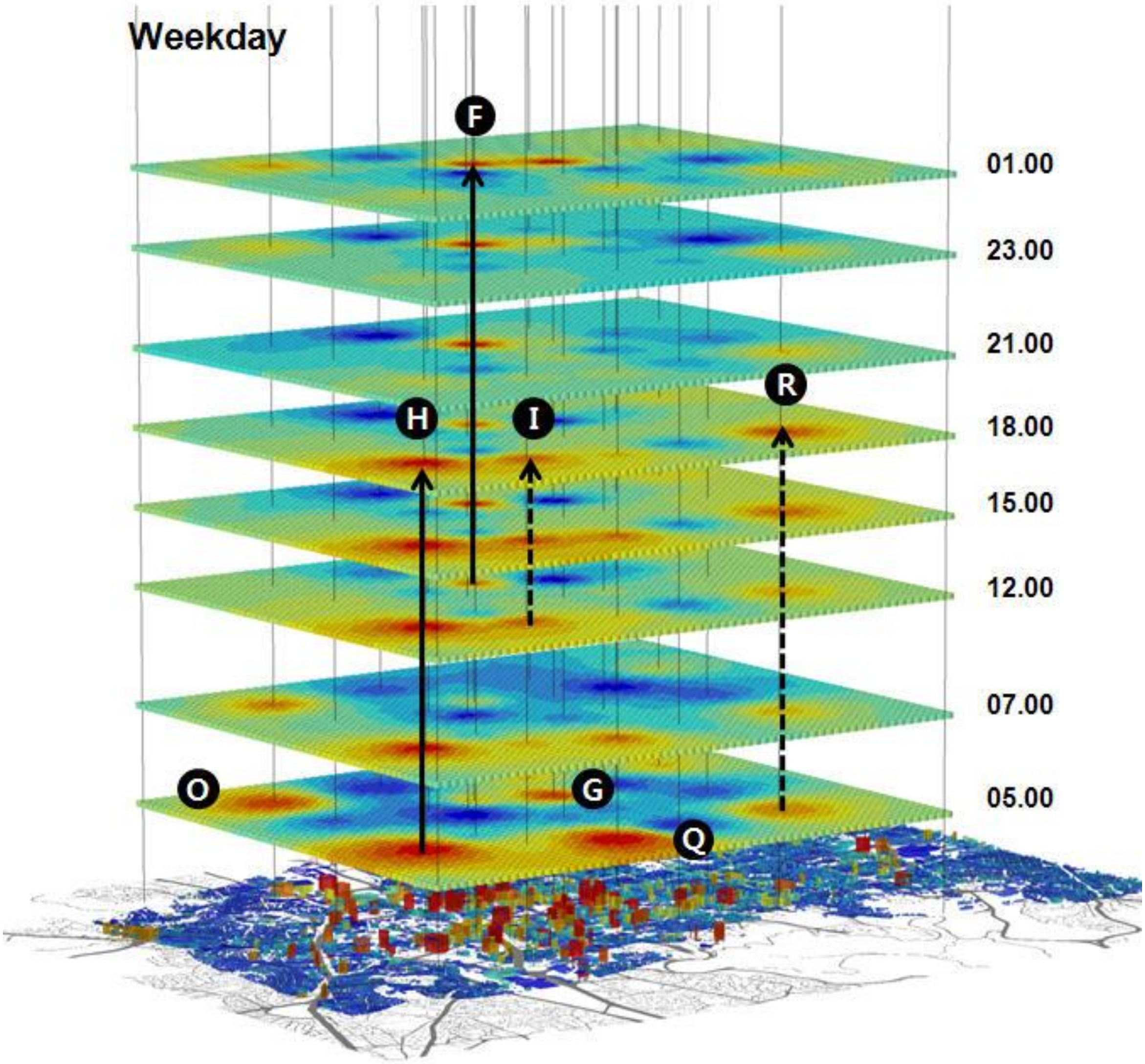


Figure 6 - 3. Temporal trajectory on a weekday

- ***Cell Space H (5.00 – 18.00): Working hours***

Cell space H is an area composed of office buildings. Observational research in this area in the morning on a weekday deviates from our expectation as the highest data level area: the streets are busy with morning commuters. Although a number of catalyst population-inducing facilities, such as a big market, an office complex and a large train station are located in the area (H), the urban situation showed a nearly empty cell, as seen in photo 10.00_H in Figure 6-4.


Figure 6 - 4. Scenes on a weekday (a weekday in September 2009)

The highest data levels in the time line originate from buildings in the cell that house a number of conglomerate offices located near this area. Unlike other cells that are hybridised zones with various mixed-use buildings, this cell (H) reflects a daily weekday routine while mixed-use areas tend to have more retail buildings that show a different rhythm of occupancy. In observations made between 7:00 and 17:00, pedestrians are much less noticeable than in other cell areas during the same time line.

On the other hand, a higher density of office buildings does not fully describe the reason for the highest level of data in this cell space because office workers generally tend to use a landline for work. On this point, the telecommunication behaviour of salesmen in travel and insurance companies demonstrates the reason for the argument above. This telecommunication activity results mostly from salesmen who tend not to have their own desks due to the mobile nature of their work; this gives rise to more mobile phone calls in this cell space.

- ***Cell Space Q (12:30 – 15:00): Lunch time in working areas***

During and after lunch time, office workers tend to take a break in front of the buildings where they work while talking and smoking. Except for 1 PM when they have lunch, a much higher level of data is shown in this area, as well as most other cells, in a day. It reflects a telecommunication pattern of people in the cell space and at the time as illustrated by interviews and observation. A substantial number of people tend make a mobile call in outdoor space during a break time after lunch while they use a landline in their office when working.

- ***Cell Space F (15.00 – 24.00): Afternoon life in weekdays***

There are a considerable number of multi-use complexes in cell F whose building uses range from commercial to residential purposes. Most facilities tend to become vibrant after working hours; in particular, there are traditional districts famous for bars that are open at night. During this time, even more people are seen on the street while others might go home. Some meet friends or may join an evening class. After work, the existing population in and around offices hours tends to change, which means more mobile phone calls tend to be made.

Multi-use complexes tend to be set by a variety of architectural programmes, which cause the frequent efflux and influx of population. Individual programs, however, have a different kind of rhythm that demonstrates a cyclical spatial occupancy. Diverse programs mean that diverse activities; it can be expected that diverse spatial layers exist. Conversely, programmes in multi-use complexes are pre-designed and specific activities are to be expected. These demonstrative traffic and spatial activities are traced first using telecommunication data visualisation and then observed accordingly.

### *6.2.2. Weekends*

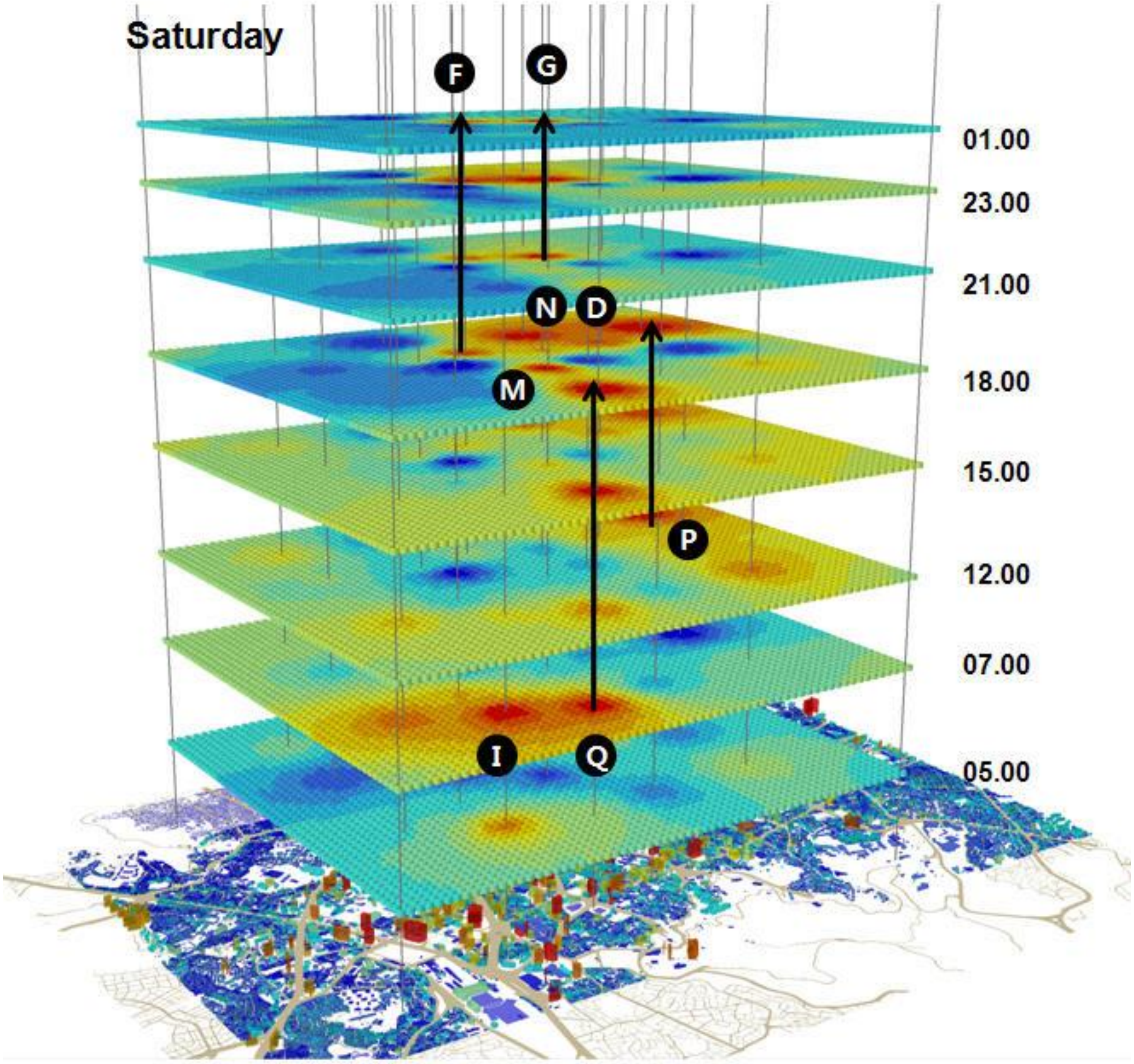


Figure 6 - 5. Temporal trajectory on a Saturday

- ***Cell Space Q (6.00 – 8.00:) Early morning working area***

Namdaemun market is located in cell Q, which is one of the largest wholesale and retail markets in Seoul and one of the famous tourist spots. As expected from an architectural programme of a wholesale markets, early morning is one of the busiest times of day. During weekdays, the relative number of mobile calls in cell Q is not unusual because other cell areas are more active from nearly the same time. On the other hand, unlike weekdays, other cells where there are various large company offices have lower data levels. This is because these areas are almost empty on Saturdays and Sundays.


Figure 6 - 6. Scenes on Saturday (September 2009)

- ***Cell Space P (11:00 – 14:00): Going out on Saturday***

The distinctive scenes of this area are characterised by a number of wholesale markets specialising in a range of items clustered along a six-lane road near Jongro5 tube station. This historic central area is populated by older generations rather than young people. Since the cell area is a transportation hub, large numbers of people converge there, particularly on Saturdays and Sundays. People who live on the outskirts of the city and want to go shopping or entertain family and friends tend to value the accessibility and the urban events designed in this architectural setting.

- ***Cell Space N, G, and P (18.00): Cultural life at the weekend***

Cell space N is one of the most famous destinations and is a popular meeting point, particularly on Saturdays. A large number of celebrated art galleries and cultural facilities are located here. In terms of the urban context, cell space N is surrounded by cell spaces F (Seolin-dong), G (Sup-yo), and P (Jongro5) where the highest data traffic is shown primarily at night, regardless of the day of the week.

Despite this, cell N (Insa-dong) does not match the three other cell spaces (F, G and P) in terms of the occupants' age and the purpose for visiting the cell area. For example, the nighttime darkness of cell N contrasts with the glaring streets of cell G, which is just across the street from cell N. Although these cell areas are highly commercialised districts, observed activities are somewhat different from the activities anticipated for the given architectural programme; in particular, spatial occupancy is shown to be different depending on age groups. This gap can be interpreted as the creation of a heterotopia according to age groups.

- ***Cell Space F and G (20.00 – 24.00): Entertainment areas 7 days a week***

Cell space F and G are famous entertainment districts: there are a large number of bars, pubs, and clubs for young people. The data from these cell spaces ranks as the highest during the night.

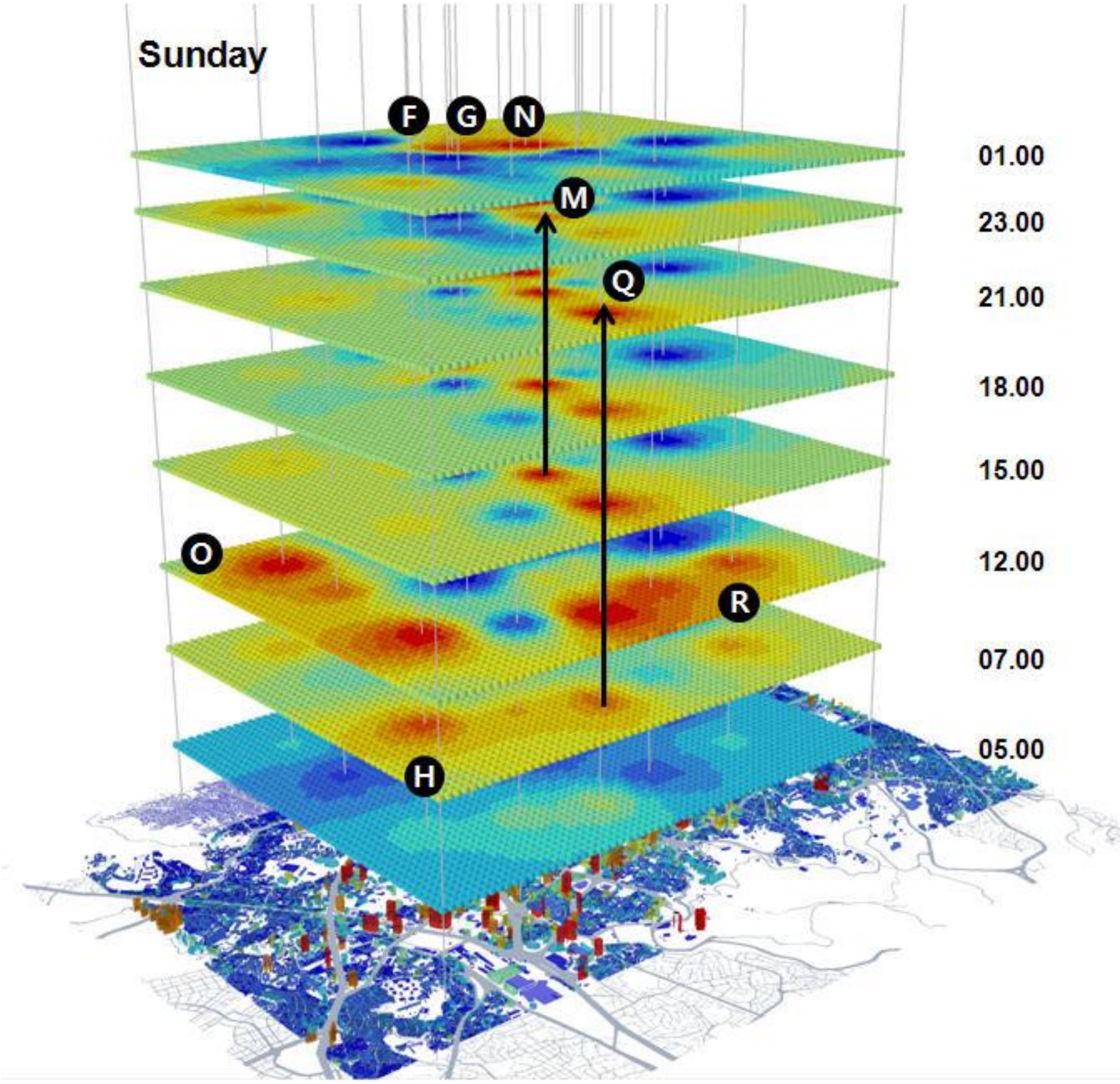

Figure 6 - 7. Temporal trajectory on Sunday

- ***Cell Space O (9:00 – 11:00): Church area***

Busy activity is not generally anticipated in urban spaces on a Sunday morning. However, the highest data level is visualised in such a space, as seen in Figure 6-7. There is nothing to attract the population, such as retail shops and markets, in the cell area, but the concentration of three churches is at the root of this high traffic level.

- ***Cell Space Q (9:00): Shopping Districts***

One of the biggest wholesale markets, Namdeamun Market, is located in this area. As expected during an early morning in a big market, many sellers are busy and move around while arranging goods. Wholesale shoppers continuously arrive to purchase and move goods at the same time. A great number of tourists and retail shoppers later join in—browsing and experiencing this vibrant and unique atmosphere.

- ***Cell Space M and Q (12:00 – 21:00): Shopping Districts***

The core area of cell space M and Q is Myung-dong, a famous district adjacent to two of the biggest department stores, a few grand hotels, and one of the biggest traditional wholesale markets in the country. The main streets and side streets are overwhelmingly crowded during the whole day. Most of the pedestrians and consumers, diners, and theatre-goers are in their 20s and early 30s. Large numbers of tourists from Japan and China also prefer travelling around these areas.

Although a number of large-scale office buildings are located within the cell area, this vicinity is highly influential in the urban structure as a shopping district mixed with diverse cultural and entertaining facilities. These cells function as heterotopia for its occupants. The mixed-use shopping venue provides a spatial experience reflecting ones desires and dreams. It is a heterotopic space where consumers purchase what they want and satisfy their desires. The cell areas are a physical part of the urban space and are simultaneously a mirrored counter space for occupiers who experience the contemporary draw of shopping. Also, shopping facilities can be a catalyst, gathering round them other relevant facilities such as restaurants, cafes, theatres and so on. These kinds of facilities increase the influx of people, which can cause a heightened level of telecommunication data.

## 6.3. Urban Situations in Telecommunication

The busiest area in observation is connected with the highest level of data. This means that higher traffic is most likely related to more people. Most of the highest traffic areas show crowded streets: observed activities and occupant density are primarily connected with the urban physical structure. For example, an increase in data is anticipated in office areas during weekdays. In other words, times connected with working, such as commutes and lunch time, are reflected in telecommunication traffic volumes. This was also confirmed via statistical study in Chapter 4 and data visualisation in Chapter 5. During weekdays, working time and working space synchronise to generate telecommunication data. Architectural programmes (zoning, building use) in urban spaces primarily determine the activities traced via telecommunication data.

- ***The Gap between Visualised data and Real Scenes in Urban Space***

It is important to note that on a weekday, just after the commuting period when data is dramatically increasing, few people are observed on the streets in cell space H. On the other hand, although the number of calls on Sunday is considerably lower than those of a weekday and Saturday, outdoor areas of cell space M and Q are much busier due to traffic and street events. A further comparison was made solely based on the data. The highest volume of calls on Sunday came from cell space M (6 639 calls). The second highest recorded volume of calls for a weekday or Saturday, however, was approximately 20 000 (cell F) and 61 345 (cell Q). Unlike numerical differences, it is interesting that digital communicative focal points on Sunday (cell space M and Q) show even busier streets than those of weekdays and Saturdays. This means there is a gap between telecommunication data and observed scenes.

In order to scrutinise the gap between the traffic data and the observed scenes, a brief interview was conducted on site. According to interviewees at telecommunication focal points on Sunday, subjects tend to make mobile phone calls immediately before activities. For example, most interviewees made mobile calls related to their immediately before meeting. Once they meet up, the groups tended not to make mobile calls. In addition, when they returned home, they tended to make mobile calls. This means that telecommunication tended to be utilised around the time before and after activities in these areas. Population-inducing facilities are likely to generate more mobile calls, which are connected with architectural programmes.

In interviews at telecommunication focal points on weekdays, office workers tended to use a landline for work and a mobile phone for private matters. Depending on the type of job, a mobile phone is utilised as one of the diverse communication means during working hours. Generally, people who work in sales tend to rely on mobile communication rather than landlines due to increased mobility. The interviews on Sunday and a weekday, therefore, exemplify the way telecommunication use is related to both time (everyday rhythm) and space (architectural programmes).

- ***Heterotopias Layers***

The interviews in cell Q on Sunday and Monday are of particular interest. Cell Q is a telecommunication focal point (a higher data level area) on both Sunday and Monday at different times (12.00 and 15.00, respectively). On the other hand, other telecommunication focal areas alter depending on whether it is a weekday, Saturday or Sunday. Interviewees in cell Q on Sunday and Monday show very different uses of telecommunication behaviours, despite occupying the same space. The interviewees on Sunday were primarily shoppers or tourists while office workers composed the interviewees demographic on Monday. This means that cell Q has diverse architectural programmes and mixed-use zoning, which are activated in different time lines.

Cell Q demonstrates a relatively high level of data between 7.00 and 21.00 (Figure 6-7). During the time line, continually higher levels of data were found on Sunday, but the activities were not the same. Cell Q at 7.00 is vibrant because of the preparation of sales while cell Q at 12.00 and 20.00 is active because of shopping and leisure, therefore, individual activities observed during the time period are not the same. Although a certain cell space graphically represents the same red colour (the areas of high data levels), the red spots can carry different meanings in the urban context depending on time.

We can interpret these differences as an urban fabric whose nature is compressed with multi-layers of architectural programmes that function in relation to temporality. This can be associated with heterotopias of time, as discussed in Chapter 2. Heterotopias are latent in the multi-layers of urban space and can be found and experienced by individuals. In particular, this kind of space is likely to be found in urban areas where diverse attributes of the urban fabric are overlapped like a collage, which conforms to mixed-use patterns as analysed in Chapter 5. Observational research following temporal trajectories calculated using visualised data maps seems to indicate heterotopias in live urban space where everyday life is practised in diverse spatial layers. In this respect, telecommunication data can be utilised as a live indicator expanding our spatial experience.

In the built environment, where our activities are expected to follow the static architectural programmes designed by architects and urban planners, heterotopias allow for people's activities to be affected and varied according to temporality. Static architectural programmes can conflict with heterotopic attributes of spatial experience (traced by observing activities). At this point, digital communication technology can intervene to provide programmatic flexibility that can bridge the gap between architectural programmes and heterotopian attributes of spatial experience. How can we achieve programmatic flexibility via technological intervention? If we have an informative medium, such as maps, reflecting the urban situation revealed by observation and telecommunication data in real time, our spatial experience can be expanded.

A holistic approach is needed for further discussion regarding locative interaction (finding heterotopia); accordingly, a design project was conducted to synthesise findings and develop the discourse of locative interaction with the position of rhythm and heterotopias. It is discussed in detail in the next chapter.

## 6.4. Summary

Most cell spaces did not demonstrate the gap between the scenes expected by visualised data maps and the actual urban situation. Activities observed on site were similar to the activities expected by architectural programmes and visualised maps.

However, not all cell areas represent the expected result regarding density: levels of telecommunication data were not always synchronised with the density of population observed in the urban space. This is because the urban fabric (buildings and certain parts of streets) is compressed with multi-layers of architectural programmes that function in relation to temporality.

Observational research following temporal trajectories from visualised data maps can indicate heterotopias in live urban space in diverse spatial layers. In this respect, if the visualised data maps are contextually interpreted with reference to spatiality and temporality in urban space, telecommunication data can offer a diagnostic reagent with which to find our individual heterotopias. Technology such as telecommunication can intervene to give programmatic flexibility, which can bridge the gap between architectural programmes and heterotopic attributes of spatial experience. An epistemic design project will be conducted and analysed in the next chapter to further discussion and draw a concept of locative interaction that reflects live urban space.

Chapter 7

# EPISTEMIC DESIGN

This design project aims to synthesise findings from the above investigations (statistical analyses, data visualisation and observation) and to develop the discourse of locative interaction. Design interventions for this project are extracted from the findings of previous chapters; key elements include ‘stereopsis’, beyond linear trends of the numerical data as discussed in Chapter 4, temporally ‘floating’ patterns of telecommunication territorialisation as found in Chapter 5, and telecommunication situations ‘reflecting’ our built environment as scrutinised in Chapter 6.

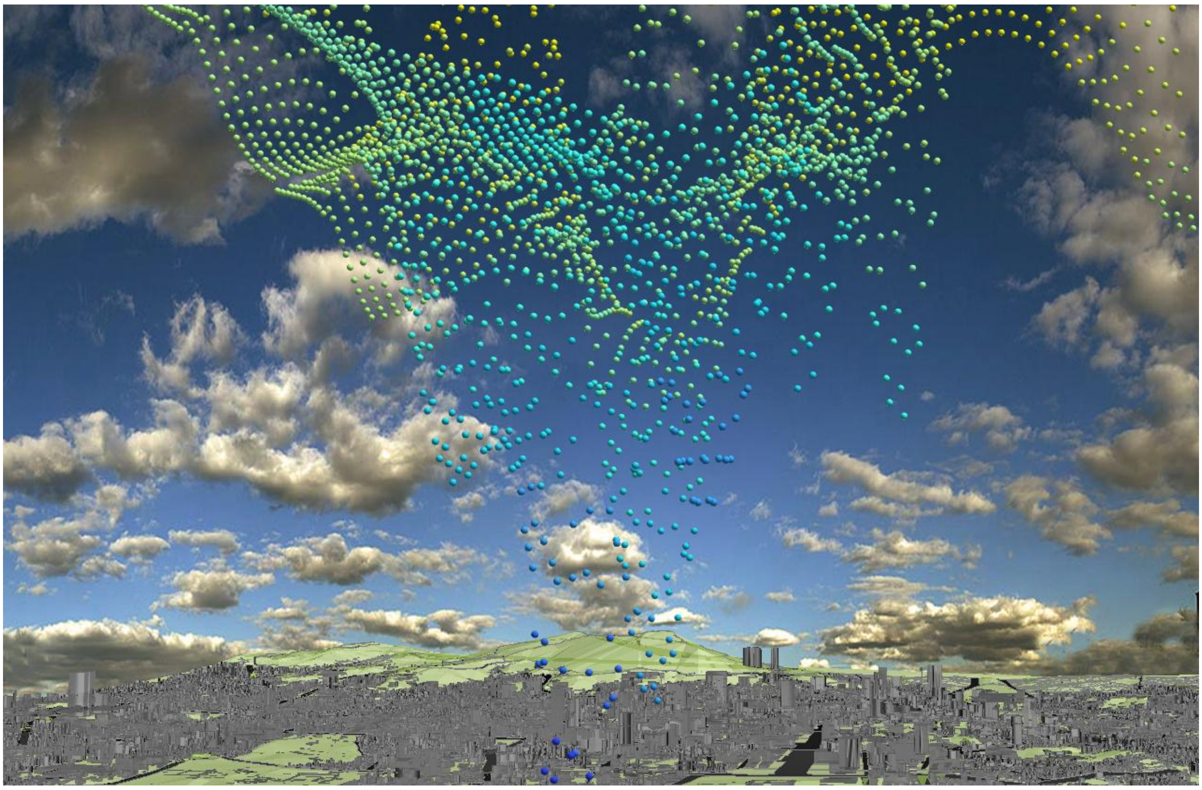

Figure 7- 1. Data cloud

## 7.1. LED installation by CNT Film

Transparency and stereopsis are key words that represent a floating data image that shows a futuristic scene of information communication technology immaterialised and permeating an urban structure. The technical design method considered focuses on these two key words: transparency and stereopsis.

### 7.1.1. *Precedent studies for transparent LED displays*

Transparent display panels were investigated to generate a tangible transparency and stereopsis, which can generate 3D and/or 4D settings via overlapping panels. Diverse materials and technological solutions were searched by web browsing. For some materials, more detailed research was conducted via emails and phone calls to relevant companies.

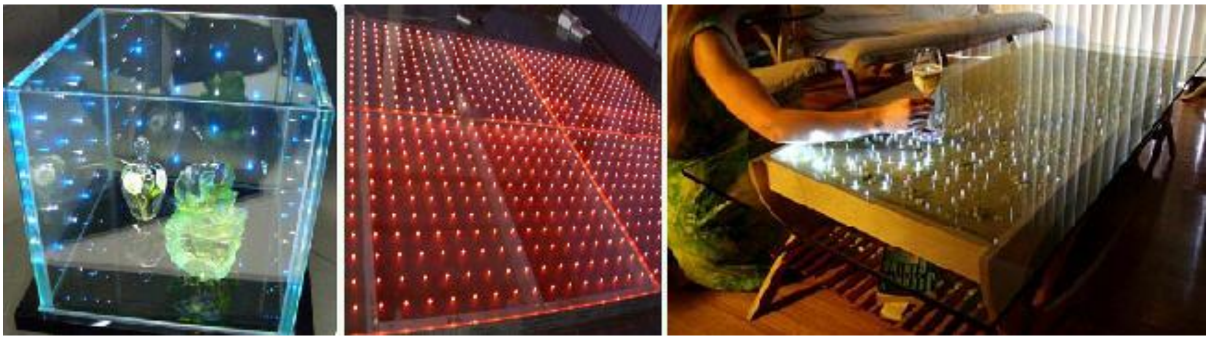

Figure 7- 2. LED laminated glass with photoelectric technology

Along with a translucent panel (figure 7-2), transparent display panels can be categoried into two types: glass-based and film-based panels.

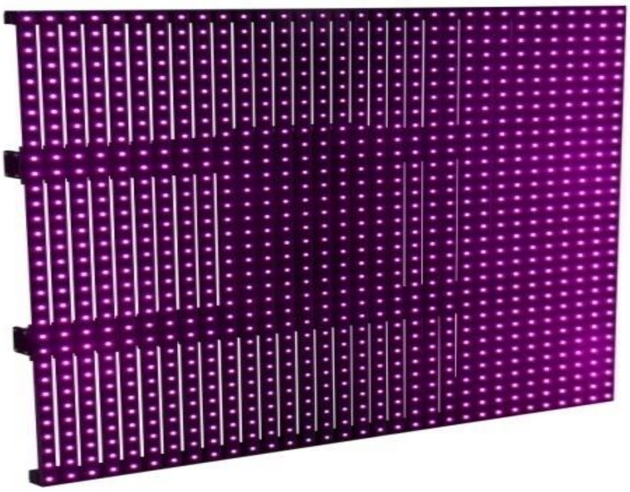

Figure 7- 3. Translucent LED panel: EVLED

Glass-based transparent LED panels are exemplified by Raytint, by Saman Electronics[1]; Glassiled, by Ravensby Glass Ltd.[2]; and LED Laminated Glass by Citiglass group Ltd.[3] LED Laminated Glass is activated using photoelectric technology[85] (right picture in figure 7-2). Glassiled (left and middle picture in figure 7-2) is a piece of glass embedded with mono-colour Light Emitting Diodes (LEDs), which are powered through a high-performance invisible, conductive coating. Glassiled is available with either standard LEDs for decorative purposes or with extra high power LED for lighting purposes. Light sources float on glass without any visible wiring allowing the full transparency of the glass.

Glassiled can be used for signage, decoration, illumination and even for lighting in mono-colour applications[4]. On the other hand, the EVLED panel (figure 7-3)[5, 6], with 35% transparency, is not stackable, and therefore unable to generate 3D effects; however, it can cover a large area unlike other LED projection devices mentioned above that have size constrictions due to the glass or a limited current capacity.

Even though these are 2D display panels, the material enables designers to create 3D stereopsis displays by overlapping multi-sheets. In this case, the visibility of this material should be considered because the more glass sheets are layered, the worse visibility becomes. 3D stereopsis displays, therefore, may be realised depending on the number of stacked sheets . When a glass-based transparent LED panel generates a 3D stereopsis display, the weight of the number of glass panels poses a challenge; therefore, some thinner and lighter materials must be investigated.

- ***CNT Film***

The thinnest material amongst film-based LED panels is created by coating a film with a carbon nano tube-based chemical substance to make it conductive. Carbon nano tubing (CNT) is an extremely thin material with a diameter about 10,000 times finer than a human hair. CNT consists of a rolled up sheet of carbon hexagons. It is realised using several techniques including arc-discharge and chemical vapour deposition and is just a few nanometers in diameter and several microns long. CNT can be metallic or semiconducting and offers diverse possibilities to create future nano-electronic devices, circuits and sensors[7].

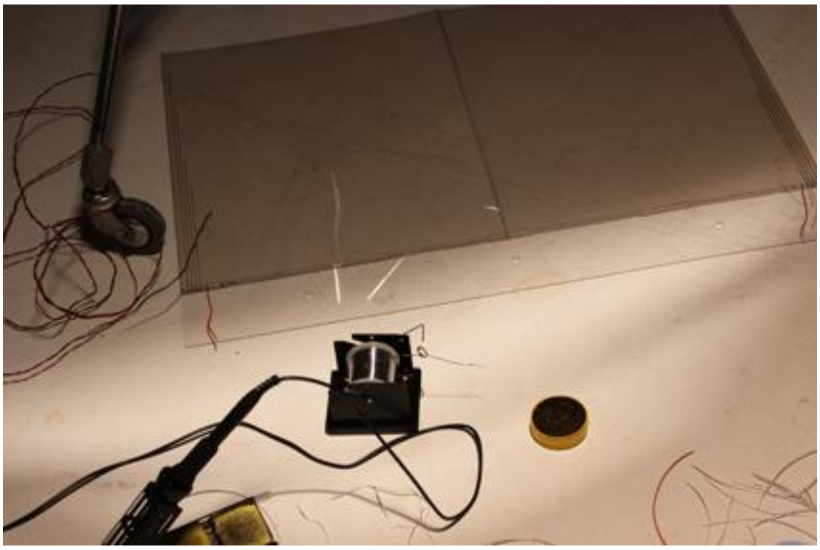

Figure 7- 4. A sample of CNT film

There are a number of material characteristics of CNT films. First, the CNT films are conductive although parts of CNT films are cut (Figure 7-5). Also, although parts of CNT films are bent or curled, the objects made of CNT films are still conductive (Figure 7-6). These material characteristics show the possibilities of how CNT films can be designed and facilitated as practical objects including lighting, signage and so on.

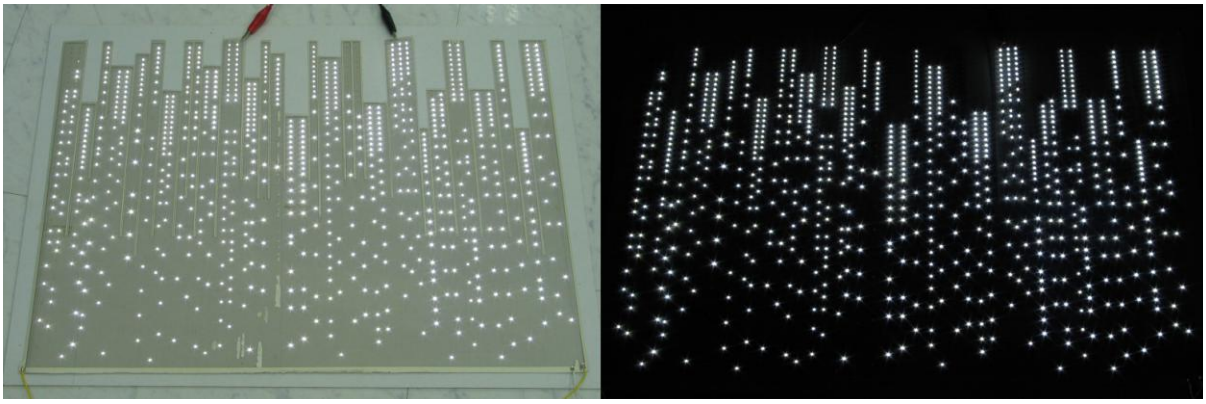

Figure 7- 5. The material characteristic of CNT film I: Although parts of CNT films are cut, the remaining parts are still conductive

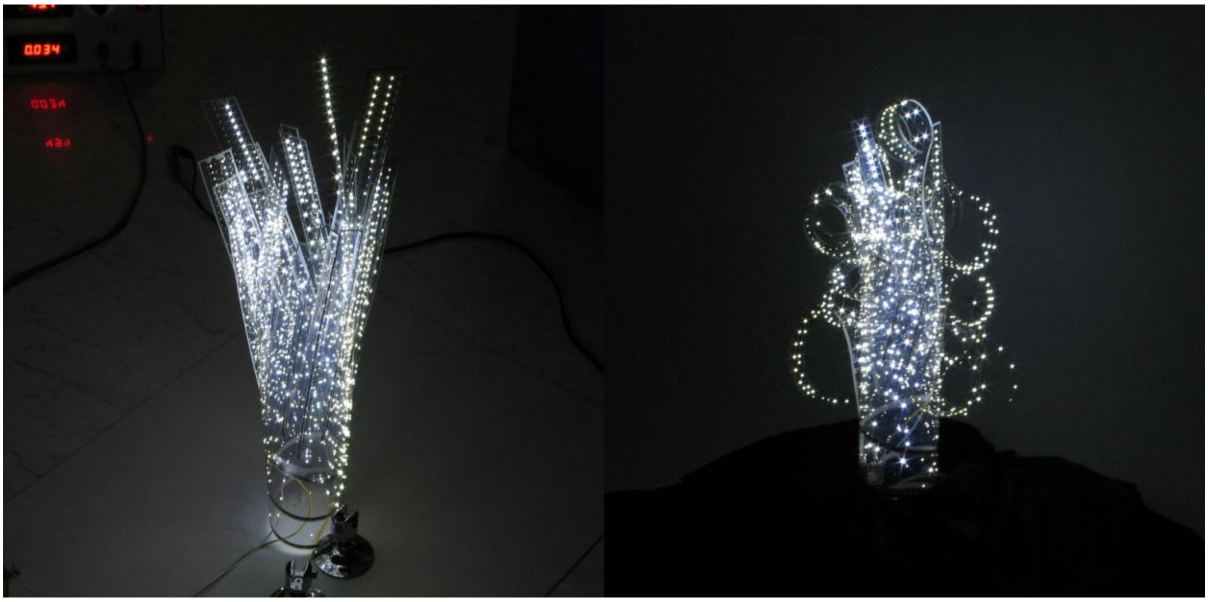

Figure 7- 6. The material characteristic of CNT film II: Although parts of CNT films are bent or curled, the objects made of CNT films are still conductive

This material has been generally applied to transparent signboards and is sometimes used as a design detail for electronic devices and appliances. However, these applications of CNT film are limited to 2-dimensional uses even though its workability and usability are significant as are its capabilities in design applications.  CNT film can satisfy the design requirements (transparency and stereopsis) if processed with special silicon-based substances.

### *7.1.2. Data Preparation and Making*

There were a number of factors limiting the project design, namely the 400mm*500mm size of CNT Film and maximum visibility of 30 sheets. To adjust data maps to a given dimension of materials, grids should firstly be placed on the 2D maps, as seen Figure 7-7. A number of 30 sheets should be determined because of the limited visibility inherent in CNT film. Although the transparency can be controlled via material processing, such as coating with a certain chemical substance, raw materials should be used due to economic considerations. Therefore, this project was conducted using the limited attributes of raw material. 36 columns were derived from the limited distance between LEDs, which should not be more than 10 mm. This project adopted a distance of 25mm between the LEDs, which is considered a safe distance for electric conductivity. The blue dotted line (figure 7-8) shows where two sequential CNT films meet.

In this given matrix (30 lines x 36 columns: X*Y), 2D maps provided the values of Z. The 2D map coloured with 15 classes was applied to the grid (30*36), then the points of XY intersections were numbered after applying the exact data on the points of base stations. This is because the concrete data relates to the geographical position of base stations in the 2D maps. Other points, except for geographical coordinates of the base stations, are presumed to rely on geographical data maps due to the 2D visualisation performed by computing processes reflecting data and topological coordinates. The process of data presumption was conducted manually on the X*Y intersections. Results of presumable data distribution are seen in Figures 7-7 and 7-8.

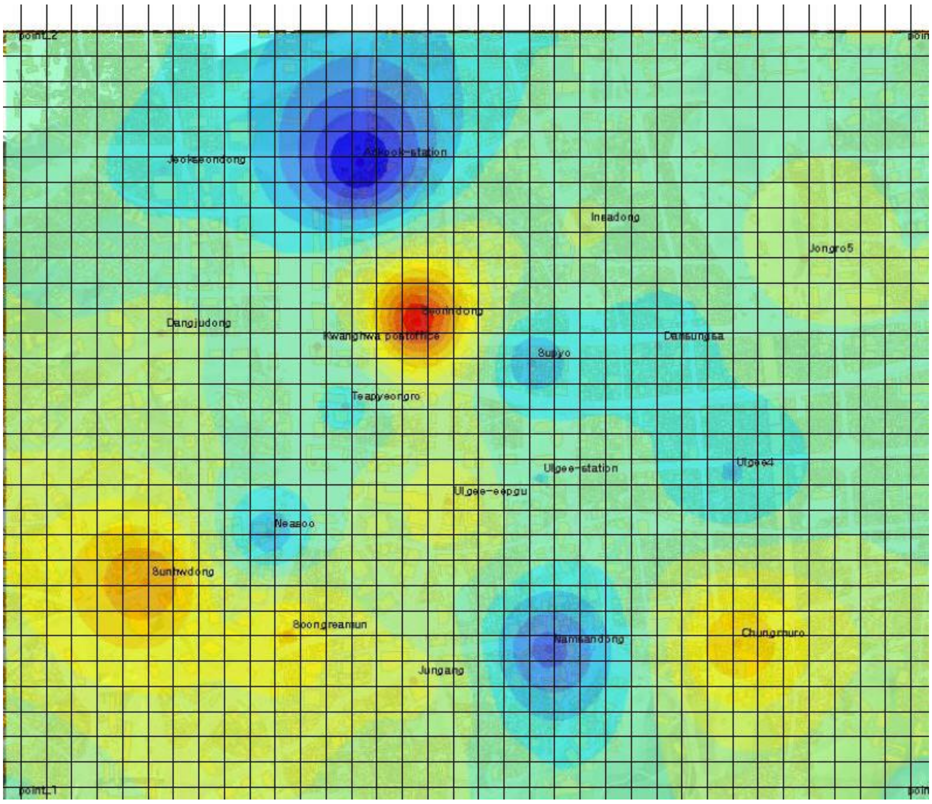


Figure 7- 7. Grid (30 lines x 36 columns) put on the 2D data visualised map

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 26 | 25 | 25 | 25 | 25 | 25 | 26 | 27 | 27 | 27 | 27 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 1 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 25 | 25 | 25 | 23 | 23 | 25 | 25 | 25 | 27 | 27 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 2 | 29 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 27 | 25 | 24 | 23 | 23 | 23 | 23 | 25 | 25 | 27 | 27 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 3 | 29 | 29 | 29 | 29 | 29 | 27 | 27 | 27 | 27 | 27 | 25 | 23 | 22 | 22 | 22 | 22 | 24 | 25 | 27 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 4 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 27 | 27 | 25 | 22 | 21 | 20 | 20 | 22 | 23 | 25 | 27 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 5 | 29 | 29 | 29 | 29 | 27 | 27 | 27 | 27 | 27 | 27 | 25 | 22 | 21 | 17 | 17 | 22 | 23 | 26 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 29 | 29 | 29 |
| 6 | 29 | 29 | 29 | 29 | 27 | 27 | 27 | 27 | 27 | 27 | 25 | 23 | 20 | 17 | 18 | 22 | 25 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 29 | 29 |
| 7 | 29 | 29 | 29 | 29 | 29 | 28 | 28 | 27 | 27 | 27 | 26 | 25 | 23 | 22 | 22 | 25 | 27 | 29 | 29 | 29 | 29 | 29 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 29 | 30 |
| 8 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 28 | 27 | 27 | 26 | 26 | 27 | 28 | 28 | 30 | 30 | 30 | 29 | 29 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 29 | 30 |
| 9 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 28 | 28 | 28 | 29 | 35 | 35 | 33 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| 10 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 32 | 34 | 36 | 38 | 38 | 37 | 34 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 30 |
| 11 | 30 | 30 | 29 | 29 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 33 | 37 | 44 | 44 | 38 | 34 | 30 | 28 | 28 | 28 | 28 | 27 | 27 | 27 | 27 | 28 | 29 | 29 | 30 | 30 | 30 | 30 | 29 |
| 12 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 28 | 29 | 32 | 36 | 42 | 43 | 37 | 33 | 29 | 26 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 13 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 28 | 29 | 29 | 33 | 36 | 37 | 34 | 29 | 27 | 25 | 25 | 27 | 27 | 27 | 27 | 27 | 27 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 14 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 28 | 29 | 29 | 31 | 32 | 31 | 29 | 27 | 26 | 26 | 27 | 27 | 27 | 27 | 27 | 27 | 28 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 15 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 27 | 27 | 29 | 30 | 30 | 30 | 30 | 29 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 27 | 29 | 28 | 29 | 29 | 29 | 29 | 29 |
| 16 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 28 | 29 | 29 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 27 | 27 | 28 | 29 | 29 | 29 | 29 |
| 17 | 31 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 32 | 32 | 30 | 29 | 28 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 26 | 27 | 27 | 28 | 29 | 29 | 29 | 29 |
| 18 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 30 | 29 | 29 | 27 | 29 | 29 | 30 | 30 | 32 | 33 | 33 | 32 | 29 | 28 | 29 | 29 | 29 | 29 | 29 | 27 | 26 | 26 | 27 | 27 | 29 | 29 | 29 | 29 | 29 |
| 19 | 32 | 32 | 33 | 33 | 33 | 33 | 32 | 30 | 29 | 27 | 25 | 27 | 29 | 30 | 30 | 32 | 33 | 33 | 32 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 28 | 27 | 27 | 27 | 28 | 29 | 29 | 29 | 29 | 29 |
| 20 | 32 | 33 | 34 | 35 | 36 | 36 | 35 | 32 | 29 | 25 | 25 | 27 | 29 | 30 | 30 | 30 | 32 | 32 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 |
| 21 | 34 | 34 | 35 | 36 | 38 | 38 | 36 | 32 | 30 | 29 | 27 | 28 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 28 | 28 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 |
| 22 | 34 | 34 | 35 | 36 | 38 | 38 | 37 | 34 | 32 | 31 | 31 | 31 | 31 | 30 | 30 | 30 | 30 | 30 | 29 | 28 | 27 | 27 | 27 | 28 | 29 | 29 | 31 | 32 | 32 | 32 | 32 | 31 | 30 | 30 | 30 | 30 |
| 23 | 31 | 34 | 35 | 36 | 37 | 38 | 36 | 34 | 32 | 33 | 35 | 35 | 34 | 32 | 30 | 30 | 30 | 30 | 29 | 27 | 25 | 24 | 25 | 27 | 29 | 30 | 32 | 34 | 35 | 35 | 34 | 32 | 32 | 30 | 30 | 30 |
| 24 | 32 | 34 | 34 | 34 | 36 | 36 | 35 | 34 | 34 | 32 | 35 | 35 | 35 | 31 | 32 | 30 | 30 | 29 | 28 | 25 | 23 | 22 | 23 | 26 | 28 | 30 | 33 | 35 | 36 | 36 | 34 | 33 | 32 | 31 | 30 | 30 |
| 25 | 32 | 32 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 34 | 32 | 32 | 32 | 31 | 30 | 29 | 25 | 23 | 22 | 23 | 25 | 28 | 30 | 32 | 35 | 36 | 36 | 34 | 33 | 32 | 31 | 30 | 30 |
| 26 | 31 | 32 | 32 | 33 | 33 | 33 | 33 | 33 | 33 | 34 | 34 | 34 | 32 | 32 | 32 | 32 | 32 | 30 | 29 | 27 | 24 | 23 | 25 | 26 | 29 | 30 | 32 | 34 | 34 | 34 | 34 | 31 | 32 | 30 | 30 | 30 |
| 27 | 30 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 30 | 29 | 27 | 26 | 25 | 26 | 27 | 29 | 30 | 31 | 32 | 33 | 33 | 32 | 32 | 31 | 30 | 30 | 30 |
| 28 | 30 | 30 | 30 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 27 | 27 | 27 | 28 | 29 | 29 | 30 | 31 | 32 | 32 | 32 | 31 | 30 | 30 | 30 | 30 |
| 29 | 30 | 30 | 30 | 30 | 31 | 32 | 32 | 32 | 32 | 32 | 32 | 32 | 31 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 27 | 27 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 |
| 30 | 29 | 29 | 30 | 30 | 30 | 31 | 32 | 32 | 32 | 32 | 32 | 31 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 29 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 29 | 29 |

Figure 7- 8. A coordinate of LED position at 19.00 on a weekday. The picture above is a layout that optimises reproduced coordinates of CNT films. The blue dotted line indicates the border between the two CNT sheets. Red dotted squares indicate the coordinates where LEDs are embedded in one CNT sheet.

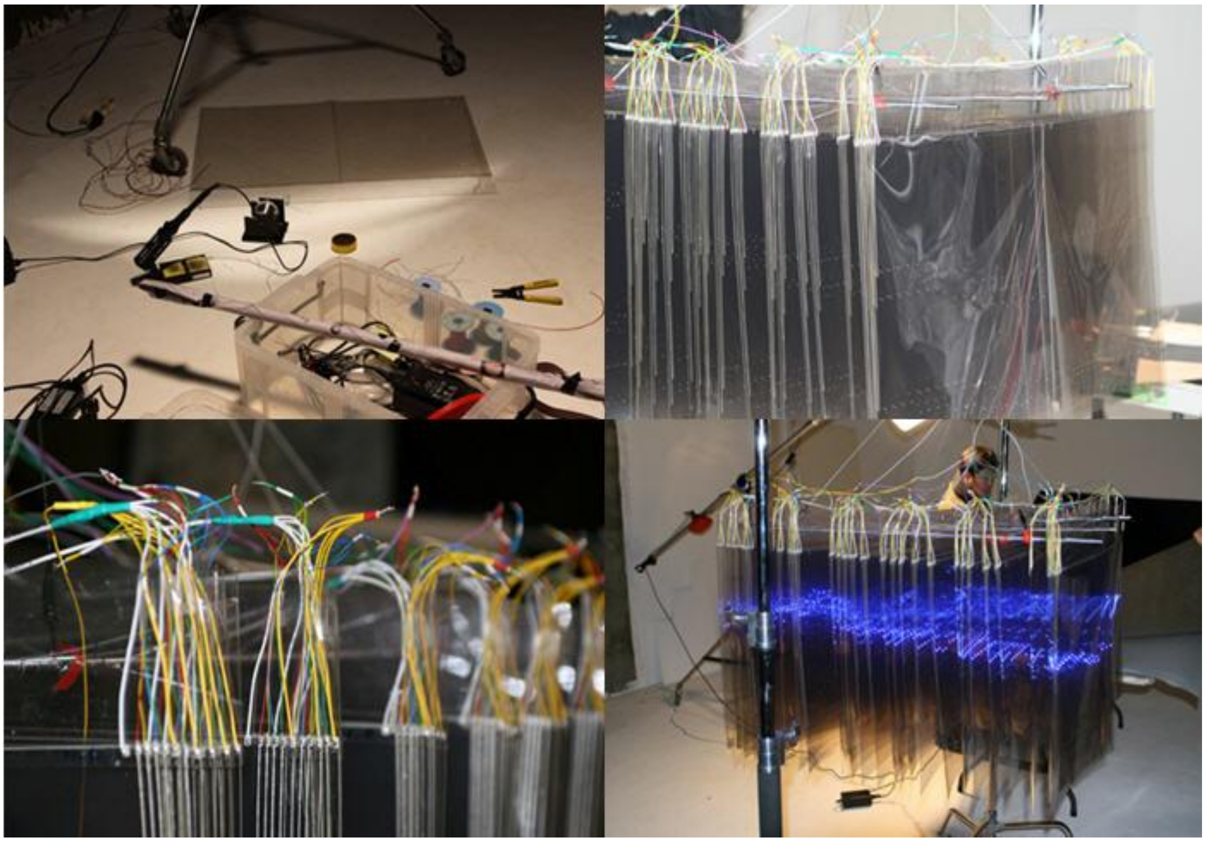
Figure 7- 9. The installation process

The electronic circuit plan was made based on Figure 7-8 and coordinate tables of LED positions at other times. Blue coloured LEDs were then embedded on individual CNT film sheets. Figure 7-9 demonstrates electronic details of this process, which is concealed by a 150 mm-width metal frame. Respective data layers represented by LEDs are worked in parallel with an urban map of Seoul.

As seen in Figure 7-9, CNT film sheets were arranged along a given distance (30mm), and then assembled as a stereopsis installation of a 3D image. Underneath this installation, the map of the central part of Seoul was unfolded at a distance of approximately 400mm. The map was covered by a transparent and reflective acrylic panel, as seen in Figure 7-9 (top left and bottom right).

## 7.2. Epistemic Design: Rhythmical Heterotopia

Contrary to the informative attributes of 3D graphic-based map (Figure 5-3), a 3D LED installation can produce an image to deduce an ideational terrain of locative interaction beyond quantitative data visualisation. This can bridge the development of a discourse of time and space in live urban space for locative interaction. This epistemic design was adopted as the key process to synthesise urban telecommunication data analysed in the above methodologies. The project is also important as a contribution to discourses of visionary urban scenarios in which spatial experience is expanded using a digitally-indicated, live urban context.

- ***Design Semiotics***

From an epistemological position, this LED installation will be reviewed using semiotics: the design elements adopted in this project demonstrate something beyond visual information. According to Krippendorff (1986), design is to make sense[8]. The semiotics of design, however, is a study of the symbolic qualities of man-made forms in the cognitive and social contexts of how they are used. The application of this knowledge is important when discussing industrial design[9].

Prior to examining the design semiotics of this installation, the process and order of decision-making in designing the LED installation should be considered. This will clarify the mechanism required to identify semiotic elements. The design objectives in this work, transparency and stereopsis, are embodied in the materials (CNT film), material application (overlapping a given distance, 3cm), installation (suspending the electronic piece made by CNT films), and the process of coating the urban map with a reflective gloss.

Firstly, transparency is an important objective in this design work, and is represented by an 'immaterialised material', the CNT film. This film is the main material that captures a sense of transparency, and it also becomes a background in which to embed LEDs. Data pixilation on consecutive transparent CNT films generates lighting contours, which are juxtaposed on the urban map.

Secondly, by overlapping films, stereopsis is created in order to reflect the spatial dimensions of telecommunication data. In Figure 7-10, the blue coloured LED pixels demonstrate the distribution of locative telecommunication. The sequence of LED pixels becomes the data contour, which is seen through overlapping films with a 3cm gap between each film. This 3cm distance is very important in creating a 3D data contour because the distance makes each film reflective, like a mirror. Reflected LED pixels make the 3D data contour look cloudy, as seen in Figure 7-11.

Thirdly, suspending the LED installation over an urban map generates a floating data contour. Depressions and peaks in the cloudy data contour are juxtaposed with the location where the telecommunication data was collected. Floating contours are structures of interaction, which can be utilised as an applicable example of design reflecting locative interaction.

Fourthly, lighting contours of data are reflected on the urban map (Figure 7-12), which is covered with a glossy acrylic panel. This demonstrates how telecommunication traffic is patterned and structures the data as a programme of human temporal and spatial interaction. The result also demonstrates how this data contour pervades our built environment akin to a weather system.

Weather can induce behavioural shifts beyond the static built environment. Also, it is locatively, temporally, and spatially influential on our everyday life—a programme prescribed by nature. If the weather is generated by collective activities (human traffic) traced by technological intervention, we can conceive a programmable terrain wherein user-tailored programmes can be installed locatively and temporally.

It is found that locative interaction between people and urban space can be considered under layered rhythm contours (Figure 7-12 and 7-13). Like the influence of the weather, which is not visible but can affect people's activities, we can conceive a weather-like ambience generated by telecommunication data. This 'digital weather' is a collective representation of people's telecommunication habits and locative interactions.

This design project involves a live urban space, Soeul, where an everyday routine is practised. The inhabitants dream, pursue ideals and can have individually practised spaces (heterotopia), within everyday urban space. These spaces are referred to as heterotopias because they are akin to utopian spaces, existing in and connecting to the real, physical world via programmatic flexibility.

Unlike the physical geographical contour of the site, respective layers represented by blue LED pixels in the installation demonstrate deformations of the site. The deformed contours, depending on time variations, reveal the spatial rhythms of the site and public heterotopias. The rhythmic layers of collective heterotopias are the latent structure of urban space, which becomes a live structure of digital ambience that effect spatial experience. The electronic ambience reflecting urban rhythms and the heterotopic layers will be specified as a concept of locative interaction reflecting live urban space, as demonstrated in the next chapter.

## 7.3. Summary

Telecommunication data was tangibly mapped in the design project: a stereoscopic LED installation. This design project aims to synthesise the findings from the previous chapters and develop the discourse of programmatic flexibility in relation to locative interaction in urban space.

This design project was generated by CNT films created by coating a film with a carbon nano tube-based chemical substance to enable conductivity. CNT film sheets embedded by blue LEDs were arranged along a given distance (30mm) and assembled as a stereopsis installation of a 3D image. Underneath this installation, the map of the central part of Seoul was unfolded at a distance of approximately 400mm. A transparent and reflective acrylic panel was used to cover the map (see Figures 7-10 to 7-15).

Through this design project, it is found that locative interaction between people and urban space can be considered under layered rhythm contours (Figure 7-12). We can conceive that temporal layers of invisible data create an influential ambience, like weather. As such, this invisible force can affect people’s activities: we can consider weather-like ambience generated by telecommunication data. It is a collective representation of people’s telecommunication behaviours and locative interaction which can provide programmatic potentials.

The data contours dependent on time variations reveal spatial rhythms in the urban environment. The rhythmic layers of collective heterotopias can be seen as latent urban structures, which become live structures of programmatic flexibility that are able to effect spatial experience. This data installation reflects urban rhythms and heterotopic layers that specify a concept of locative interaction reflecting live urban space.

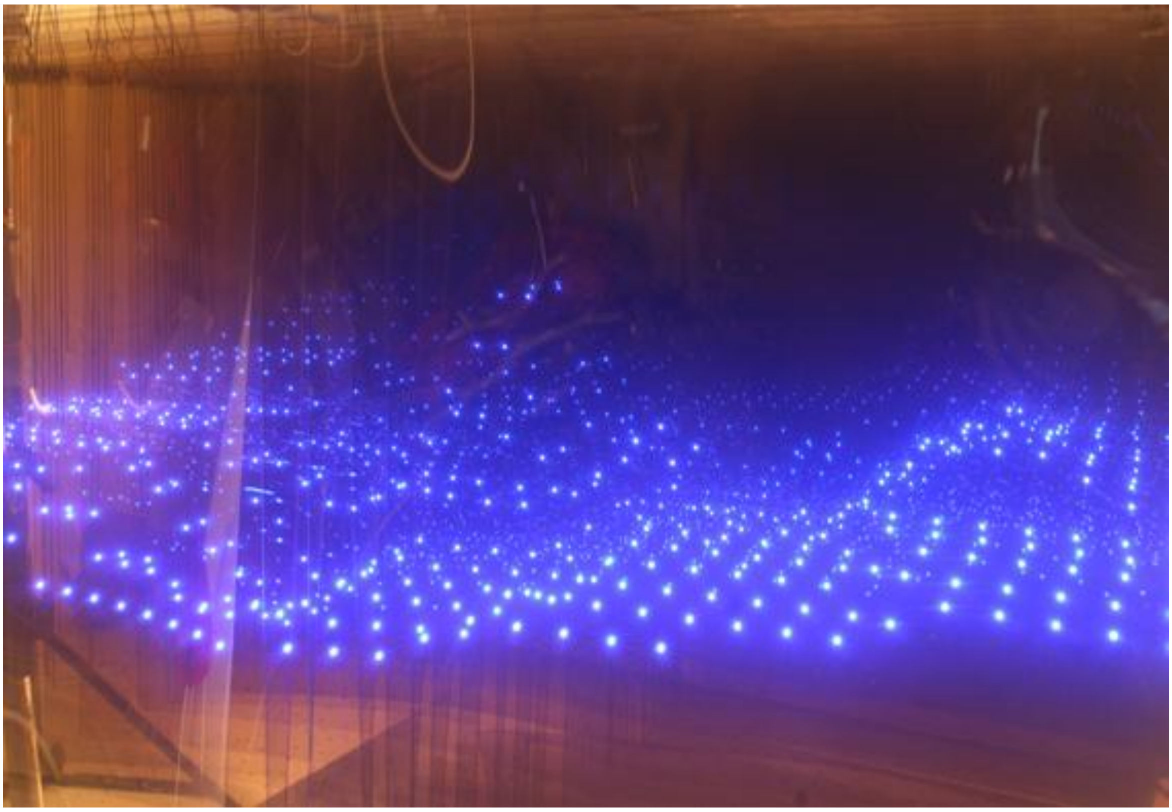

Figure 7- 10. Stereopsis created by overlapped transparent CNT films (front view)

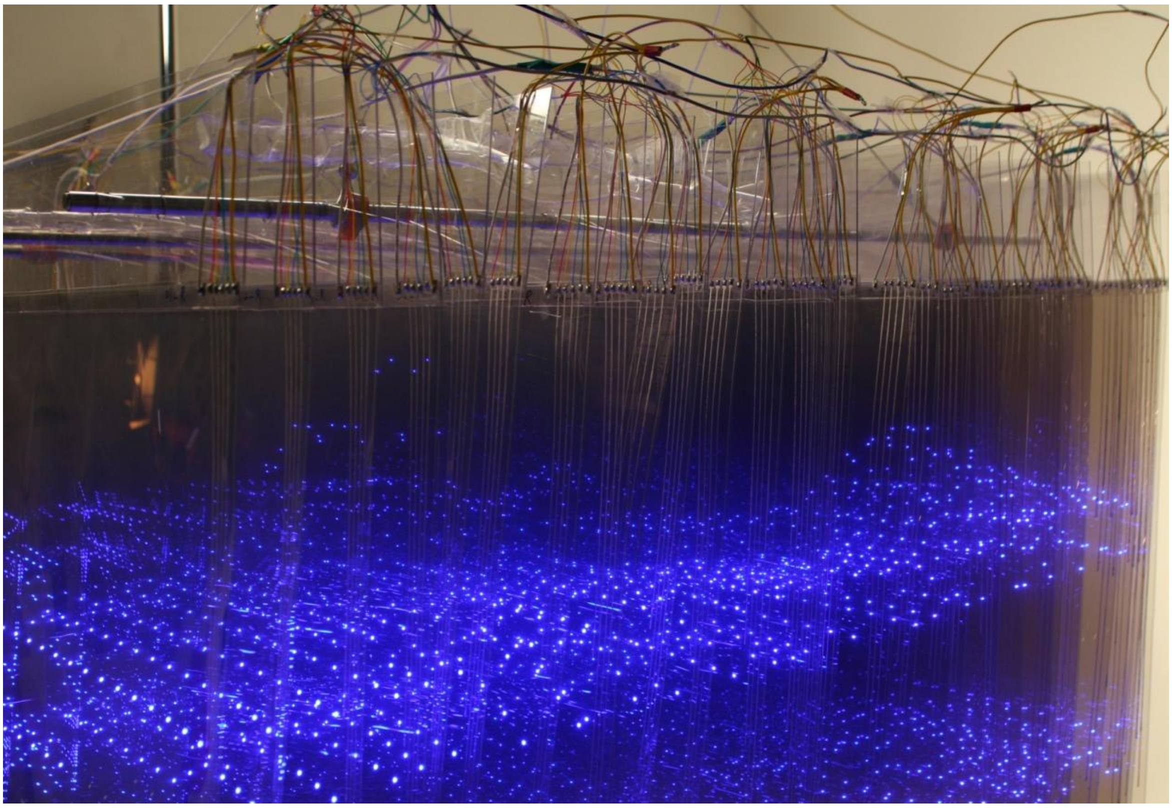

Figure 7- 11. Stereopsis amplified by reflection of CNT films. (side view)

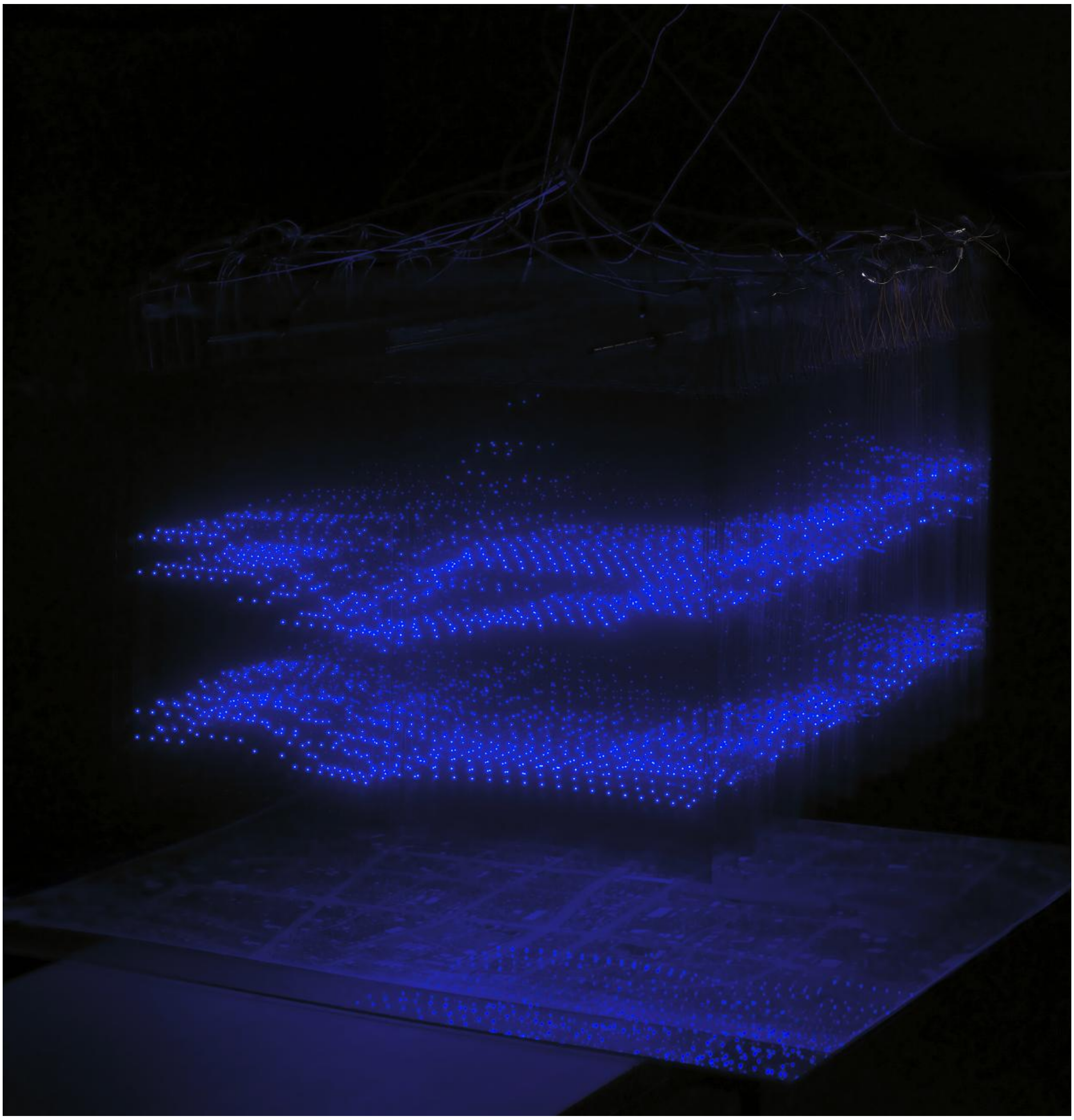

Figure 7- 12. Floating data contours and reflecting cloudy contours on the urban map

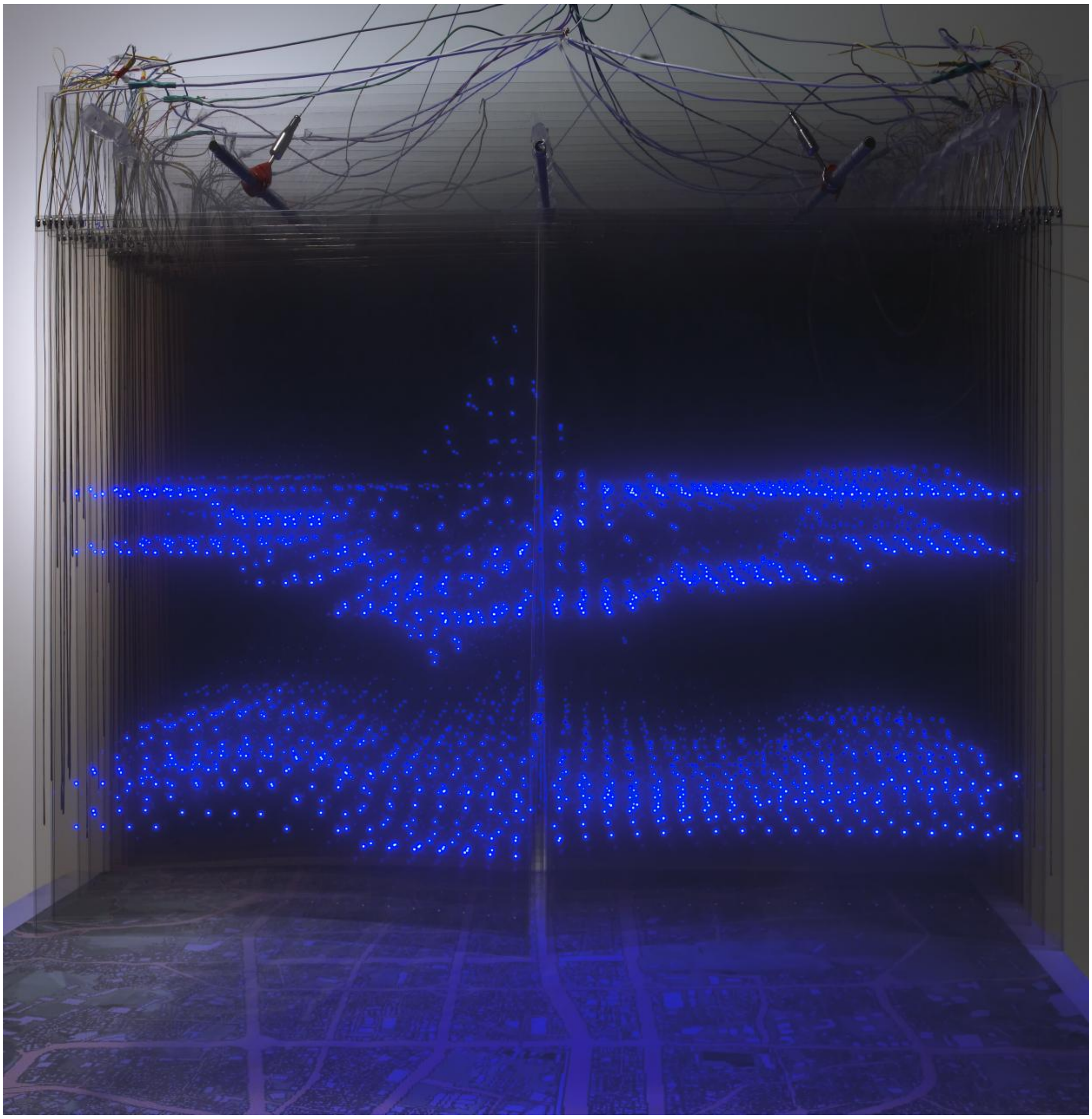

Figure 7- 13. Floating data contours

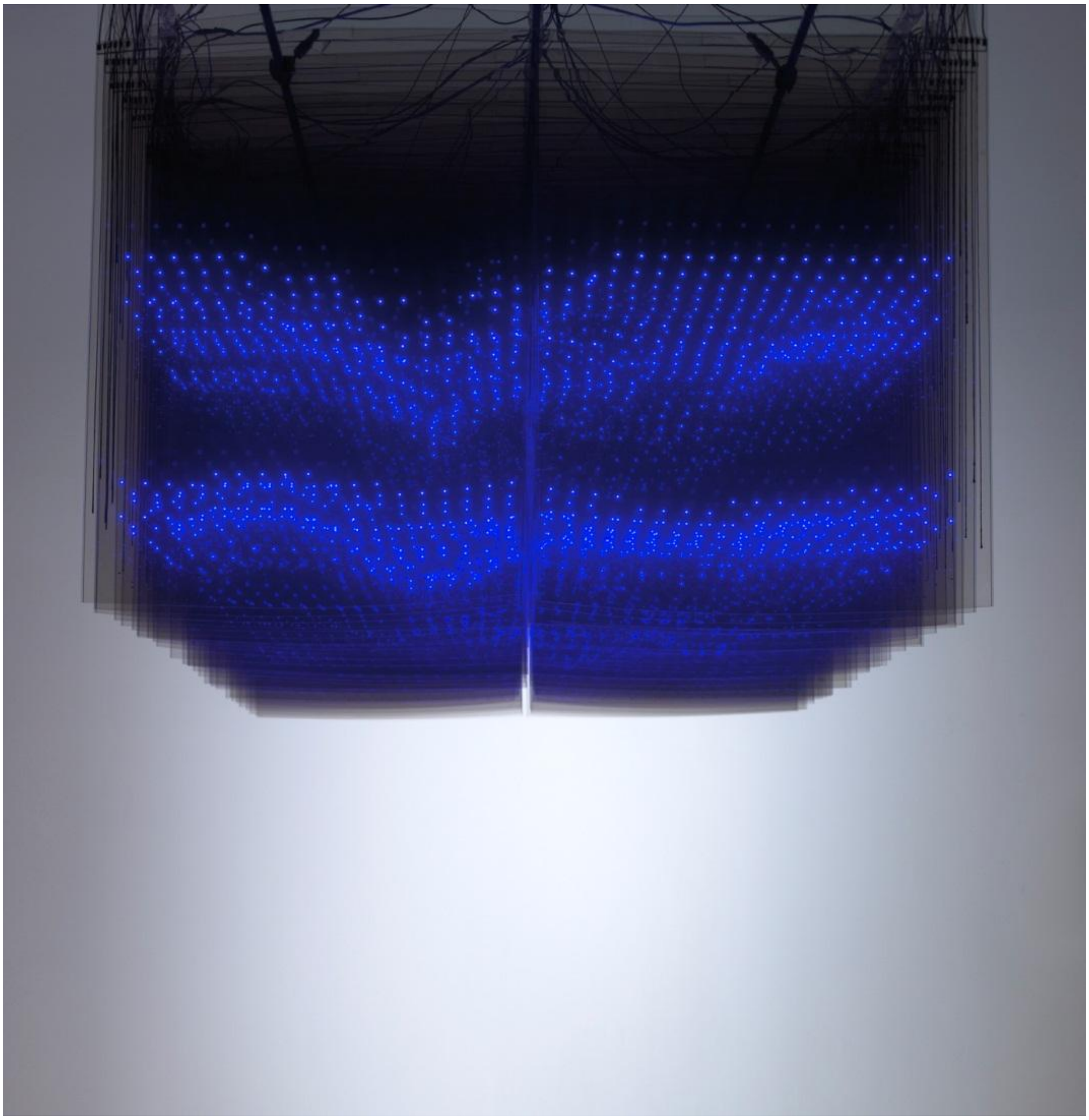
Figure 7- 14. Rhythm Analysis: the LED installation of urban telecommunication data

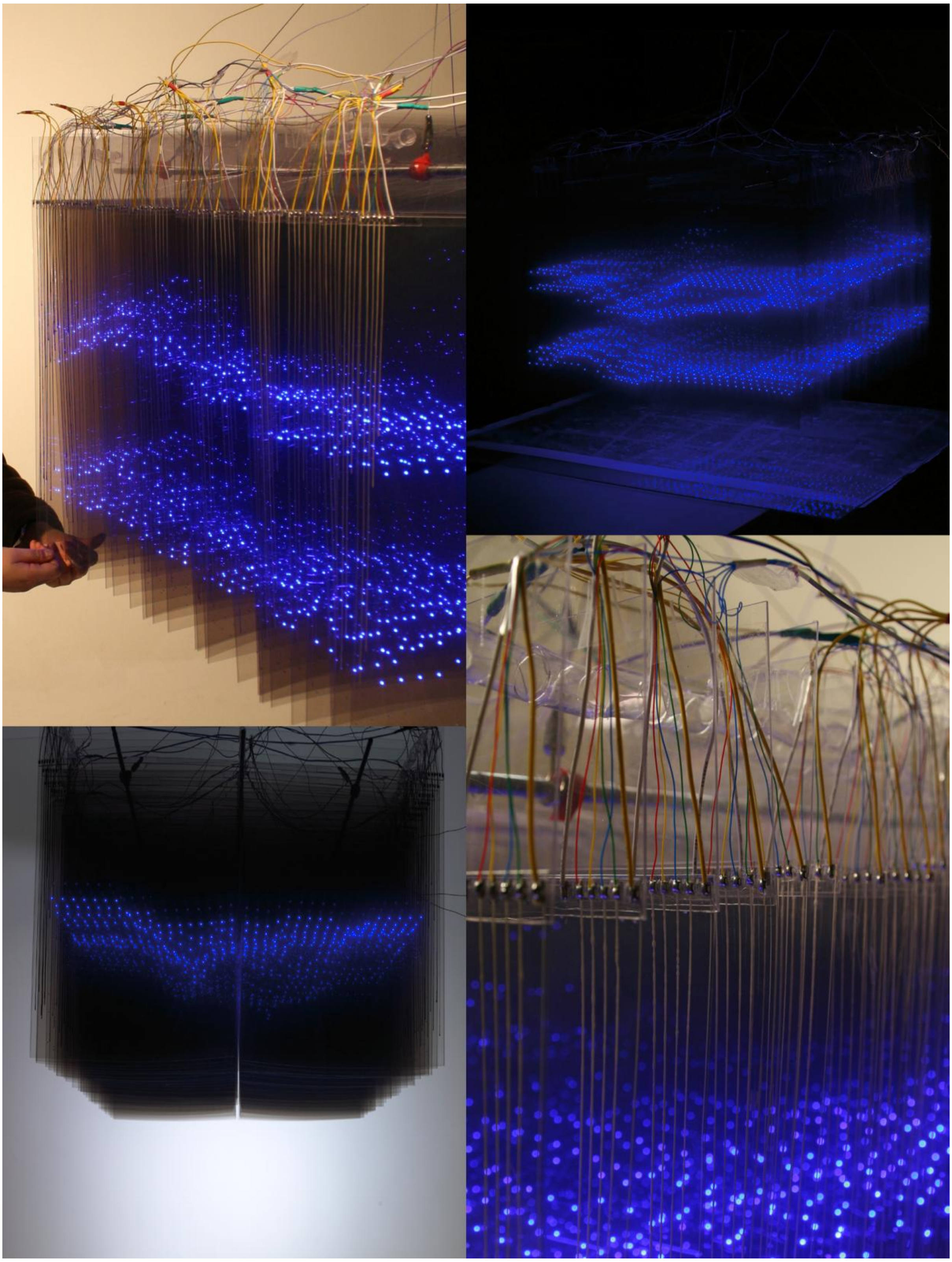

Figure 7- 15. . Detailed pictures of Rhythm analysis

[1] http://www.samanelt.com/default/ retrieved as of 26 Feburary 2012
[2] http://www.ravensbyglass.co.uk/glassiled.cfm retrieved as of 26 Feburary 2012
[3] http://www.citiglass.cn/ProductShow.asp?ID=58 retrieved as of 26 Feburary 2012
[4] http://www.ravensbyglass.co.uk/glassiled.cfm retrieved as of 26 Feburary 2012
[5] http://blog.livedesignonline.com/briefingroom/2009/07/01/pixel-perfect-elations-new-lightweight-transparent-led-video-panels-feature-ip65-rating-and-daylight-viewability/ retrieved as of 26 Feburary 2012
[6] http://www.elationlighting.com/ retrieved as of 26 Feburary 2012
[7] http://www.topnanosys.com/ retrieved as of 26 Feburary 2012
[8] Krippendorff, Kraus (1986) ‘Design is making sense’ :in Victor Margolin and Richard Buchanan (eds) (1995) *The Idea of Design*, New York: MIT press, pp. 156-157
[9] Krippendorff, Kraus and Butter, Rainhart ed. (1984) ‘Product Semantics: Exploring the Symbolic Qualities of Form’, *Innovation*, Vol 3 no 2, pp. 4-9

# Chapter 8
# LOCATIVE INTERACTION IN LIVE URBAN CONTEXT

Heterotopic attribute and rhythms in urban space were investigated to generate a concept of locative interaction that reflects a live urban context and expands spatial experience. Telecommunication data was collected from various base stations in the physical realm of urban space. The data was temporally visualised to discern spatial occupancy as an indicator of the interaction between people and urban space. Based on these visualisations, telecommunication activities were physically observed to explore the gap between these activities and extant architectural programmes. Research findings were developed as a design project in order to explore programmatic flexibility. In this chapter, a concept of locative interaction will be discussed based on key aspects raised by the design project.

## 8.1. Locative Interaction and Programmable Flexibility

Locative interaction is one of the most important aspects of our everyday life. For example, the locative services range from programmes informing us where we are to applications that search for nearby restaurants. Bridging individuals and information on maps is a key issue in the development of locative interaction. Matching geographical positions of people and information is the most rational approach for locative communication and information acquisition. If maps become more logical, they can be utilised as a smart platform for communication and information dissemination.

Locative information is positioned in urban contexts ranging from zoning to human traffic. Since obtaining locative information tends to accompany spatial experience, a concept of locative interaction should consider the relationship between architectural programmes and spatial experience as scrutinised by data visualisation and physical observation, as discussed in Chapters 5 and 6. This is because our spatial experience tends to be guided (and/or somewhat controlled) by architectural programmes. As investigated in Chapter 2, the flexibility of architectural programmes can be connected with the expansion of spatial experience. Flexible architectural programmes can enhance locative interactivity, however, how can we make architectural programmes in the static built environment flexible? This is enabled with a locative digital presence reflecting the live, built environment traced using digital communication data (Figure 8-1).

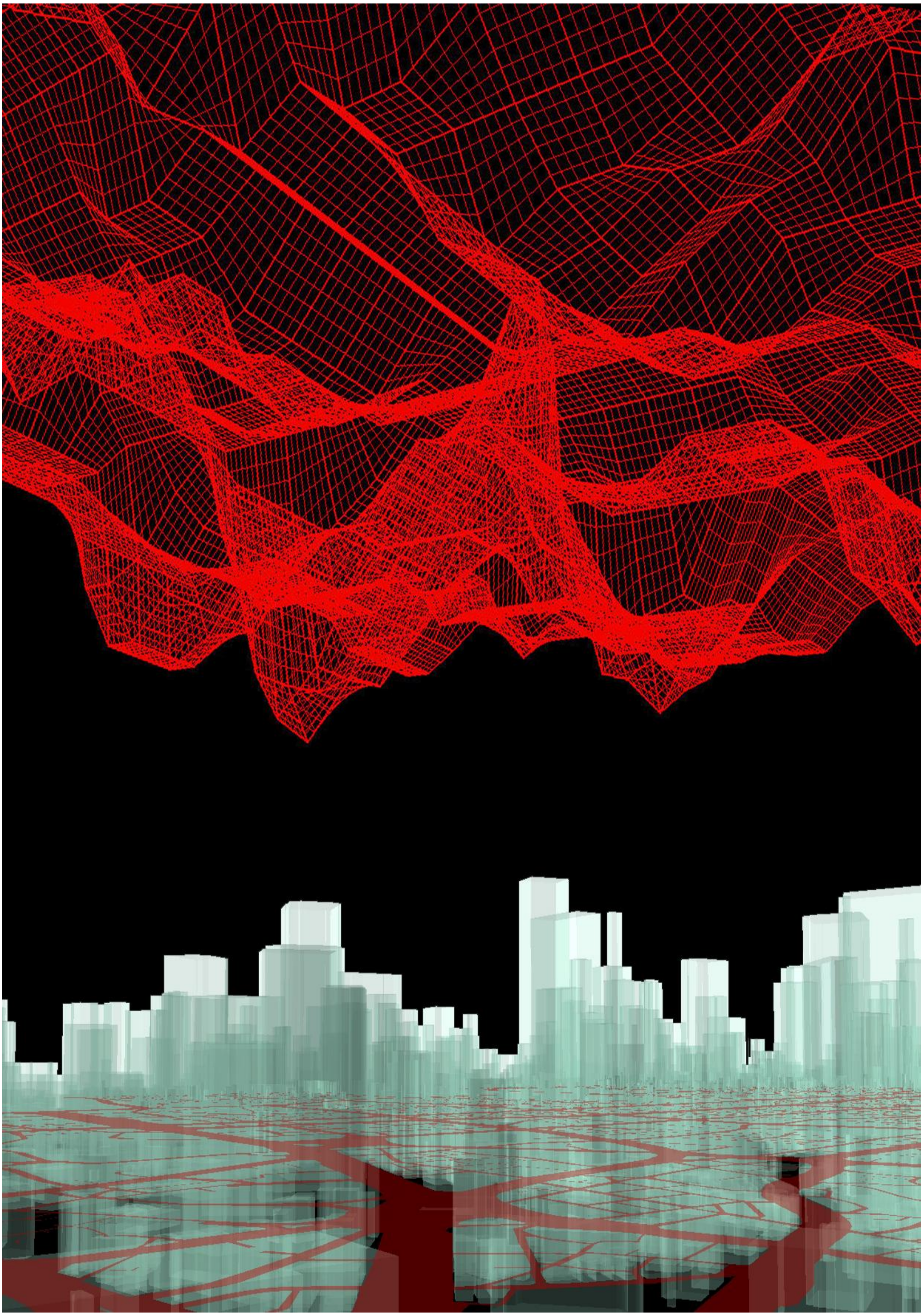

Figure 8- 1. Locative digital presence mirroring the live built environment traced by digital communication data

As investigated in Chapter 7's discussion of the LED-based installation, the live built environment is altered depending on urban daily rhythms. This rhythmical data topography is a fundamental ground that endows the flexibility of architectural programmes to enhance locative interaction.

The next two sections specifically demonstrate a concept of locative interaction reflecting live urban space, urban rhythm and locative virtual layers. The last section exemplifies two projects with applicable scenarios, a heterotopia finder and a floating gallery in London.

## 8.2. Urban Rhythm

The study of numerical data patterns in Chapter 4 revealed that the pattern of telecommunication use is connected with the rhythm of everyday life (see Figures 4-4, 4-5 and 4-6). Additionally, 2D and 3D data visualisations (Chapter 5) demonstrated that temporal layers reveal a dynamic fluidity of spatial occupancy in urban space. These changing data patterns in urban space revealed the interaction between people and urban space. This offers a foundation from which to discuss architectural programmes that connect with spatial experience via interpreting visualised maps juxtaposed with the built environment. These data visualisations represent the spatial rhythm of urban life. In Chapter 6, temporal contexts guide observation in order to compare the relationship between actual activities and given architectural programmes. The actual activities change depending on everyday rhythm in urban space, while the built environment and planned architectural programmes remain static. Urban rhythms reveal the gap between actual activities and given programmes.

Following Lefebvre's indication of rhythm analysis, as discussed in Chapter 2, this research suggests that urban rhythm should be considered an applicable design intervention of locative interaction and urban design. As demonstrated by statistical study and data visualisation, a general trend of inflection is incorporated rather than hourly data figures because the inflection points reflect the temporal pattern changes of telecommunication use in certain areas over a day. The distance between one inflection point and another inflection point (see 4-1, 4-2, and 4-3) can be considered as the start and end point of certain activities. For example, in Figure 4-1, the inflection points are shown at 7.00, 12.00, 13.00, and 19.00, which are to be expected as the general schedule of people on a weekday. Interestingly, graphs for Saturday and Sunday (Figures 4-2 and 3) show less data traffic and fewer inflection points. The rhythm recognised by data variations will help in applying time-tailored programmes, both of telecommunication services and of urban design, depending on cell spaces. This can create a more ubiquitous interaction in urban space.

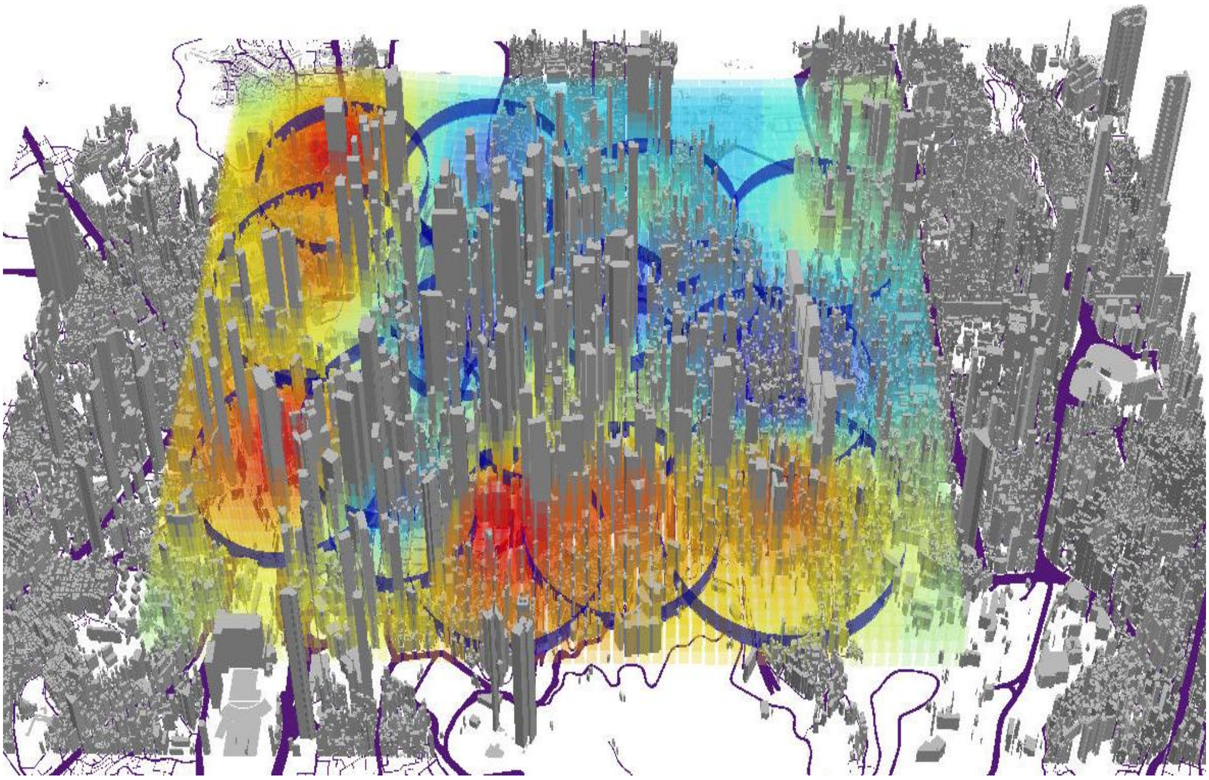

Figure 8- 2. Cell space and telecommunication data distribution at 10.00 on a weekday in the center area of Seoul

## 8.3. Locative Virtual Layers

### *8.3.1. Mirror Space and Layering*

Returning to the spatial notion of heterotopia in Chapter 2, this research must readopt the mirror analogy to suggest a specific design of locative interaction for urban spatial experience. Contrary to the mirror discussed in the notion of heterotopia, the mirror space in this research refers to virtual layer(s), namely communicative and informative layer(s) loaded with locative information and memories that are represented as a kind of map. The informative layer should be synchronised with urban structures that reflect live urban contexts (live occupancy) as investigated in Chapter 5.

From images presented in Chapter 7, we found layered urban images generated from the static built environment. In fact, our urban space is like a collage of diverse factors that are connected with individual or collective memories and spatial experiences from daily life.

The collage can be fragmented layer by layer. This can be considered as a kind of categorisation of locative information. Locative information is correlated to spatial experience. When we want to arrange a travel route or choose a destination, maps including locative information can effect our spatial experience. If the maps are composed of ‘diverse layers of information,’ and if we can choose and combine ‘informative layers mirroring urban space’,, technology could offer customised locative information as well as locative communication and information acquisition.

### *8.3.2. Programmable Flexibility*

The informative layers can be compared to the ‘other space’ addressed by Foucault and discussed in Section 2.2. He describes other spaces as compensatory, ‘contesting counter-sites: real and illusory’[1]. This is because the informative layers are based on real locations and times and can make a connection between physical urban space and digital presence. The informative layers should be locative, virtual and depend on time; we can refer to them as ‘locative virtual layers’.

These locative virtual layers are developed by the scenes of accumulated temporal layers shown by the LED installation project in Chapter 7. The design project’s contours accumulated depending on hourly time intervals, thus demonstrating an altering spatial occupancy over a static built environment. In other words, people’s daily activities (detected by telecommunication use data) generate different types of programmable layers that mirror the built environment. If the LED installation consisted of a single data distribution layer that moved depending on time variations, this would simply be a moving image of live urban space. However, the accumulation of temporally different contour layers implies that urban space includes diverse programmable layers. Although the variable urban layers in this installation are merely time variations, subliminal situational layers mirroring urban space are revealed in reflections: this is the attribute of locative virtual layers.

Locative virtual layers in this research are generated as a counter-site mirroring our memory of the built environment. More specifically, although we are in the same space in a city, our own spatial experience can differ from that of others. We tend to have our own maps that reflect individual spatial experiences. These kinds of maps exist as layers juxtaposed with urban maps that generally reflect the static built environment. Although we live in a static built environment, everyday spatial experience can be practised as locative virtual layers rather than in the form of general information maps. These locative virtual layers are a kind of mirror-space, which reflects our everyday spatial experience in live urban space. Locative virtual layers can include various kinds of information that can be useful to the general public, however, locative virtual layers can be individually customised and can include information based on individual needs or experience. Locative virtual layers are characterised by programmatic flexibility enabled by technological intervention, which contrasts static architectural programmes imposed in the built environment.

The arbitrariness of spatial experience can be affected by live urban space (people traffic and the built environment) because people traffic, reflected by telecommunication use, is an important context in live urban space. Using temporal-spatial distributions of telecommunication use data, we can anticipate an approximate density of people traffic and telecommunication situations related to urban events and architectural programmes. Our spatial experience is practised within the rhythmical contour of people traffic traceable by telecommunication data. We can, therefore, obtain programmatic flexibility beyond the static architectural programmes in the built environment, which can expand spatial experience. (This is exemplified by an applicable scenario in Subsection 8.4.1.)

The diagram of locative virtual layers in Figure 8-3 demonstrates how locative virtual layers are structured using technical elements of telecommunication: base stations, cell space (radius of base station), the maximum number of active users within cell space (as the number of telecommunication users tends to be limited within a cell space), time scale and so forth.

Locative virtual layers can be virtually activated based on location and time. These contexts (location and time) are mediated by cell spaces as they cover a certain area where telecommunication data can be traced. Cell spaces can be represented by hourly sliced cylinders. Red curved surfaces in hourly sliced cylinders (Figure 8-3) represent locative virtual programmes that can be generated by mirroring the built environment (and complimenting architectural programmes connected with urban space) within a cell space. As individual cell spaces have a limited number of active users, the size of the arc can represent how many people access certain virtual programmes. For example, organisers planning a large number of events in an urban square (or public open space) can expand their programmes by adopting locative virtual layers as and when needed. If music performances occur in a certain urban square, we can almost instantly set up temporally locative virtual programmes, such as comments boards or digital commerce initiatives, during the concert (or from immediately after the performance until audiences are disassembled). These ideas will be clearly demonstrated in Subsection 8.4.2.

This concept of layering locative virtual programmes can make architectural programmes in the built environment flexible, which can expand our spatial experience. In other words, programmable flexibility can be endowed in our built environment via technological intervention (telecommunication). This can bring abundant programming to benefit people's spatial experience and enhance locative interaction.

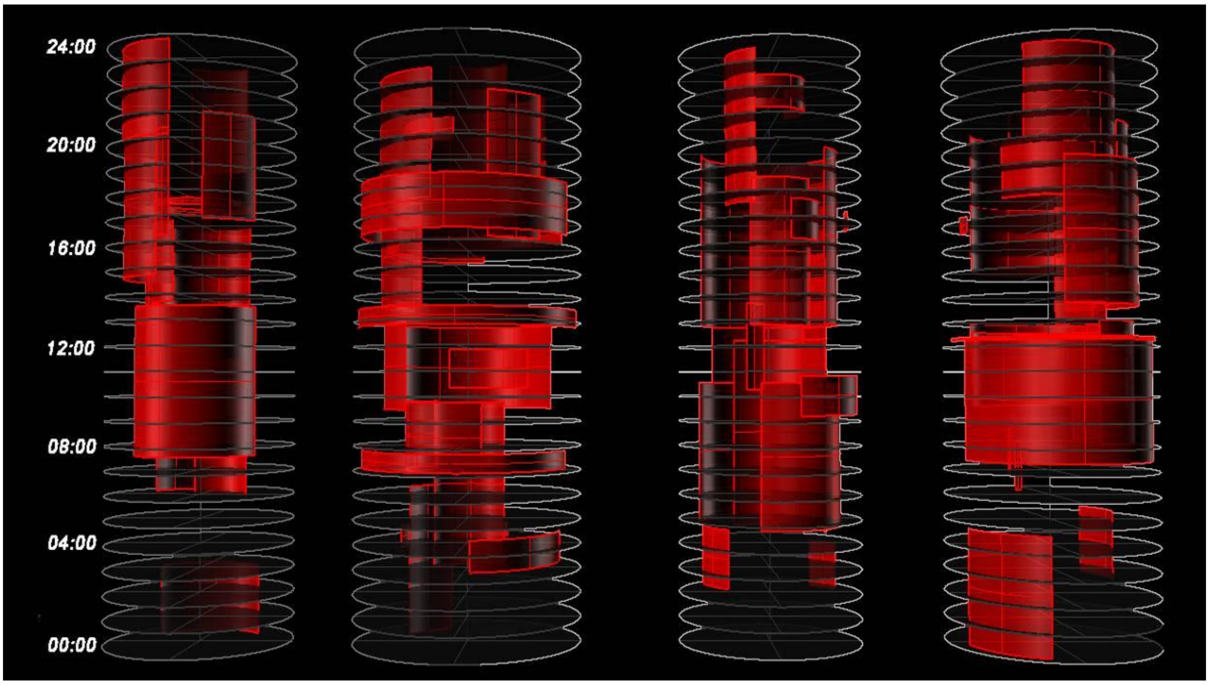


Figure 8- 3. The diagram structure of locative virtual layers: Each cell space can be represented temporally as hourly sliced cylinders. Red curved surfaces express possible locative virtual programmes that are connected with architectural programmes within a cell area.

## 8.4. Summary

Developed from discourses about mapping telecommunication data as a technological intervention in live urban space, a concept ('urban rhythm' and 'locative virtual layers') of locative interaction reflecting live urban space is suggested in order to expand spatial experience.

The consideration of urban rhythm should be premised in the concept. 'Urban rhythm' is related to 'relative time' in urban space rather than 'chronological time'. The rhythm recognised by data variations will help in applying time-specific programmes, both for telecommunication services and for urban design, depending on cell spaces. More specifically, urban rhythm is embodied by temporal-spatial coordinate and live data as design intervention for urban locative interaction.

'Locative virtual layers' in the research can be generated as a counter-site, mirroring our memory of the built environment. More specifically, although we are in the same space in a city, our own spatial experience can be different from that of others. We tend to have our own maps reflecting spatial experience regarding everyday life: these maps can exist as layers juxtaposed with urban maps that reflect the static built environment. These locative virtual layers are characterised by mirroring space programmes based on location and layering informative virtual programmes connected with space programmes.

| **Production of space**[2] | A.<br>Spatial practice<br>(The Practiced) | B.<br>Representations of space<br>(The Perceived) | C.<br>Space of Representation<br>(The Imagined) | |
|---|---|---|---|---|
| | Physical Infrastructure | New system of mapping; Architectural discourses | Imaginary landscape; Science fiction ontologies and space; Artists' sketches | |
| **Digital Space** | • Cell spaces<br>• Base stations | • Geography of Telecommunication | • Location of Representation | |
| **Methodology**: Rhythm analysis | • Data Collection<br>• Statistics | • Data Visualization<br>• Observation | • Epistemic Design<br>• Scenarios | |
| **Discourses**: Heterotopias: Programmatic Flexibility | • The temporal and spatial patterns of telecommunication: | • Geography of spatial experience<br>• Gap between Existing programs and programmatic flexibility | • The mechanism of Programmatic Flexibility for expanding Spatial Experience | |
| **Design Intervention for Programmatic Flexibility** | | • Altering spatial occupancy and heterotopic attributes: **Multi-layered space programs and individuals' spatial experience** | • **Urban Rhythm** | • **Temporal-spatial coordinate**<br>• **Live Data** |
| | | | • **Locative Virtual Layer** | • **Mirroring**<br>• **Layering** |
| **Design Works** | | • 2, 3 and 4D visualized data maps | • Data installation<br>• ***Applicable scenarios;***<br>- ***Diagrammatic representation of new spatial experience***<br>- ***Representational sketch of new mechanism*** | |

Table 8- 1. Production of New space of Locative interaction in Urban space

[1] Boyer, M. Christine (2008) 'The many mirrors of Foucault', In: Dehaene, Mitchel et. al. (eds) *Heterotopia and the City*, London: Routledge, p.55-56
[2] Harvey, David. (1990) The Condition of Postmodernity: an Enquiry into the Origins of Cultural Change, London: Blackwell, pp. 220-221

# Chapter 9
# APPLICABLE SCENARIOS

Following the design installation in Chapter 7 and the concept of urban rhythm and locative virtual layers generated in Chapter 8, we can create applicable scenarios. One such scenario includes users' spatial experience layers represented by a dynamic map that can play a role in finding directions and relevant user-tailored information based on location (see Figure 8-4). Another applicable scenario demonstrates the possibilities of urbanism interweaving physical and virtual space via applying the concept (urban rhythm and mirror layers) to London. The two applicable scenarios focus on how to expand spatial experience in urban physical space complemented by locative virtual space. Specifically, the heterotopia finders are primarily created through layering and combining user experience and other informative maps. These dynamic generative maps can guide people's spatial experience and information acquisition by combining users' previous experiences and current urban situations. The Floating Gallery in London seeks to interweave the physical built environment and the realm of digital presence via adopting urban rhythm and locative virtual layers—the same concept of locative interaction discussed in this research.

## 9.1. Iteration and Sketch

It has been recognised as one of the most feasible human-centered design methods in the field of human computer interaction (Nielson 1993)[1]. In terms of the attributes of interaction design, the design process cannot be finished at one step. Generally, iteration design process is divided into the three stages: design, prototyping and evaluation (Nielson 1993; Pousman 2004)[2, 3]. Design should be prototyped and evaluated to indicate unseen and possible design problems that are revised through iterations: redesign, prototype and evaluation.

The stage of design tends to be illustrated as sketches that reflect the essential part of the idea. The sketches can be implemented in diverse media such as a moving image and interactive story boards. These serve as a tool and a method through which designers render vague design specific (Forlizzi, Jodi and et. al. 2009: Tohidi, M., et. al. 2006: Johnson, Gabe and et. al. 2008)[4,5,6].

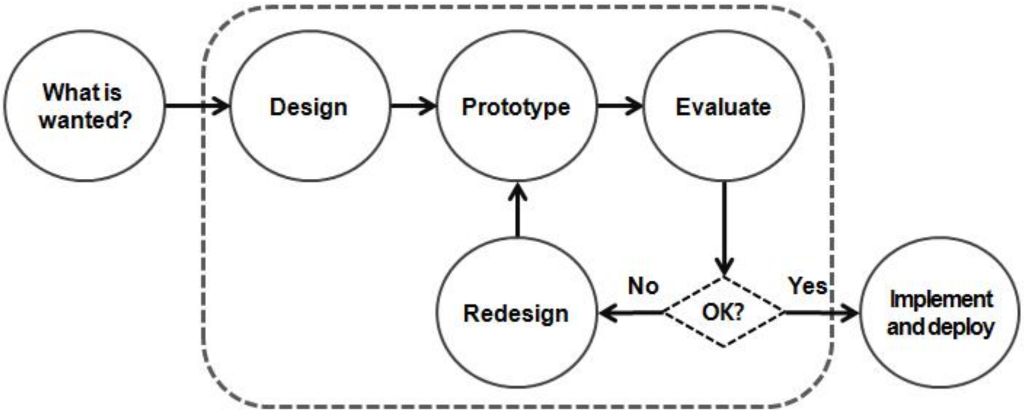


Figure 9- 1. The process of iteration design[7]

In contrast, the stage of prototype is more concrete. Once we produce a sketch reflecting ideas as a design process, the sketch is then prototyped on the level of low, medium and high fidelity. The more iteration design process approaches to the completion, the higher fidelity prototype is needed in general. While a sketch is something suggesting, exploring and proposing, a prototype is something describing, refining and testing (Buxton 2007).[8] Figure 9-2 demonstrates the continuum of sketch to prototype.

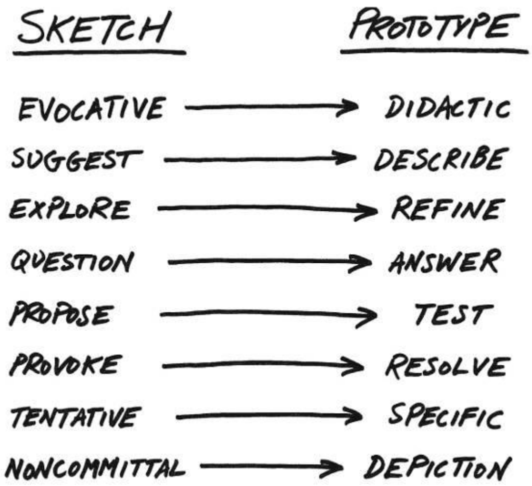


Figure 9- 2. The sketch to prototype continuum (Buxton 2007)[9]

- ***Usability evaluation in the early stage***

The prototype reflecting sketch in the design is evaluated generally focusing on usability. However, we should carefully consider usability evaluation as it might be harmful particularly at the early design stage (Greenberg and Buxton, 2008)[10].

First of all, we should consider the difference of attribute of a sketch and a prototype (Figure 9-2). A sketch will tend to have many deficiency and undeveloped attributes. But it implies many possible ideas for better design. On the other hand, a prototype as an approximation of completed product should be more specific and definite for usability evaluation. If sketches in the early stage of design are prototyped and evaluated, we might miss an opportunity to excavate better ideas and develop to better design.

Moreover, usability evaluation tends to be adopted as a method to test how the new design of applications is better than the existing ones. The suggested design of application can be considered as a hypothesis formation and usability evaluation can be a testing, which is an existence proof. Within design research, we tend to believe that scientific method (hypothesis formation and testing) can bring a validation

At first glance, this logic seems like science. But Greenberg and Buxton indicate that the usability evaluation in many human-computer interaction fields tends to pursue confirmatory evidence through a safe test, which can produce a weak validation. How can usability tested by a number of people be applied to a majority of actual users? This question of usability evaluation insinuates how we should have a position for evaluation within iterative design process.

- ***Subjectivity and Objectivity***

Interaction design should be objectively reliable in the pursuit of subjective value (Cockton, 2004)[11]. If usability evaluations in the early stage might be ineffective, how can our design be evaluated? Greenberg and Buxton (2008) argue objectivity in design can be fostered by design critics with relevant expert groups. In fact, peer evaluation has been considered as a powerful method to learn diverse contexts (Kali, Y. and Ronen, M, 2005; McConnelll, 2006)[)12,13.]

Moreover, 'value scenarios' should be considered when developing new applications of technology (Nathan, L., Klasnja, P and Friedman, B., 2008).[14] Value scenarios are extended from scenario-based development (SBD) in human computer interaction (Rosson, M. and Carroll, J., 2001).[15] They are narrative descriptions of the interaction between individuals and technology to recognize usability problems and needs.[16]

Traditional scenarios portray the technology being used with the designers' intention, mostly in a positive manner. They tend to focus on the firsthand stakeholders with a short-term viewpoint. Value scenarios differ from traditional SBD, in that they typically consider five key elements(Nathan, L., Klasnja, P and Friedman, B., 2008).[17]:

- Stakeholders (direct and indirect users)
- Pervasiveness of technology
- Time (not only short-term but also long-term)
- Systemic effects (multi-dimensional interactions among a technology, culture, and the environment)
- Value implications (including both positive and negative aspects)

Design projects in this research are sketches, rather than completed works. These projects outline and illustrate the main discourses of interaction design — urban rhythm and locative virtual layers — and show examples of applicable scenarios. The efficacy of design works at the sketch stage depends on whether the sketch properly reflects and demonstrates design intervention (or factors) derived from the main argument. How the main arguments (the value being pursued in this research) reflect on design projects and how the images help to reflect the value and envisage the future is most significant for the research process. Thus, design projects in this research are qualitatively evaluated — via the value scenarios demonstrating programmatic flexibility in urban space to extend spatial experiences — through factors extracted from the main discourse, including temporal-spatial coordination and mirroring; methods to reflect space programmes and layering; and methods to structure virtual programmes derived from these space programmes.

## 9.2. Applicable Scenario I: Heterotopia Finder

### *9.2.1. Map and Spatial Experience*

Recently, a large number of smart phone applications are adopting GPS technology for location-based programmes as we investigated in section 2.4. Various kinds of information can be loaded on to the telecommunication data map via geo-tagging. Figure 9-3 shows geo-tags representing on Google map where diverse spatial experiences were captured and attached based on location. This tagged information can be referred by others who particularly have a plan to travel to the place tagged. If there are geo-tags made for oneself and one see the tags a few years later, they can be also useful information to affect the current or future experience in urban space. This accumulation of previous individual spatial experiences can be categorised as informative layers in manner that users intend. Also, if telecommunication traffic revealing live urban structure is adopted on top of user layers created by customisedly categorising locative information (tags), we can more specific locative information to find heterotopic (individually tailored) spots for next travels.

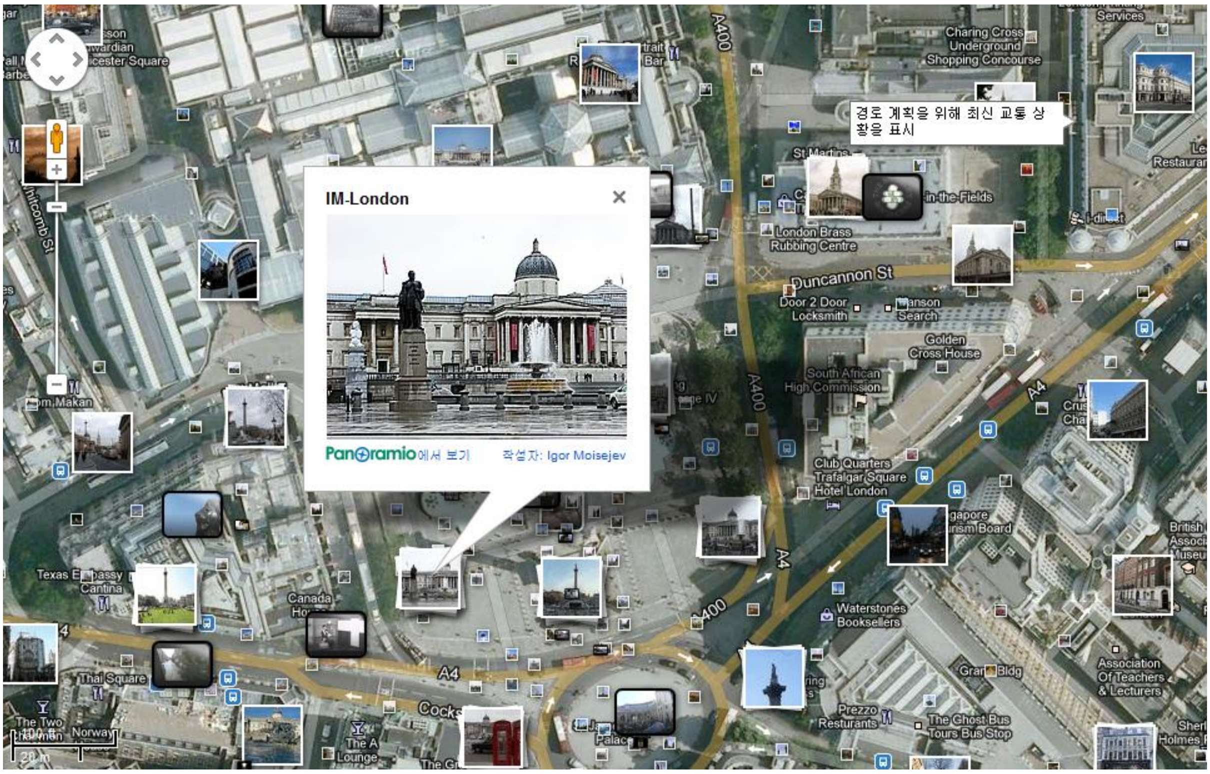


Figure 9- 3.Geo Tagging on an internet map [18].

- ***User Layers***

Geo-tags or locative information that can be represented as a kind of cartopraphy can be categorised depending on user's interests. They can be represented as contour maps or pin-pointing maps.

User Layer I and II (Figure 9-4) can hold memories regarding certain spaces based on previous experience. One could mark a favourite spot geographically on a map. One could also generate User Layer III and IV (Figure 9-4) wherein informative maps may be downloaded from application stores or local government sources. These maps (User Layer I, II, III and IV) could be thoroughly customised via combination.

This diagram demonstrates a way of combining various user layers by mapping respective user layers. Specific user layers can be demonstrated by geographies of frequency that reflect user experience.

This data map primarily informs users of locative traffic information juxtaposed with the urban physical context in real time. Thus, the data map will be generally useful for those who need to consider locative and real-time people traffic for their work. For example, the data map will provide information about where passengers would likely need a taxi service.

Additionally, the data map can convey the time-space trend of people traffic mapped onto the urban situation (of the built environment) for campaign strategists or corporate promotion planners who consider numbers of people as key determinants of successful projects. Furthermore, as crime is more likely to happen in busy places where a wide cross-section of people come and go, a crime map applied to locative crime history can be useful for local government and inhabitants.

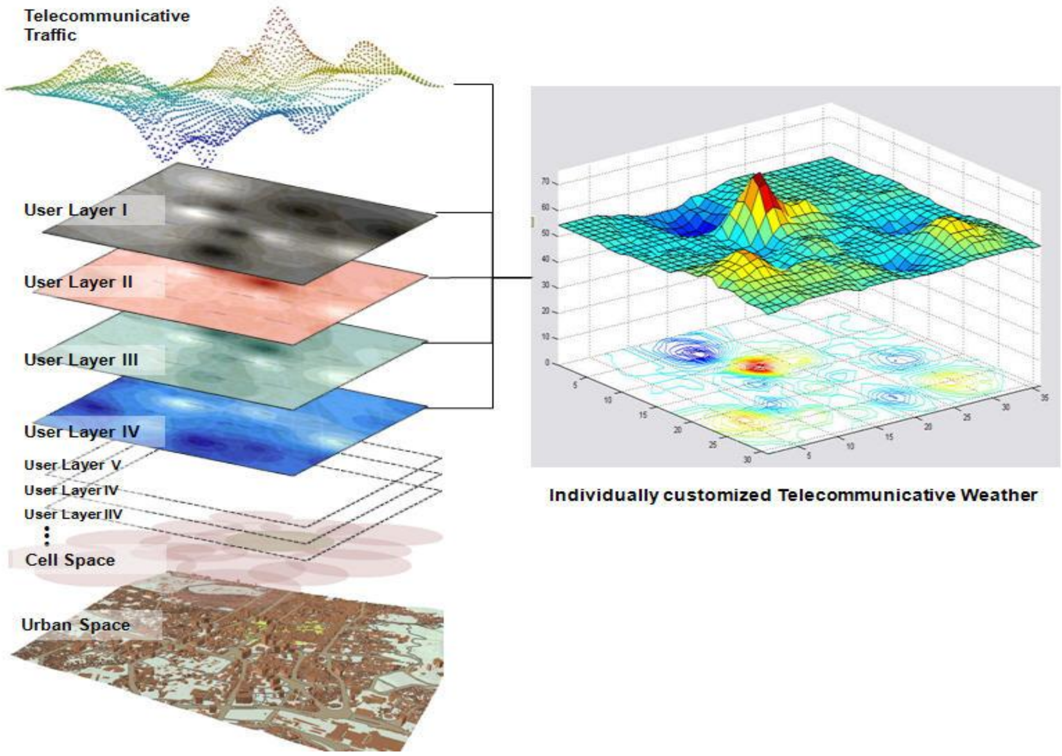


Figure 9- 4. A Scenario of User layers

From the above diagram, maps in this design project can be categorised as three types of cartography including different attributes of everyday life. One is a general map indicating the built environment. Another is telecommunication data map illustrating a fluidic occupancy in urban space. Others are user layers, maps reflecting users' spatial experience, which can be individually generated depending on themes of what ones focus on. For example, themes can be derived from individual experience such as personal preferential for locations or public information such as a crime rate map. These three types of map can be consolidated to indicate an individually tailored location (heterotopia) where we want to travel. The specific process of consolidation is demonstrated as the below chart (Figure 9-5).

- ***Workflow***

The Workflow below demonstrates how maps variously visualising our everyday life can be consolidated (Figure 9-5). Firstly, we should set a general map, geo-spatial data focusing on where we will come. Secondly, urban live context traced by telecommunication data should be added on top of the general map. Thirdly, maps representing diverse themes will be chosen, and then put some weighted-value when individual maps are applied to the general map. Finally, three type maps are consolidated as a map indicating heterotopic spots through which we can expect our spatial preference reflecting previous experience.

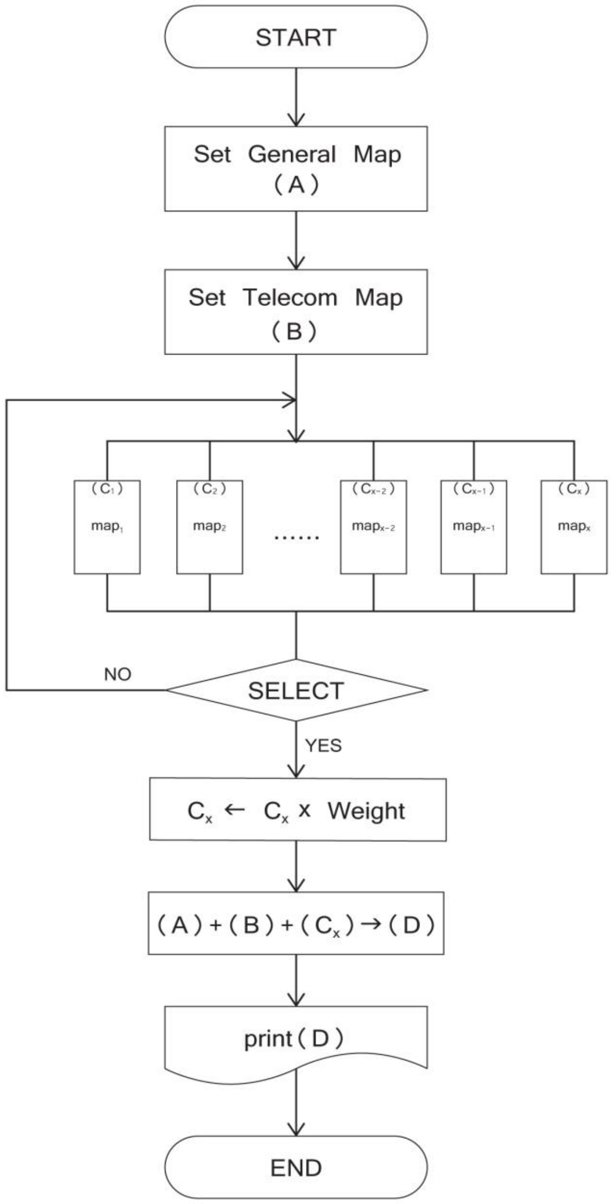


Figure 9- 5. Workflow of Heterotopia Finder

In this interface design, it should be considered that spatial experience in the past and the future are displayed at once. Also, larger screen or a display on augmented reality is considered as currently screen size is getting lager. Based on these requirement and workflow above, a sketch and a prototype of the interface of Heterotopia finder is generated (Figure 9-6 and 7).

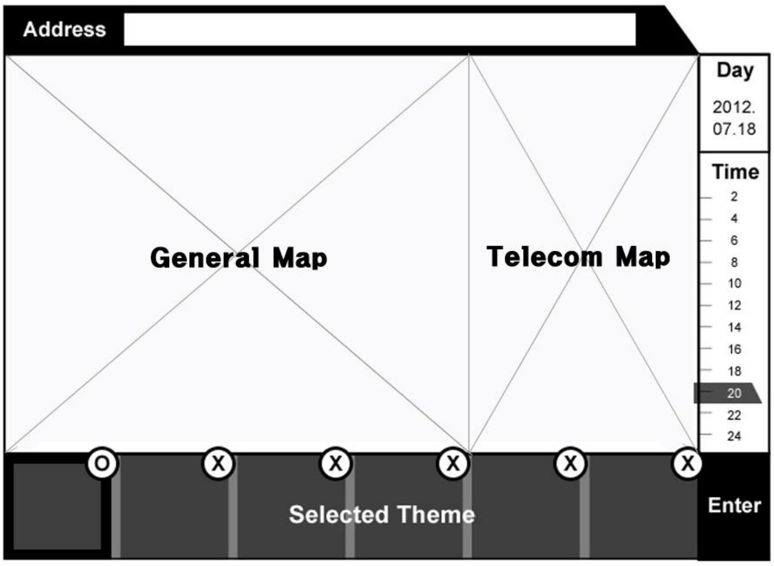


Figure 9- 6. Sketch of interface

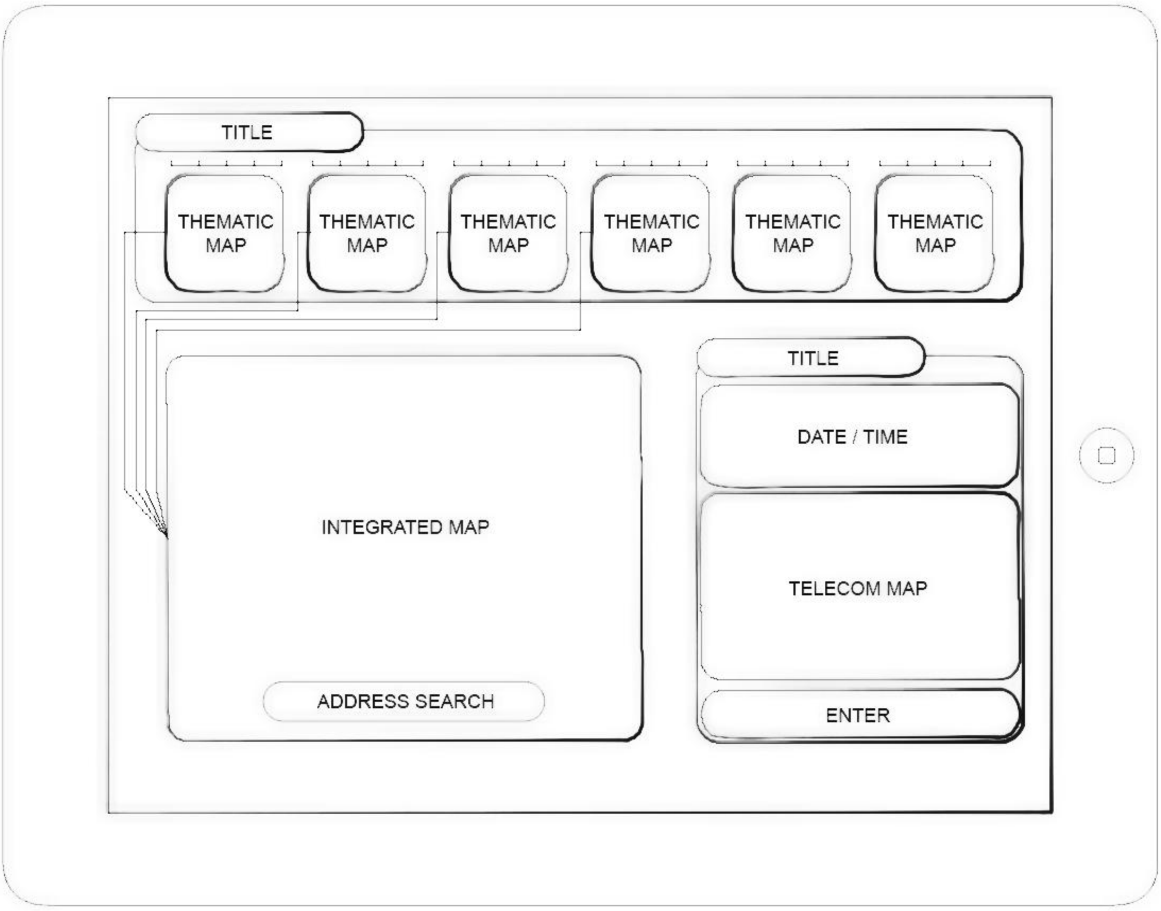


Figure 9- 7. Prototype of the interface


Figure 9- 8. Interface design of Heterotopia Finder

Figure 9- 9. Applicable situationI

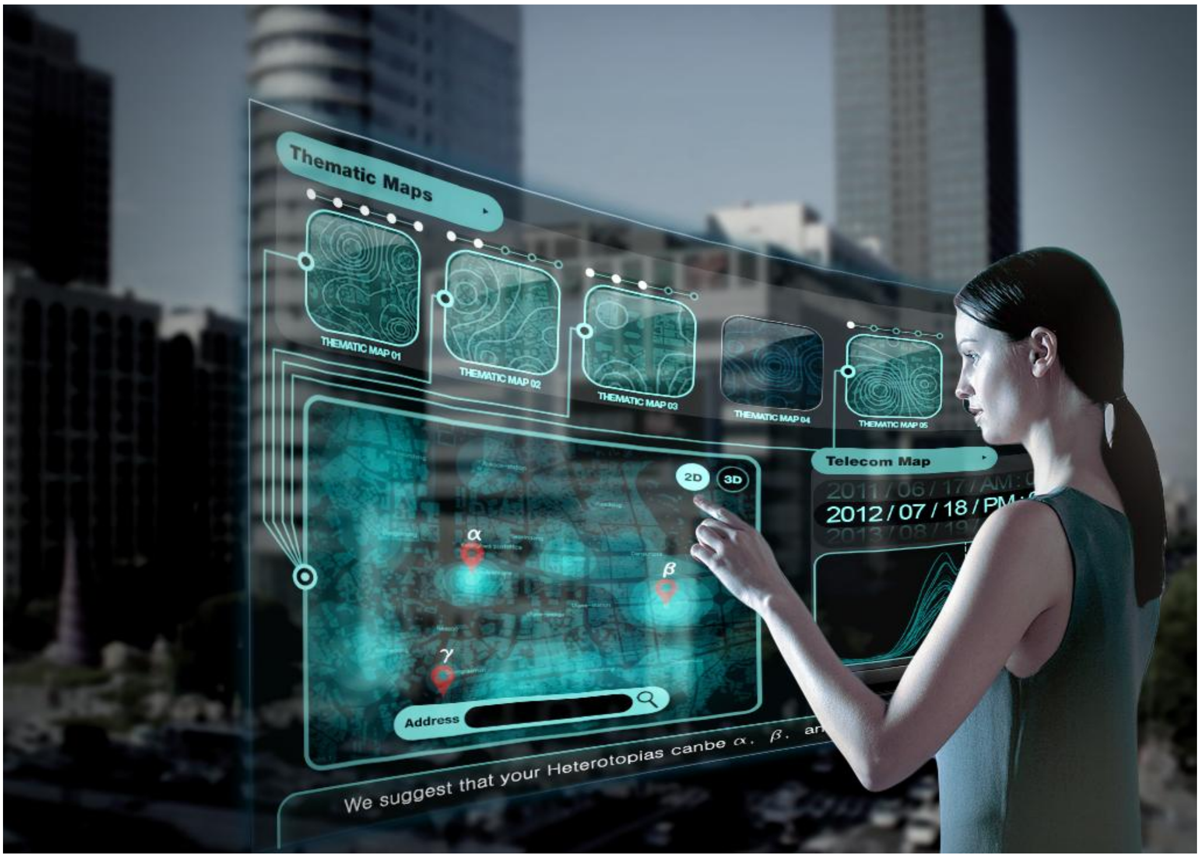


Figure 9- 10. Applicable situation II

How design interventions (factors) are reflected for the main argument should be stated (Table 9-1). Urban rhythm suggested as design intervention for programmatic flexibility is specified in this design project as user layers. User layers are created by spatial experience at a certain time and a certain location reflecting live data of digital communication. Locative virtual layer embodying ‘mirroring’ and ‘layering’ is reflected to a structure of this project (heterotopia finder). User layers can be interpreted a mirrored space made by individually practised urban space.

| **Design Intervention** | **Design factors** | **Reflection** |
|---|---|---|
| Urban Rhythm | Temporal-spatial coordinate | User layers are created by spatial experience at a certain time and a certain location. |
| | Live Data | Applying live data to user layers |
| Locative Virtual Layer | Mirroring | Individual user layers are generated through mirroring a different kind of spatial experience |
| | Layering | Different categories of spatial experience are structuralised by layering. |

Table 9- 1. Applying design interventions

### 9.2.2. Locative Interaction by Heterotopia Finder

- ***Value Scenario***

*Min is a marketing assistant. One of her jobs is to arrange a hot spot for diverse events or meetings. While she has been previously finding the best spots through the Internet (Figure 9-11, A) or obtaining information from others' comments, heterotopia finder provides satisfactory recommendations to find the right spots for an event or a meeting through synthesizing the previous memory of the location which she has visited, and selected user layers that contain customized categories of locative information (Figure 9-10). Heterotopia finder also indicates how busy the location is — a temporal factor — which is helpful to expect and plan more specific situations in advance.*

*User layers play a significant role in making Min's personal appointment. Each user layers include the themes that Min considers important. One of her user layers can be created as if it were a diary of space. On a map, she can record how she felt or what she experiencde, for example, via geo-tagging photo or comments or through mapping preferences. Also, user layers made by other users' experiences can be exchanged, which can be useful as we can learn from other's experiences. Maps indicating public health and safety can be distributed pervasively; they can be updated in real time by local government or relevant figures. In fact, user layers can be created by collection, accumulation and tailored categorization of individuals' spatial experience.*

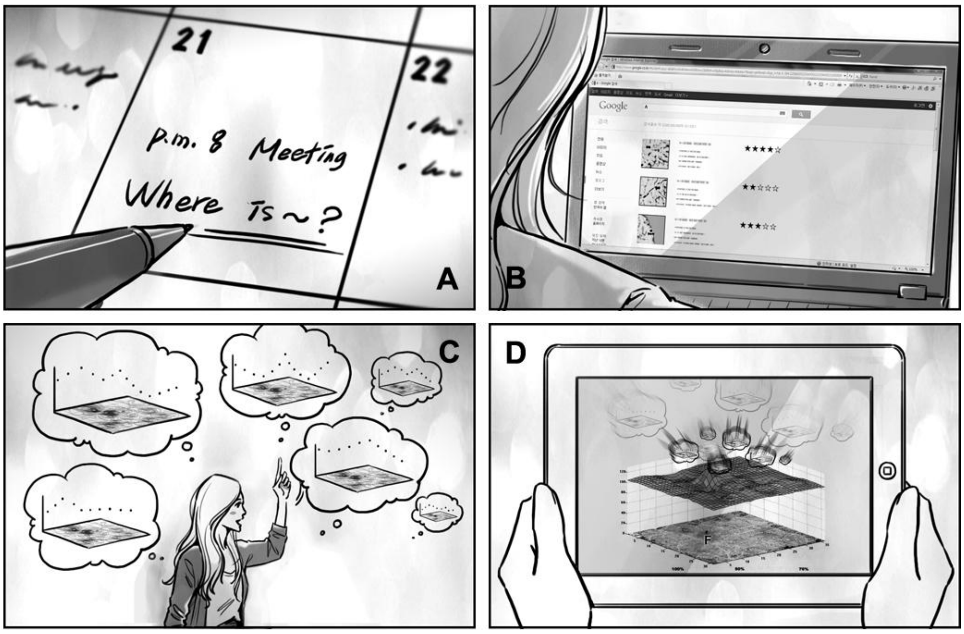


Figure 9- 11. A story board for using Heterotopia Finder

- ***Discussion***

Heterotopia finder (Figure 9-8) demonstrates a specific example of applying the concepts of expanding spatial experience in urban telecommunication space and mirrored spaces reflecting urban rhythm. The concepts include traffic distribution (urban rhythm) and customised user layers (locative virtual layers), which are synthesised in the telecommunication data map. The map will guide users' spatial experiences — wandering, arranging meeting points and/or browsing locative information — as an individually tailored informative map.

In the value scenario, Min and others who use Heterotopia finder are both an 'indirect stakeholder' as a provider of spatial experience and 'direct stakeholder' as a real user. The long-term accumulation of data of experiences in urban space can be shared a through 'systemic effect.' By using this project, users can find more individually adjustable spaces and a more specifically anticipated spatial experience in advance. Also, such programming could provide a complementary mechanism for telecommunications traffic data as digital intervention. The locative interaction between people and urban space will then be augmented through the telecommunications reflecting locative virtual layers ('value implications'). Locative interactions with live urban spaces guide us to these 'urban heterotopias' in rhythmic urban space and expand our urban spatial experiences.

## 9.3. Applicable Scenario II: Floating Gallery in London

Macroscopically, iteration is a natural process in nearly every design. Typical iteration process is being used particularly to develop IT-related products such as games, interactive devices, interfaces and so on. However, in larger scale of design project such as architecture designs and urban projects, articulations of three stages (design, prototyping, and evaluation) might not be meaningful. Graphical and physical modeling can be a type of prototyping. Evaluations tend to be conducted by heuristic methods and expert reviews which cannot be clearly articulated. In larger scale projects, a much greater number of design factors should be considered. On top of this, this design project is a kind of applicable scenario as a visionary sketch for a next digital ambience rather than application design such as App programmes for smart phones. In this kind of project, usability evaluation based on possible user groups is not that effective. Although iteration is adopted in this project, evaluations will be heuristically conducted primarily based on the catechetical methods for myself at every stage except for the final stage where this project will be evaluated by critics of an expert group. Thus, this project will be designed as an urban scenario, as if it were architectural projects, to demonstrate how the concepts of locative interaction (urban rhythm and locative virtual layers) can be applied to urban space (in London).

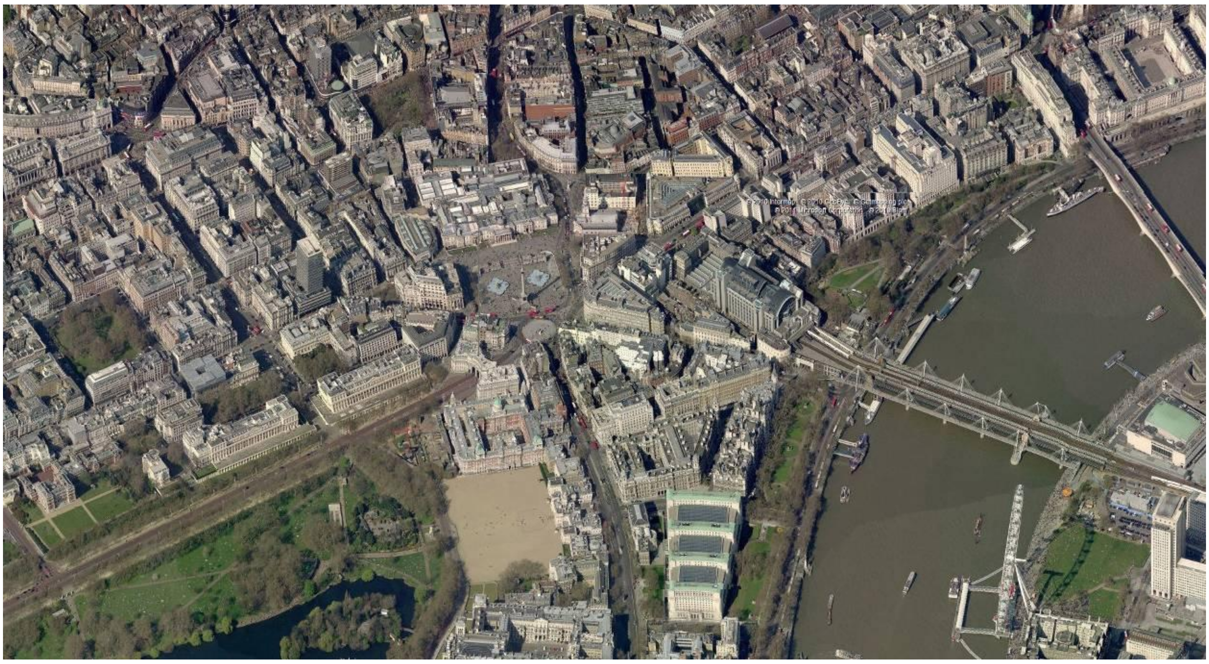

Figure 9- 12. London's West End

Although the concepts of locative interaction were embodied via telecommunication data and the urban context of Seoul, the concepts can be applied to vibrant spaces in other cities. This is because technological elements (cell spaces, temporal calibration, and telecommunication data) discussed in the concepts are universal in any city where telecommunication is used.

### 9.3.1. Framework

- ***Site: The West End of London***

This urban scenario is created in an area in London's West End (Figure 9-12). Firstly, the opening and closing times of certain facilities are temporally analysed as one of the operational factors connected with architectural programming. This analysis can inform the possibility of more activities in this area depending on the time of day. If people traffic is traced via telecommunication data and compared to business hours, one could estimate the gap between architectural programmes and people's activities. In addition to the gap, when the spatial and temporal attributes of individual spots, such as buildings, streets, and squares are anaysed, one can superimpose virtual programmes via locative layering. This enables the expansion of architectural programmes by inserting complementary virtual programmes. As a result, architectural programmes statically connected in urban space can become flexible depending on the urban rhythm indicated by temporal traffic shifts, which become locative virtual layers.

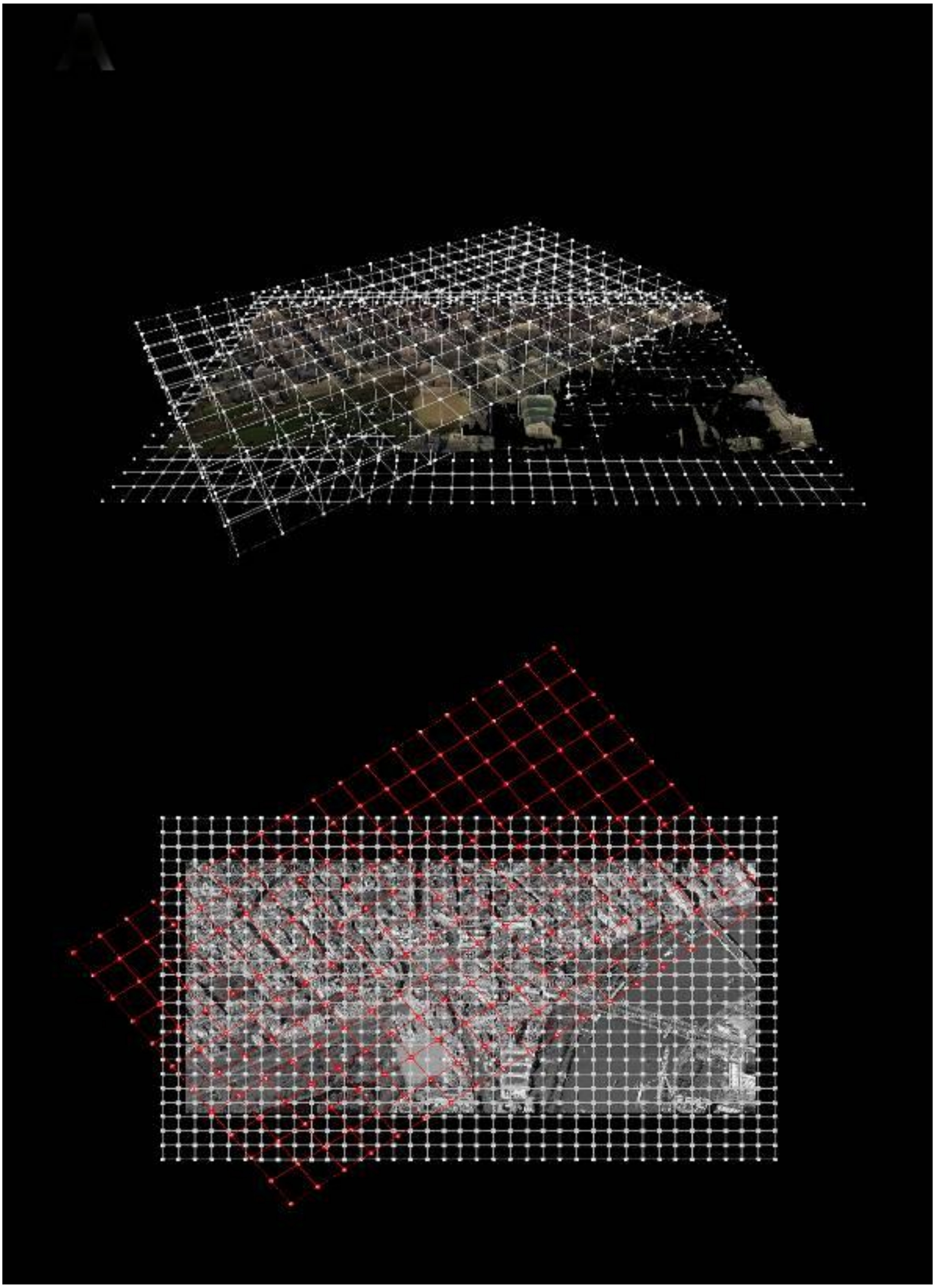

Figure 9- 13. Urban Grid

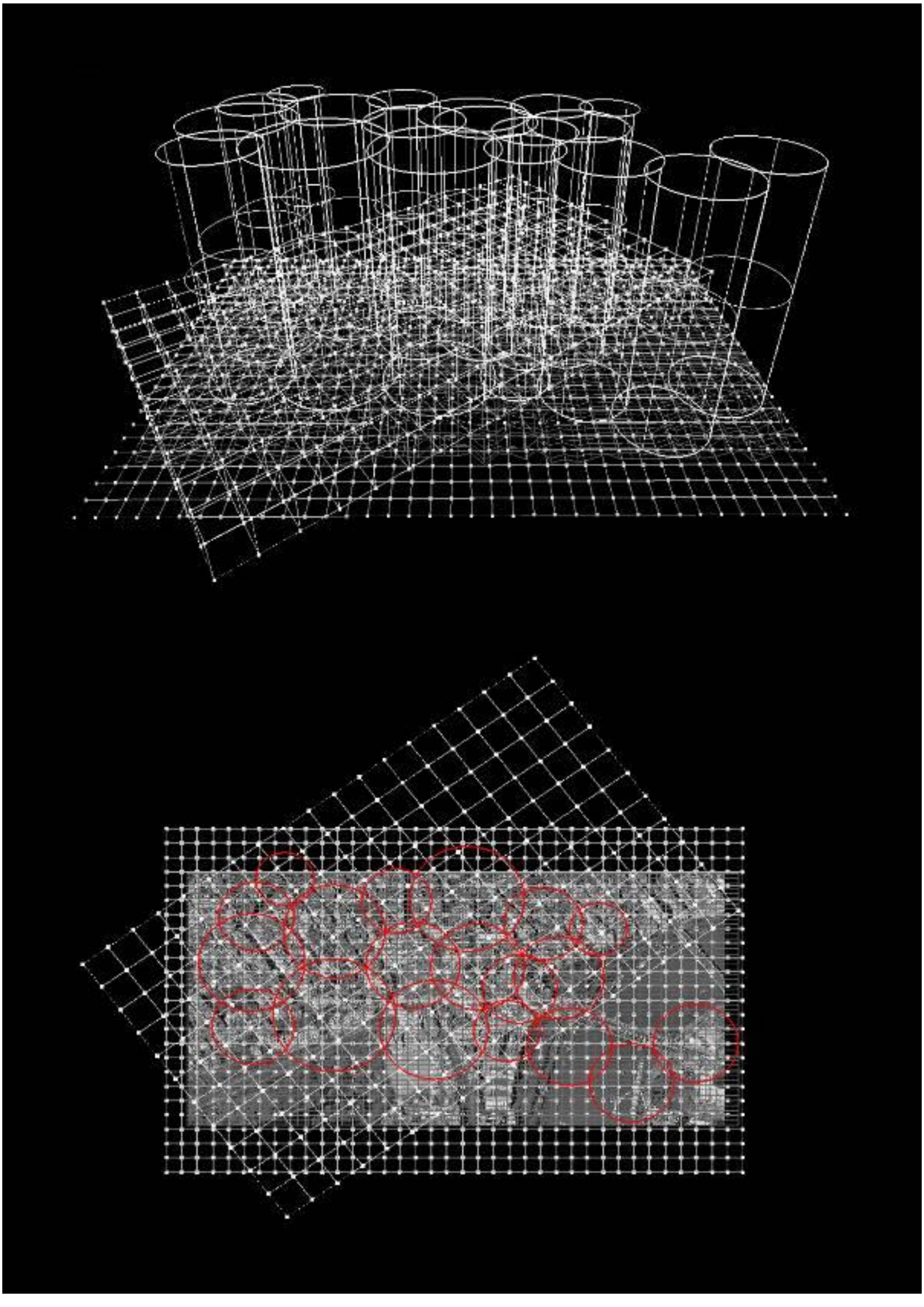

Figure 9- 14. Cell space

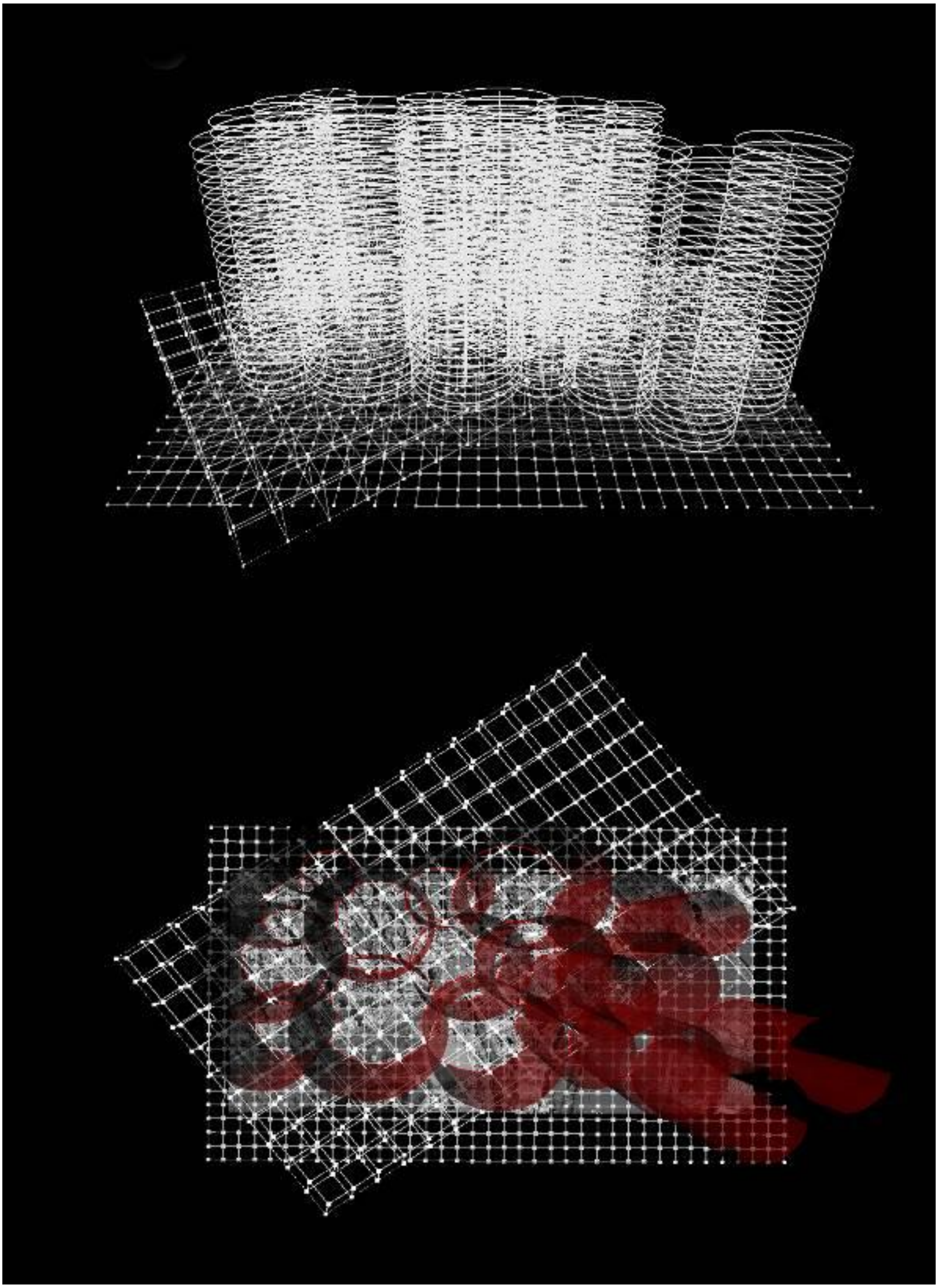

Figure 9- 15. Temporal Calibration

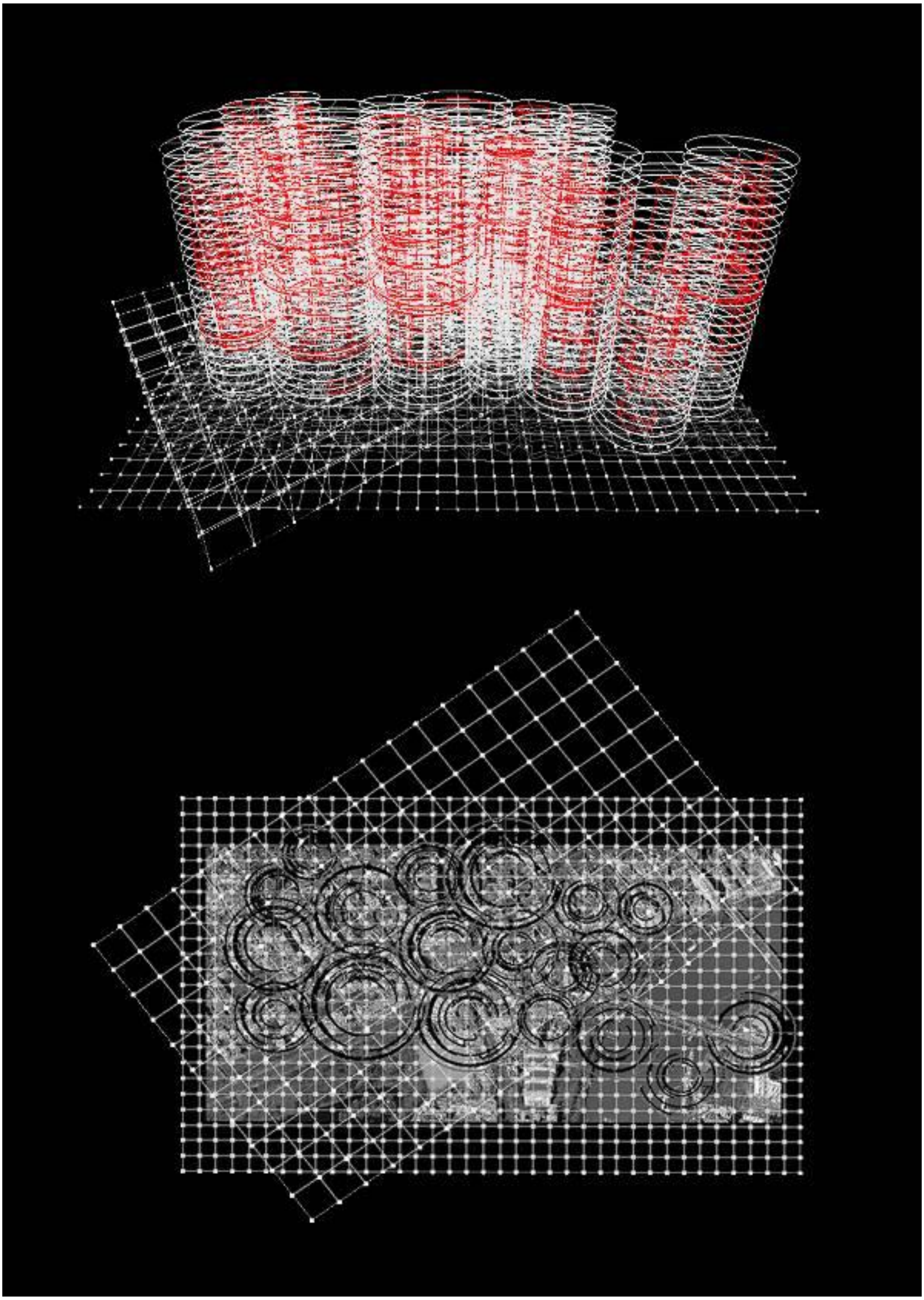

Figure 9- 16. Expanding Space Programmes from the physical built environment

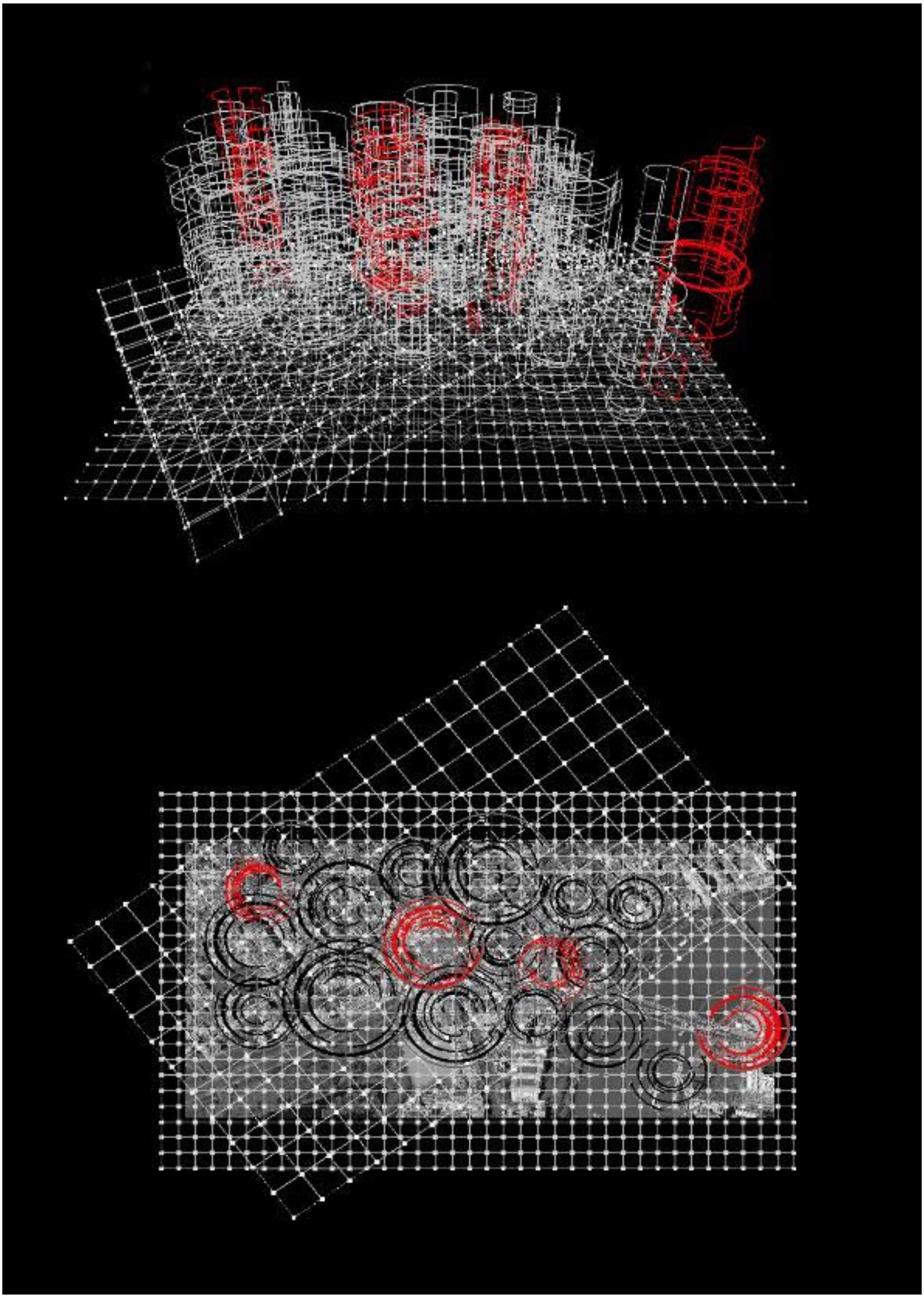

Figure 9- 17. Floating Galleries

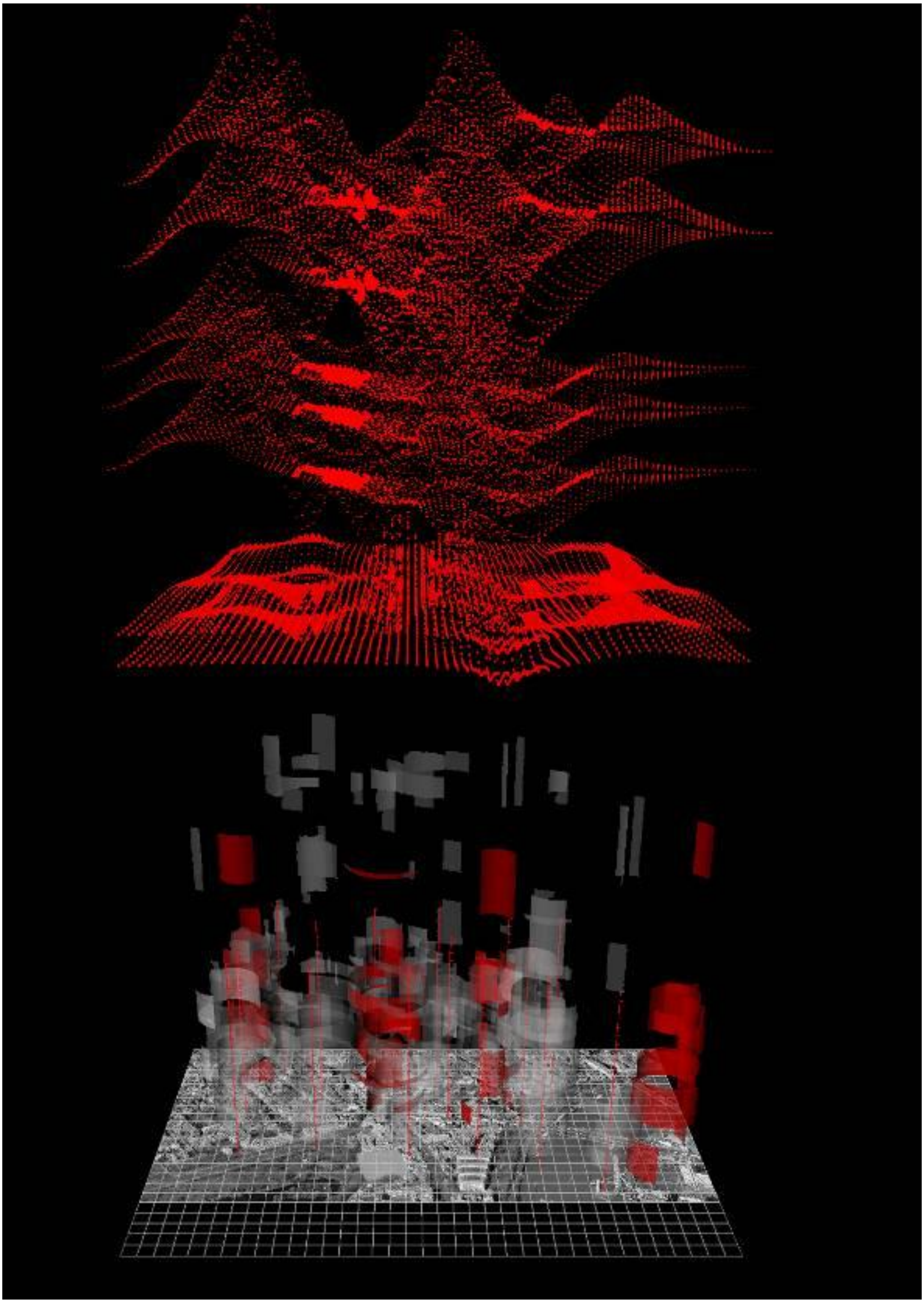

Figure 9- 18. Reflecting Urban Rhythm

- ***Architectonic Scenario: Virtual Structure***

More specifically, firstly one must find the urban grid of this site, in this case the West End (Figure 9-13). The grid is a physical structure of urban space, a fundamental system of buildings and settings in the built environment. Spatial programmes of architecture and urban space are contextualised by urban grids and zoning.

Secondly, the hypothetical plan of cell spaces (Figure 9-14) can be superimposed on the orthogonal grid of urban structures. This introduces another system of urban space. Although the plan of cell spaces is invisible, it significantly influences our everyday life as a digital presence of communication and information acquisition. This digital presence based on cell space can be represented as if it were an architectonic structure, as discussed in Section 8.3. Architectonically structuralised digital presences can be considered as possible expansions in space that reflect temporal shifts in everyday life. It can contain location-based, time-related, and even user-tailored programmes reflecting architectural programmes in the physical urban space.

Thirdly, this digital presence based on cell space can be represented as a 24-sliced cylinder (temporal calibrations) with each slice representing one hour of the day (Figure 9-15). This temporal calibration can be a structure where locative virtual programmes reflected by space programmes within cell space can be laid.

Fourthly, locative virtual programmes can be superimposed on this temporally calibrated cylinder depending on urban rhythm traced by the telecommunication data. Figure 9-16 and 9-17 show a diagrammatical representation of locative virtual layers based on cell space. For example, various shops around Regent Street can use a few slots amongst 24-hour time calibration within given cell space in order to price for a number of promotion items by a bottom-up approach (like an auction). And at the same time, the shop using a locative virtual programme can promote their items via this scenario. The shops should consider the traffic of target users temporally at the cell space where the shops are located. Users of locative virtual programmes can experience a hybrid shopping in physically and virtually at the same time. Also, this virtual structure can be utilised as complimentary means of physical facilities. After working hours of shops, shopping can be possible via locative virtual layers. If a shop set a virtual shop at a number of temporal slots in locative virtual layer after working hours, users can access a virtual shop juxtaposed with a real shop while users look at real goods through physical show room.

This means that locative virtual space can provide expanded experiences for users in urban space.

- ***Floating Galleries in London***

Within diverse applicable scenarios, we can create 'floating galleries' across the sites. For example, we can create a locative virtual layer expanded from the National Gallery after closing time, hypothetically from 18:00 to 23:00, in the same cell space. When, where and how many people can access the locative virtual layer of the National Gallery can be set depending on an urban rhythm (temporal shifts of people traffic), the radius of cell space and telecommunication capacity (the limited number of active users) within the cell space. Locative virtual layers of the National Gallery are represented as a yellow curved surface (Figure 9-22 and 9-23).

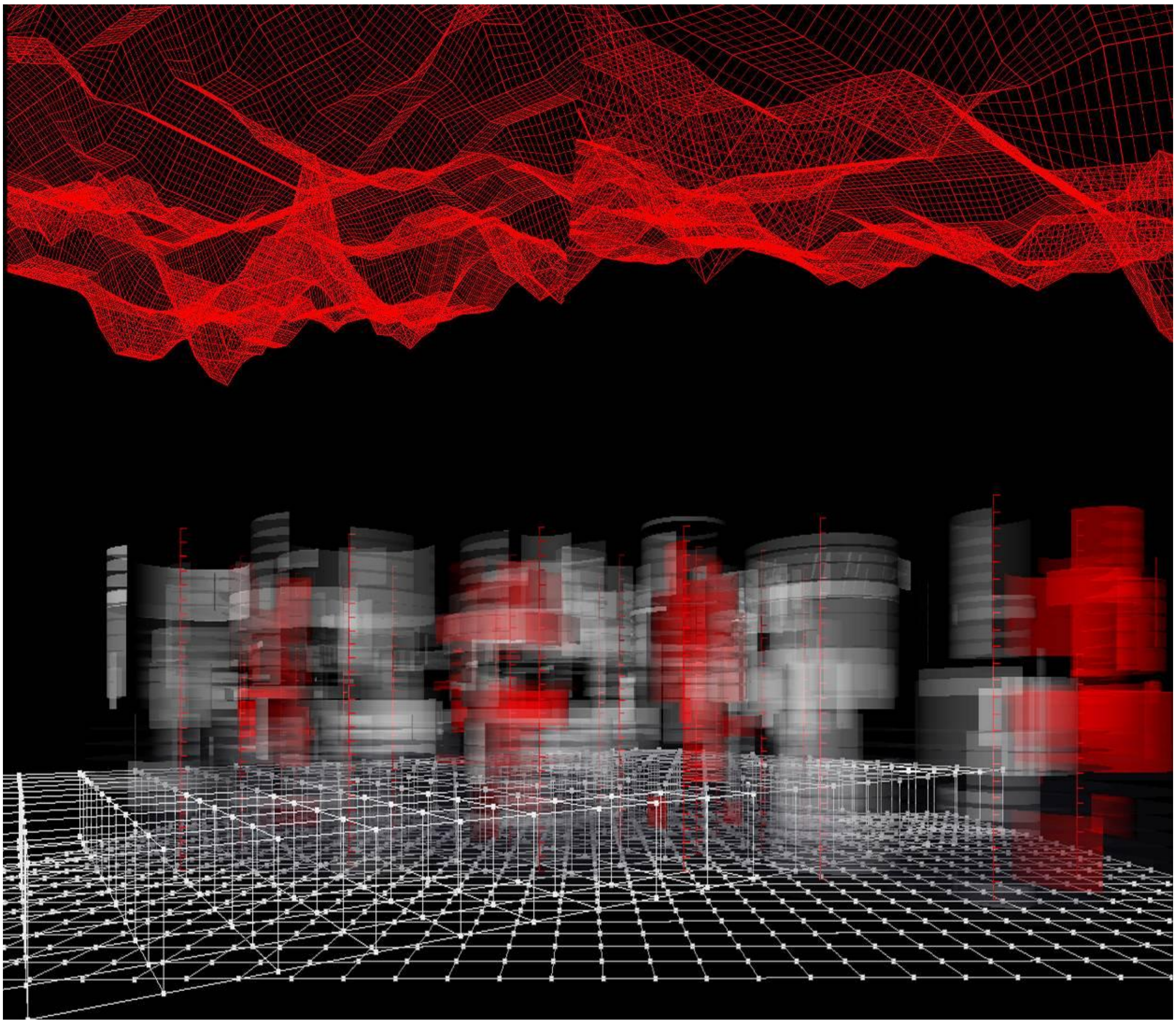

Figure 9- 19. A diagrammatical presentation of locative virtual layers superimposed on hourly calibrated cell spaces reflecting the existing architectural programmes

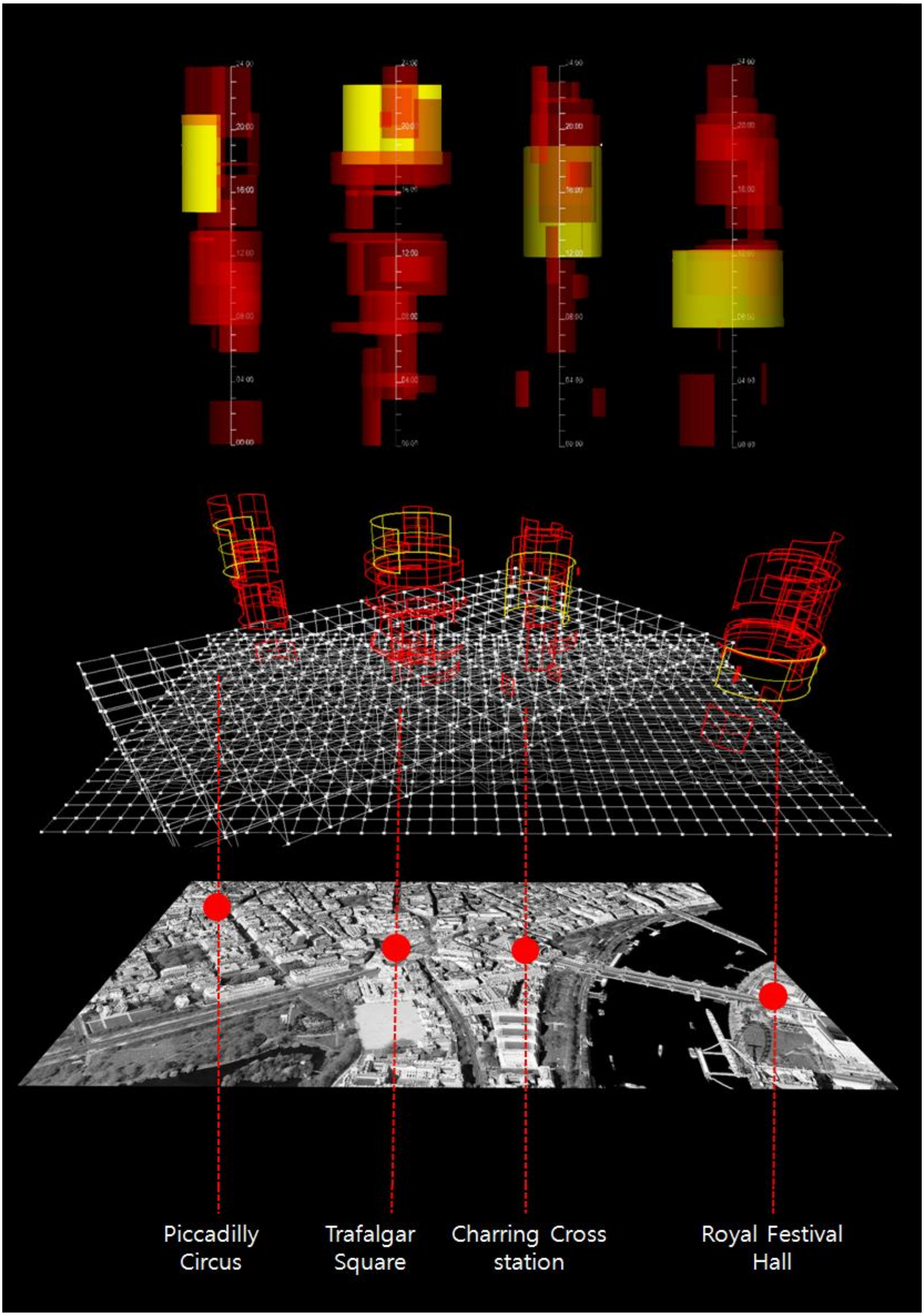


Figure 9- 20. Floating galleries over the West end of London (yellow curved parts)

Users in the National Gallery cell space can have access to the virtual gallery via their digital communication devices at the cell space during the time planned by urban rhythm. Also, the number of users of the virtual gallery is limited by telecommunication capacity in the cell space. Specific information considering urban rhythm traced by telecommunication data in the urban context can enable curatorial exhibitions specialised for a certain user group. One can plan similar initiatives for other galleries or areas nearby, such as Piccadilly Circus, Charing Cross Station or the Southbank Centre (Figure 9-20). The locative virtual galleries can be planned depending on architectural programmes and live urban contexts in the appropriate cell spaces. Curatorial contents and activation times can be planned by the urban rhythm (Figure 9-20). This floating gallery scenario can offer hybridized spatial experience in both physical and virtual space. What and how we will experience in this scenario will be specifically demonstrated in the next sub-section.

### *9.3.2. Digital Heterotopias: What will we experience?*

What will we experience in this virtual structure? We can detect locative virtual layers in augmented reality through mobile devices. As we can see in Figure 9-21, the layers can be detected like a structure over urban space. Individual curved pieces of this virtual structure symbolise locative virtual programmes that are extended from space programmes in the built environment. As previously demonstrated, time scale is in the centre of virtual structure reflecting live traffic.

Locative virtual layers (Figure 9-21) are basically a mirror domain reflecting complementary programmes extended from space programmes of buildings within cell spaces. For users, the complex of locative virtual layers is informative ground as if it were a portal site based on time and location. Also, public facilities such as museum can use it as affiliate spaces to expand their programmes and to deliver more customised service to users. For retailers, it is market place where promotion programes are based on time and location.

- Informative ground for users
- Affiliative ground for directors or planners of public facilities
- Market place for commercial sectors

More specifically, Figure 9-21 demonstrates a four hour programme representing a Trafalgar Square Book Show taking place before noon in locative virtual layers. If the Book Show event is opened at 12pm in Trafalgar square, organisers can use this virtual layer as a promotion tool reflecting target demography through live digital communication data. Geo-demography can reveal where the most effective time slots for the organisers are. On-site ticket sales can be programmed using information transmitted electronically from the bottom upwards. A limited number of virtual tickets selling on site and accessing via locative virtual layers can be priced by users of the virtual layer. Thus, locative virtual layers can be utilised in both ways of top-down and bottom-up.


Figure 9- 21. Locative Virtual Layer juxtaposed with urban physical space

- ***Value scenario***

*When One focuses on a locative virtual layer related to a museum, the layers can be used during a number of situations (Figure 9-22). When One arrives at the museum after opening hours, or is confronted with a long queue, One can access museum programmes via virtual layers (Figure 9-22, A and B). When people go to the museum, they expect to view exhibitions. If they cannot enter the museum because of opening hours and limited capacity due to a long queue, the mirrored museum on locative virtual layers can deliver the museum experience via augmented reality. Although the exhibition can be browsed via the Internet, special experiences based on location will be achieved through different means. Locative virtual layers can be substituted for the real museum for people who cannot access the museum due to the limited time and space of the venue. Through virtual layers, the museum can provide customised service for audiences (Figure 9-22, C). Virtual layers are generated along with timelines (Figure 9-23. Bottom) and users of certain facilities can vary depending on time variation. For example, as One can see at Figure 9-25, C, users at 10.00am and 3.00pm can be different. For this situation, One can put children-related programmes at 10.00pm and adult-related programmes at 3.00pm without any physical building extension. In this mechanism, if museum-related virtual layers can be intervened at other structures of locative virtual layers that reflect live traffic of the location, the museum can generate a number of affiliate museums in urban space (Figure 9-22, D).*

*One can detect a structure of locative virtual layers via digital mobile device (Figure 9-23), and then select a museum layer. One can then choose an informative piece after browsing the whole structure of locative virtual layers (Figure 9-24). Through this, the user can enter a virtual gallery layer. From this point, a virtual programme unfolds diversely: various plans for the exhibition of gallery collections are contained within a virtual layer (Figure 9-25, 9-26); individual layers can guide different kinds of curatorial programmes (Figure 9-25, 9-26 and 9-27; and different curatorial programmes can guide users to different kinds of spatial experience. One such curatorial programme brings the user inside The National Gallery as if they were actually in attendance (Figure 9-31). Users are not in the National Gallery, but are likely to be somewhere inside a wider cell space of which the institution takes part.*

*All the same mechanisms of scenarios are applied to augmented structures in the Piccadilly, Charring cross station and South bank. Ultimately, the scenario of floating galleries is generated.*

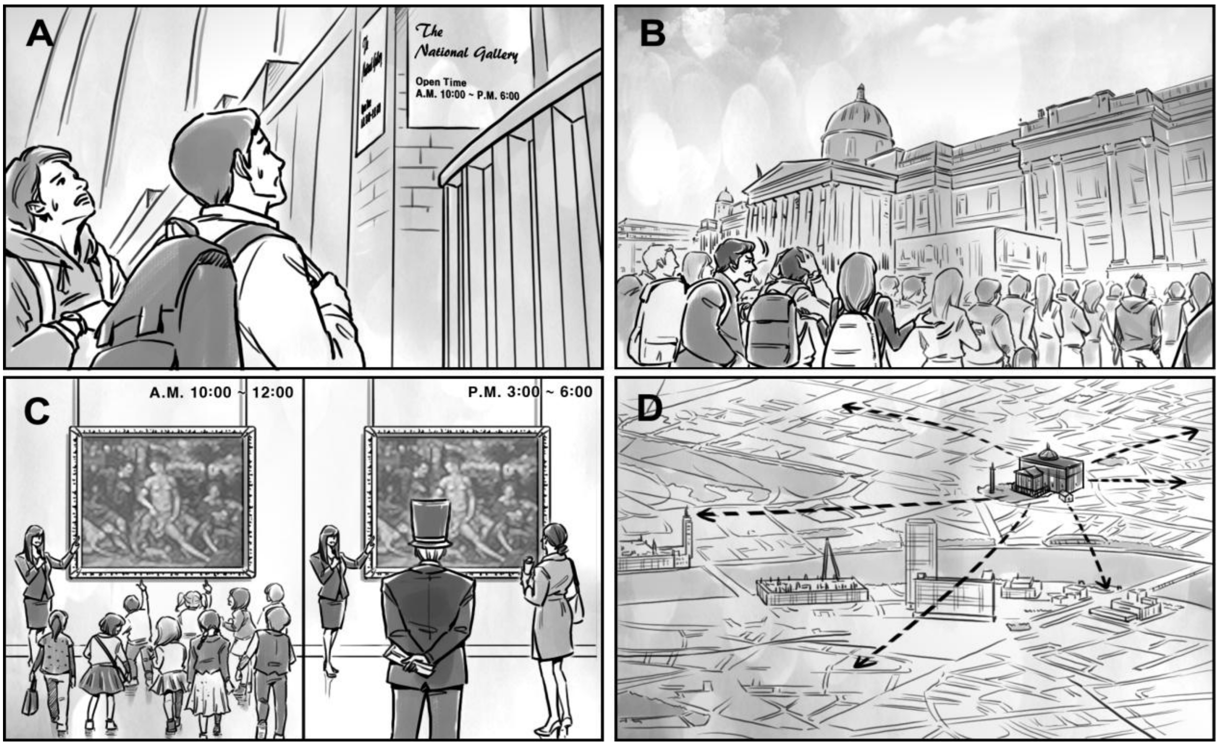

Figure 9- 22. Museum-related situations needed for Locative virtual layers

- ***Discussion***

Diverse direct ‘stakeholders’ seek information in urban space via locative virtual layers, such as curators, restaurant owners, event planners, and museum visitors. Indirect stakeholders do not utilise this program in urban space, but perhaps are isolated from the opportunity of information acquisition, although they are in the same area. ‘Systemic effects’ spread, ranging from locative technology to urban culture, with the information structure of locative virtual layers (‘pervasiveness’).

The floating galleries are programmatically flexible virtual layers activated by telecommunication. These virtual layers embedding architectural programmes can reflect diverse activities in urban space in real time, which can expand existing architectural programmes through technological intervention: the creation of a programmable city thus becomes possible (‘value implementation’).

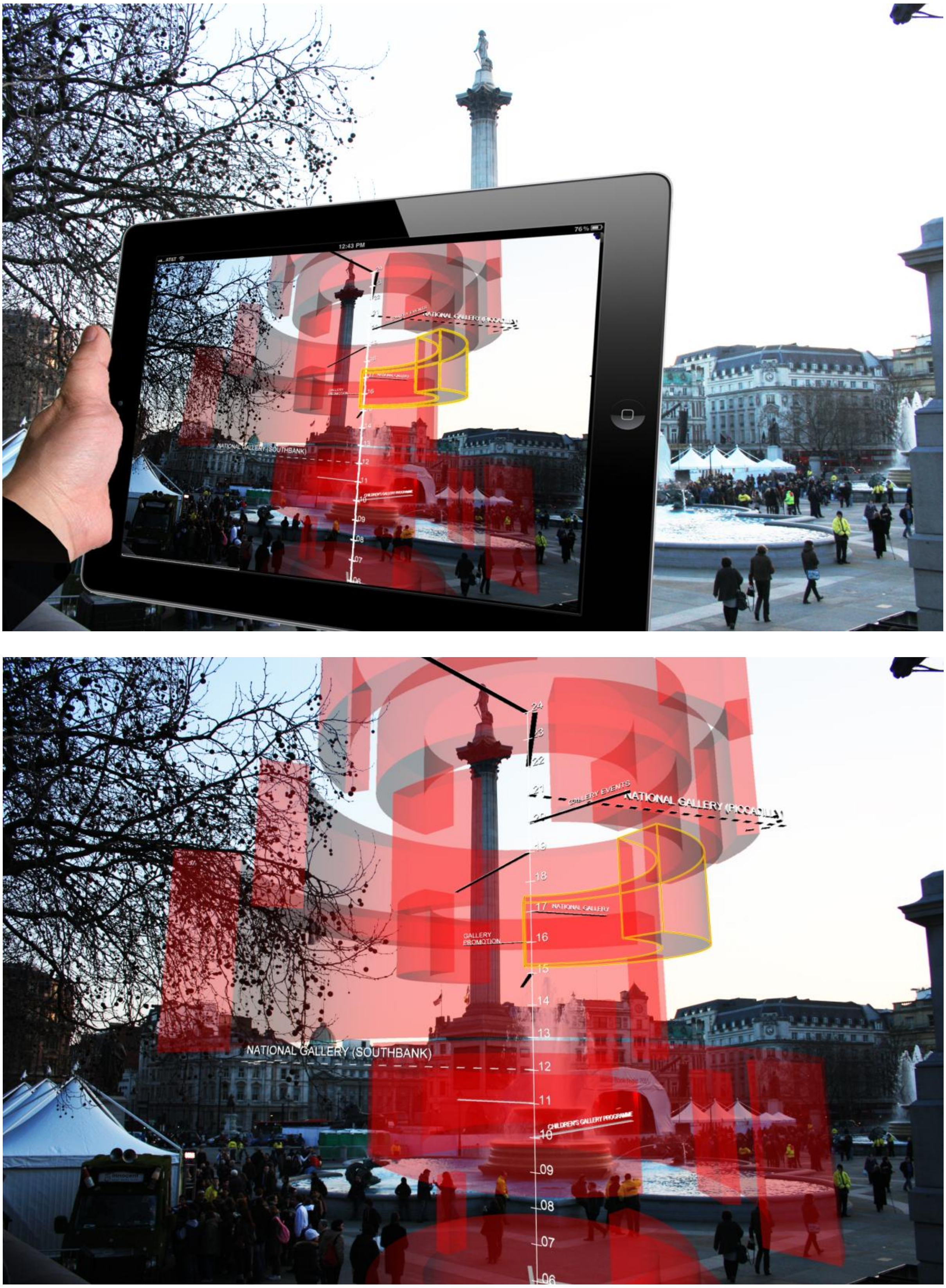


Figure 9- 23. Detected locative virtual layers (Augmented reality): One can detect locative virtual structure via a mobile telecommunication device. Locative virtual layers in Trafalgar square and floating gallery via yellow lined part (upper) and detail (bottom).

Figure 9- 24. Select the layer of gallery programme

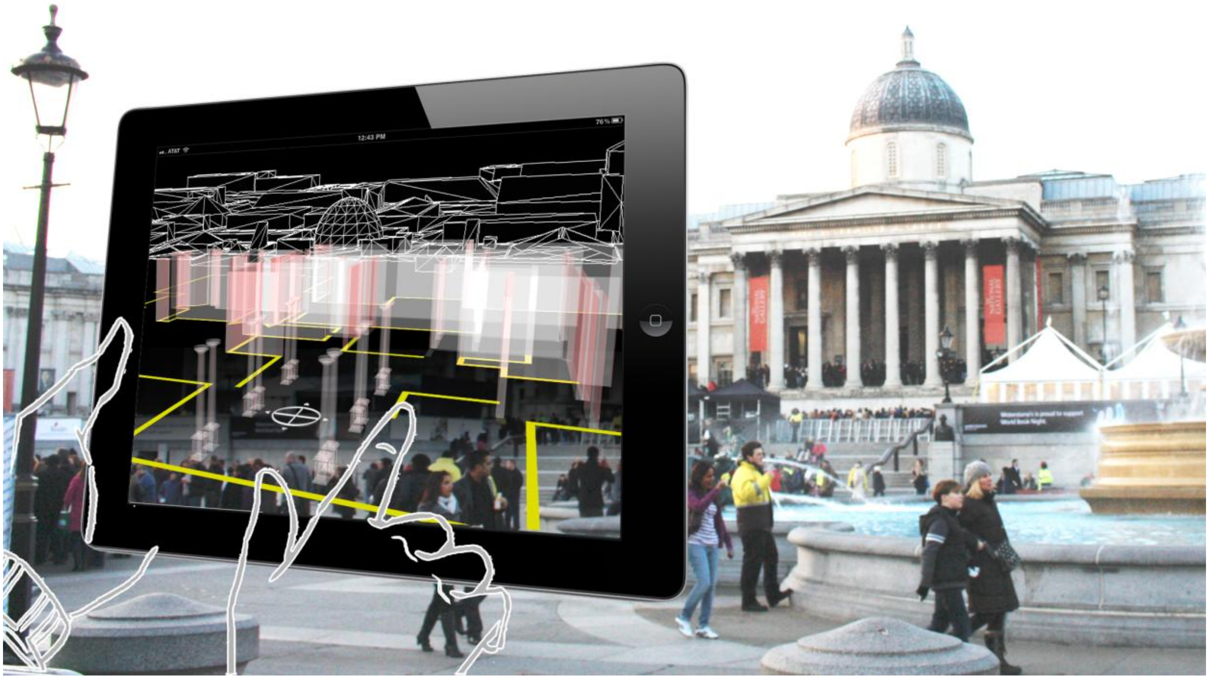

Figure 9- 25. Inside of virtual layer (Parade of Info: exhibition contents):

Figure 9- 26. . Zoom in to the gallery: Selected virtual layer is juxtaposed with the building related to a virtual programme in the virtual layer.


Figure 9- 27. Select a gallery programme (Google virtual gallery[19])


Figure 9- 28. Locative virtual layers in Piccadilly circus and floating gallery via yellow lined part (upper) and detail (bottom)

Figure 9- 29. We can access a floating gallery in Piccadilly circus via one of virtual layers

Figure 9- 30. We can browse art pieces via the virtual layer

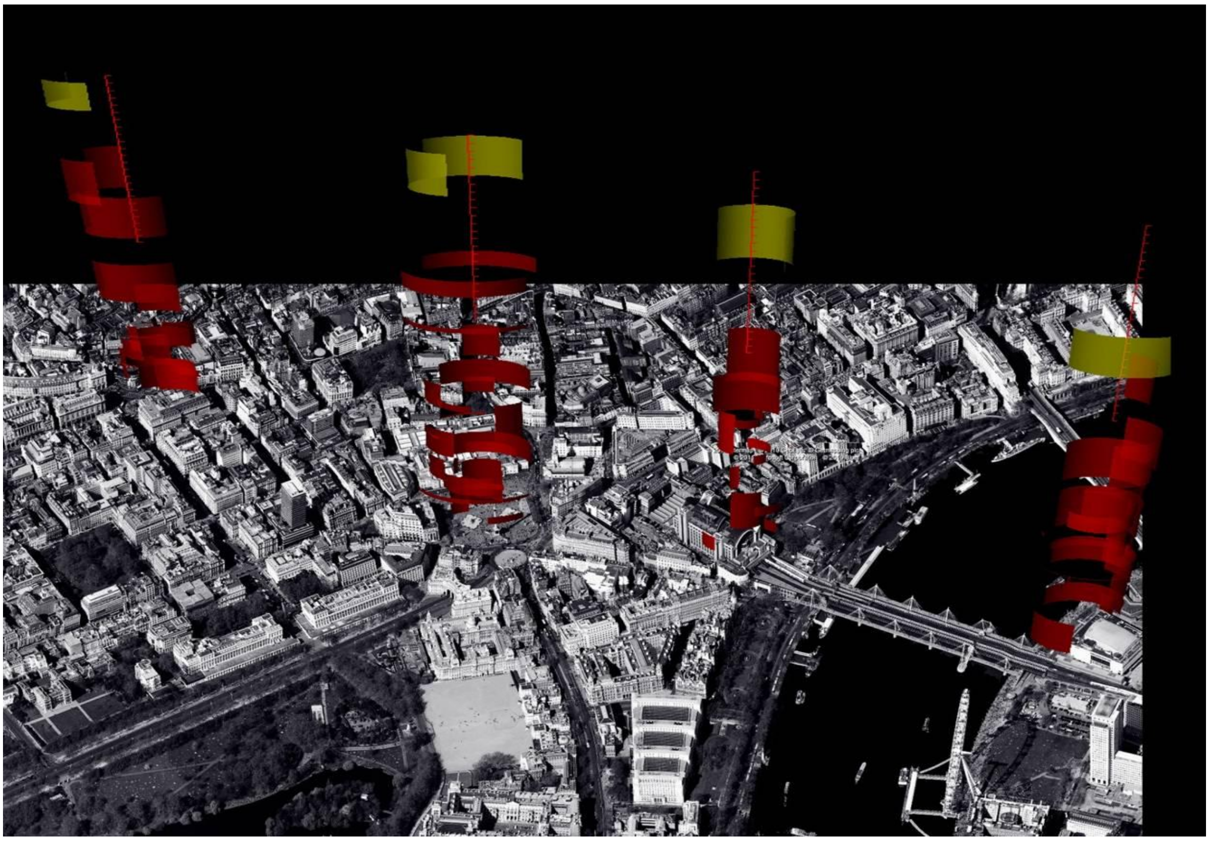

Figure 9- 31. Locative virtual galleries over the National Gallery, Piccadilly Circus, Charing Cross station and the Southbank Centre

### *9.3.3. Toward a Programmable City*

In this applicable scenario, design factors for locative interaction are reflected as the adoption of vertical axis with time including live data and a structure of locative virtual layers. Vertical axis of locative virtual structure within a cell space (temporal calibration of cell space) is used as an indicator to apply live data variation to virtual programmes, which is time. Programmes in locative virtual layers are generated from space programmes of facilities within cell space. Digital intervention specifies our heterotopic spatial experience via layering of virtual programmes linked with space programmes in urban space. In this locative virtual structure, diverse virtual programmes will be released based on geo-demographic information. This gives us more opportunity of individually tailored spatial experience. This means that the more flexible space programmes are, the more chances of customized spatial experience we have. All these design factors (Table 9-2) are materialised in a mechanism of locative virtual structure and its scenario. If this scenario is realised, locative interaction will increase and then our spatial experience will be expanded.

| Design Intervention | Design factors | Reflection |
|---|---|---|
| Urban Rhythm | Temporal-spatial coordinate | Vertical axis of locative virtual structure within a cell space is time used as an indicator to apply live data variation to virtual programmes |
| | Live Data | Applying live data to virtual programmes |
| Locative Virtual Layer | Mirroring | Programmes in locative virtual layers are reflected from space programmes of facilities within cell space |
| | Layering | Digital intervention make us enable our heterotopic spatial experience |

Table 9- 2. Applying design interventions: Floating galleries

The floating galleries are programmatically flexible virtual layers activated by telecommunication. These virtual layers embed architectural programmes and can reflect diverse activities in an urban space in real time. This capability can expand the existing architectural programmes via technological intervention. Furthermore, the digital spatiality interpreted as an architectural rhetoric (particularly Figure 9-21 and 9-23 ) can be utilised as if it were an architectural structure. The cylindrical structures of cell space sliced according to time (Figure 8-2) can be planned with architectural programmes that complement the existing programmes endowed in the built environment. This ultimately means that one can have a programmable structure (locative virtual layers) over respective buildings or urban settings or squares.

## 9.4. Summary

As applicable scenarios, heterotopia finders and floating galleries in London were suggested as particularly apt models for demonstrating the argument for inbuilt programmatic flexibility for locative interaction in urban space.

The heterotopia finder was created to reflect hypothetical user layers and live urban space, combining locative virtual layers and live urban contexts. This displays the concept of locative interaction in live urban space, which guides us to heterotopias in rhythmic urban space and expands our spatial experiences.

The Floating Galleries in London were designed to provide another applicable scenario. The hypothetical plan of cell spaces can be superimposed atop London's West End using an orthogonal grid of the urban structure. Through an architectonically interpreted digital presence based on cell space, we can create these galleries over sites where virtual programmes are expanded from the existing architectural programmes. The floating galleries are then programmatically flexible virtual layers activated by telecommunication. These virtual layers embedding architectural programmes can thus reflect diverse activities in urban space in real time, which can expand the existing architectural programmes by technological intervention, and the creation of a programmable city becomes possible.

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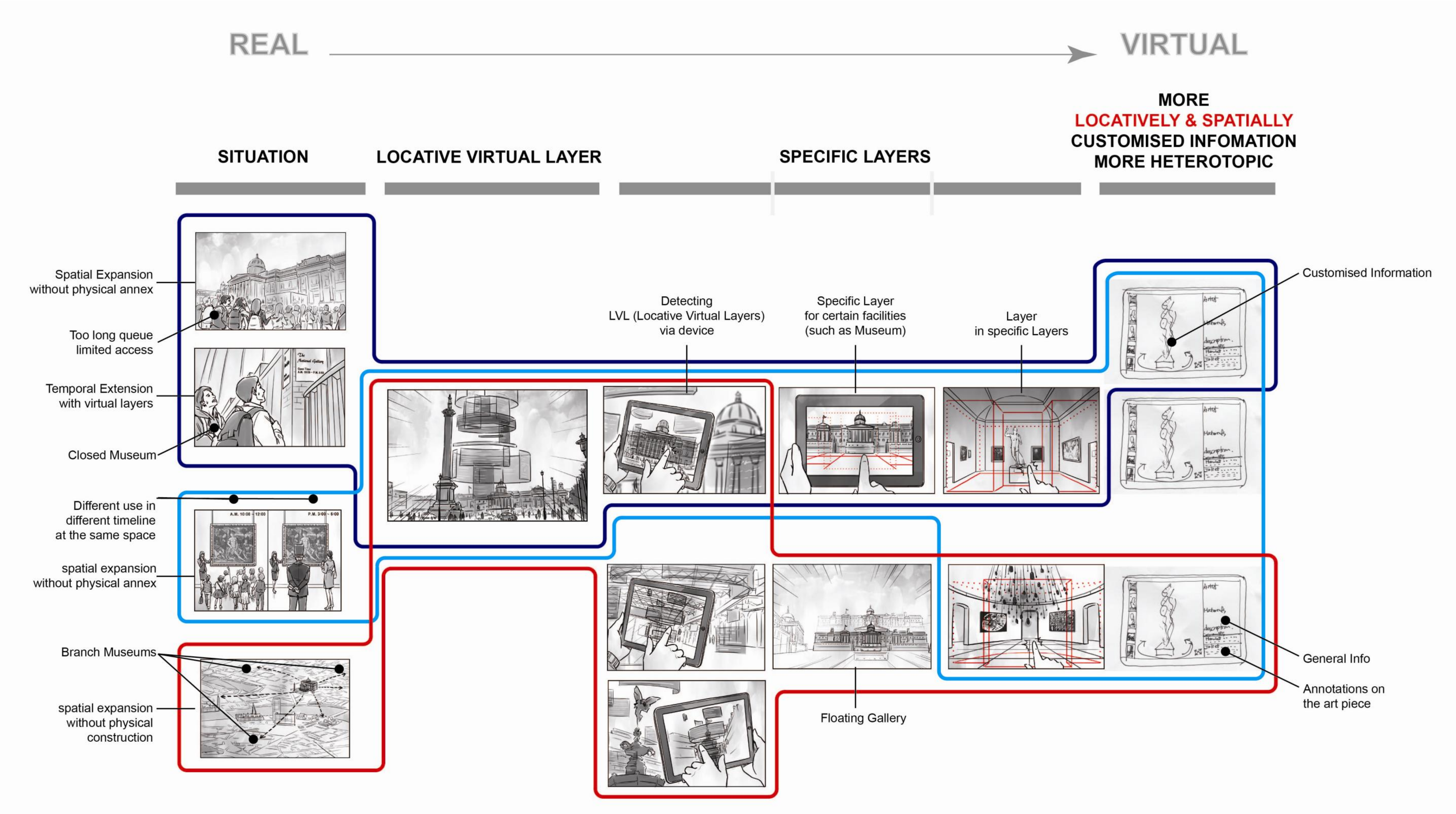


Figure 9- 32. A story board for Programmable City as well as Floating Gallery

Chapter 10
# CONCLUSION

## 10.1. Summary

This thesis proposes a concept of locative interactions: programmatic flexibility to expand our spatial experience in urban space with the research question:

**How can we expand spatial experience via locative interaction in urban space?**

The positions and context of this research imply the methodology (rhythm analyses), the structural outline of possible outcomes (heterotopia: other space) and the character of the data (a digital intervention detecting people's live movement in urban space).

Research sub-questions were articulated with relation to the production of space (experience, perception and imagination):

- **i.** How are the temporal and spatial patterns of urban activities traced by telecommunication data?
- **ii.** What is the correlation between urban activity and architectural programmes on site?
- **iii.** How can a design project synthesize urban rhythm and heterotopias?
- **iv.** What is the concept of locative interaction that expands spatial experience and its applicable scenarios?

Methodologies (data visualisation, observation and epistemic design) were adopted to decode the meaning of telecommunication data as a significant indicator to expand spatial experience for better communication and information acquisition.

- ***A study for sub-question i: the temporal and spatial patterns of urban activities***

Telecommunication data was collected in the form of mobile phone calls from cell spaces covered by the radius of base stations in central Seoul. The calls made by people can be interpreted as the number of people activeness at a certain time and location. In particular, the calls can be considered as the representation of the communicative willingness of the persons who made mobile calls in a certain urban situation (time and location). This is a manner in which to analyse patterns of urban telecommunication (locative interaction).

It is evident that traces of telecommunication reveal the temporal rhythm of everyday life as well as the relationship between this everyday rhythm and spatial occupancy. Furthermore, the study of telecommunication patterns in individual unit spaces created by base stations show ‘temporal digital footprints’.

Visualised data maps reveal the temporal attributes of urban space as a number of patterns: singular-use space, intensive-use space, and mixed-use space. Time-based visualised maps deliver truly situational information of an urban space. This kind of spatial information exists beyond typical geographical information based on a static built environment; it is more indicative of a spatial experience.

- ***A study for sub-question ii: the correlation between urban activity and architectural programmes on site***

Using physical observation, heterotopic spaces were indicated in live urban space across diverse spatial layers. Telecommunication data can play a role in offering a diagnostic reagent to find our own heterotopias if the data visualised maps are contextually interpreted considering spatiality and temporality in urban space. Technology such as telecommunication can intervene to give programmatic flexibility, which can bridge the gap between architectural programmes and heterotopic attributes of spatial experience.

- ***A study for sub-question iii: synthesizing urban rhythm and heterotopias***

The epistemic design project demonstrated how telecommunication data was tangibly mapped as a stereoscopic LED installation. In the installation, the data contours (as dependant on time variations) reveal the spatial rhythm of urban space and public heterotopias. This installation is a collective representation of telecommunication behaviours and locative interaction. Rhythmical heterotopic layers were demonstrated as immaterialised terrains temporally layering and mirroring the urban space where lived experience takes place. This shows a possible structure of programmatic flexibility that can expand spatial experience and enhance locative interaction.

- ***A study for sub-question iv: the concept of locative interaction that expands spatial experience***

Discourses developed regarding telecommunication data mapping as a digital intervention in live urban space, urban rhythm and locative virtual layers are suggested as concepts indicative of locative interaction reflecting live urban space for expanding spatial experience. Locative interaction can affect spatial experience as a live context, thus mirroring locative interaction in urban space.

The consideration of urban rhythm should be considered in the concept. 'Urban rhythm' is related to 'relative time' in urban space rather than 'chronological time'. The rhythm recognised by data variations will help in the application of time-specific programmes, both of telecommunication services and of urban design, depending on cell spaces.

'Locative virtual layers' in this research can be generated as a counter-site, mirroring our memory of the built environment. More specifically, although we are in the same urban space, our own spatial experience can vary. We tend to generate our own maps to reflect daily spatial experiences. These maps can exist as layers juxtaposed with urban maps that reflect the static built environment.

- ***Application scenarios I: Heterotopia Finder***

Heterotopia finder was designed to provide an applicable scenario for this research. It does so by reflecting hypothetical user layers in a live urban space. Urban rhythm suggested as design intervention for programmatic flexibility is specified in this design project as user layers. User layers are created by spatial experience at a certain time and a certain location reflecting live data of digital communication. Locative virtual layer embodying 'mirroring' and 'layering' is reflected to a structure of this project (heterotopia finder). The map of combining customised user layers and live urban context that guides us to heterotopias in rhythmic urban space, and expands spatial experience.

- ***Application scenarios II: Floating Gallery in London***

A second applicable scenario was provided in the form of 'floating galleries' in London's West End. These were designed to demonstrate the urban application of programmatic flexibility by urban rhythm and locative virtual layers. The hypothetical plan of cell spaces can be superimposed on the orthogonal grid of urban structure. By architectonically interpreting digital presence based on cell space, we can create 'floating galleries' over the site where virtual programmes are expanded from the existing architectural programmes. The floating galleries are programmatically flexible virtual layers activated by telecommunication. These virtual layers embed architectural programmes and can reflect diverse activities in urban space in real time, which can be expanded beyond the existing architectural programmes. Such planning can yield a programmable city wherein spatial experience can be expanded by adopting better locative interaction.

## 10.2. Contribution

Firstly, this research contributes a new way of perceiving the world via mapping telecommunication data onto a live urban space. This research isolates undiscovered realms of spatial experience beyond visible and tangible interactions between people and the built environment. Telecommunication data and its patterns juxtaposed with urban space can be visualised and utilised as a catalyst for locative interaction.

Secondly, this holistic approach, which considers interwoven telecommunication contexts in the city- space, enhances an understanding of the interaction between people and the built environment through providing an informative and holistic structure of architecture and urban design. This shows the possibilities of digitalised expansion of the extant urban space through complementing architectural programmes via locative virtual layers (without physical constructions).

Lastly, this research ultimately contributes to enhancing ways of information acquisition and communication in urban space through a new way of spatial experiences. This research provides applicable scenarios of communication and information technology in urban scale through locative interaction through which physical and digital realms are interwoven.

## 10.3. Limitations and Future Work

- ***Limitations of Data***

Although numerous kinds of data are generated in contemporary digital life, this research collected telecommunication data from cell spaces of base stations in Seoul. These sources yielded limited information regarding locative interaction because of the nature of telecommunication in relation to privacy and accessibility difficulties. An attempt was made to overcome this limitation using data interpretation tactics such as physical observation, which juxtaposed numerical results with qualitative research.

- ***Weighting of User Layers***

Locative virtual layers are the key mechanism in the concept of locative interaction as a reflection of live urban space. These layers are reflected in the creation of the heterotopia finder (applicable scenario I). Although the heterotopia finder shows an applicable scenario for the concept of locative virtual layers, the way of combining user layers and live telecommunication traffic should be developed further. It is suggested that this could be approached from a sociological viewpoint.

- ***Future Project: Urban Interface***

If one can access diverse kinds of telecommunication data, this concept could be developed as a feasible programme providing innovative locative information maps for spatial experiences. Also, different kinds of telecommunication data can reveal a diverse range of characteristics of urban space and access spatial depths, which have been indicated in the digital adaptation of architecture.

The current interface is confined to the small screen of mobile devices. It is akin to viewing information through the window of a small screen; this information is intangible and invisible without digital communication devices. We are mining for information and communicating through the limited size of these interfaces.

By interweaving the urban rhythm and mirror space (locative virtual layers), this research suggests that our built environment becomes an interface for communication and information; this could be the matrix of temporal and spatial contexts of urban telecommunication.

In fact, our built environment is a kind of synthetic visualisation of collective knowledge. It can be utilised as the wisest category (repository) of information regarding our daily life as it exists in the built environment. By adding a digitally-informative virtual layer to the urban structure, the matrix of rhythm and mirrored space, we can achieve highly locative and ubiquitous interactions.

# APPENDICES

The observational factors focused on are how many pedestrians there are, what kind of urban events there are, and what kind of building uses (Physical built Environment) there are.

- ***Weekday***

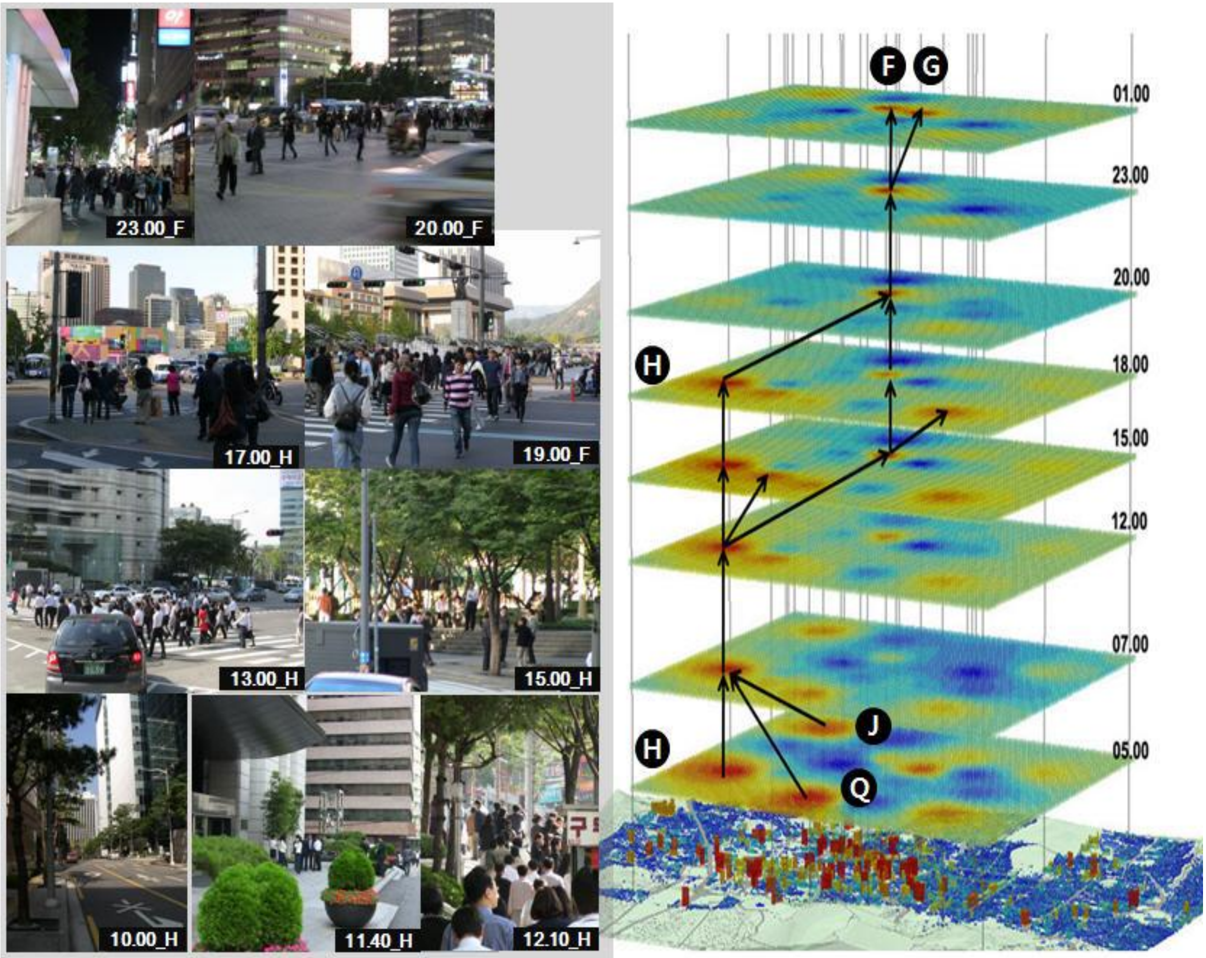


Figure A. Scenes observed by temporal trajectory on a weekday and the interview points

**7:00 – 17:00 (H: Sunhaw-dong)**

This was conducted in the last week of September, 2009. Most interviewees tended to use a landline in their company rather than their own mobile phone during working hours. However, they made mobile phone calls for a private appointment or for asking or letting their family know where they are or will go after work.

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for (A) calls |
|---|---|---|---|---|---|
| J. Lee | M, 32 | 9:00 – 18:00 9hours | 0 | 9 | |
| S.W. Ahn | M, 31 | 9:00 – 18:00 9hours | 5 | 6 | Private matter |
| J.J. Lee | M, 27 | 9:00 – 18:00 9hours | 1 | 5 | |
| S.I. Moon | M, 33 | 9:00 – 18:00 9hours | 3 | 3 | |
| G.J. Lee * | M, 26 | 9:00 – 18:00 9hours | 6 | 9 | |
| H.C. Kim * | M, 57 | Random | | | |

(A): Number of phone calls made while staying this area
(B): Average number of phone calls made during the day before this interview

# Case1: G.J. Lee

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 | | | | 1 | 2 | | | | | | 2 | | | | 1 | 2 |

He is in his 20s, working in a software development company in cell E. Whenever he has a break, he tries to contact his girlfriend. Most calls on record were to her. When commuting, he nearly always make a phone call to her.

# Case2: H.C. Kim

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 2 | 1 | | | 3 | | | | | | 2 | 1 | | | | | |

He is a taxi driver visiting this area frequently (E). Generally, he tends to make about 10 calls a day. Most calls were made to colleagues and family. He told me that he always tries to use a landline rather than mobile, because of the charges.

**12:30 – 15:00 Q (Jungang)**

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for (A) calls |
|---|---|---|---|---|---|
| S.J. Kim * | F, 29 | 9:00 – 18:00 9hours | 0 | 1 | |
| B.R. Kang | F, 27 | 9:00 – 18:00 9hours | 2 | 7 | Private matter |

(A): Number of phone calls made while staying this area
(B): Average number of phone calls made during the day before this interview

# Case3: S.J. Kim

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | | 1 | | | | | |

She works as a secretary in a small company. She used her mobile once. She usually tends not to make phone calls on weekdays. Instead, she uses a landline in her workplace. The only call was to let her mother know where she was and when she would arrive home.

**17:00 – 20:00 F (Seolin-dong)**

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for (A) calls |
|---|---|---|---|---|---|
| K.H. Kim * | F, 40s | 8:00 – 20:00 8hours | 10 | 1 | |
| Y. S. Lee * | M, 30s | 9:00 – 10:00 | 7 | 10 | Business, family, friends |
| E. Y. Lee * | F, 40s | 8:00 – 10:00 | 18 | 21 | Business, family |
| J.M. Lee | F, 13 | 16:00 – 19:00 | 6 | 16 | family, friends |
| S.K. Bae | F, 14 | 16:00 – 19:00 | 6 | 9 | family, friends |

(A): Number of phone calls made while staying this area
(B): Average number of phone calls made during the day before this interview

# Case4: K.H. Kim

<table>
<tr><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td></tr>
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</table>

She is trying to find a job and spends her time studying in a language class in cell F. She made the first two calls of the day to find out where her friend was after arriving at the class and studying, before 8 AM. The second call was made to her family at 3 PM, then one call to a friend, before 4 calls to her family. From time to time, she tends to use her mobile despite being at home because it makes it easier to move about doing household chores while taking a call.

# Case5: Y. S. Lee

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 1 | | | | 1 | | 1 | 1 | 1 | 1 | | | 2 | | |

He is a salesman for a major property development company. He tends to use both landline and his mobile phone for customer management during working hours.

# Case6: E. Y. Lee

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 6 | 1 | | 2 | | 2 | 3 | 2 | 2 | | | | | | |

She is a saleswoman for an insurance company. This cell area is the main area for her sales, as there are many large and small companies where a substantial number of younger office workers are sited.

- ***Saturdays***

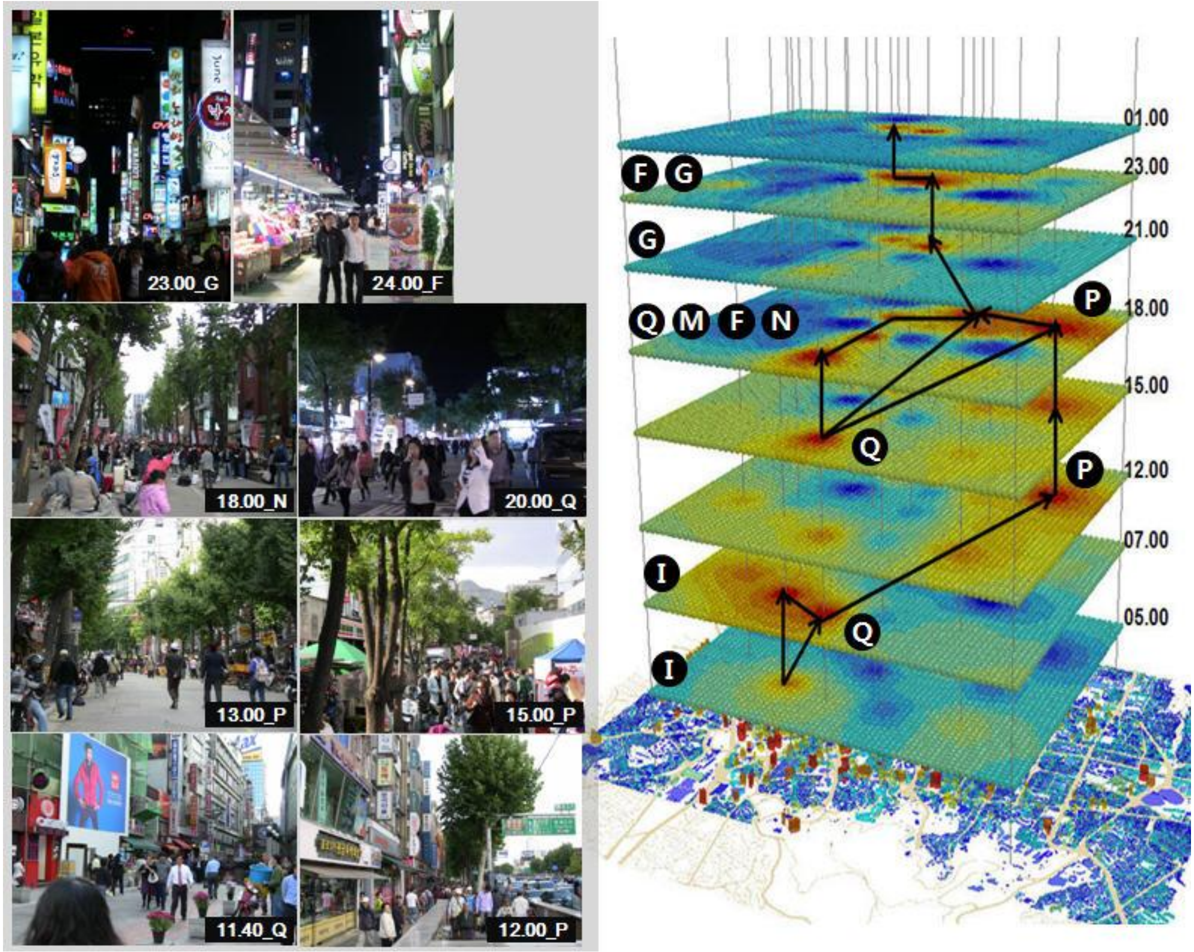


Figure B. Scenes observed by temporal trajectory on a Saturday and the interview points

**18:00 N (Insa-dong)**

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for(A) calls |
|---|---|---|---|---|---|
| Y.J. Lee | F, 28 | 14:00 – 20:00 6hours | 3 | 15 | Family/friends |
| M. J. Yoon | F, 32 | 12:00 – 16:00 4hours | 4 | 17 | Family/friends |
| S.C. Kim | M, 26 | 15:00 – 22:00 7hours | 7 | 25 | Family(1)/friends(2) |
| J.Y. Lee | F, 19 | 15:00 – 22:00 7hours | 0 | 5 | |
| E.Y. Cha* | F, 43 | 11:00 – 19:00 8hours | 7 | 22 | Work |

(A): Number of phone calls made while staying this area
(B): Average number of phone calls made during the day before this interview

# Case7: E.Y. Cha

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 3 | | 1 | | | 2 | | 3 | 1 | | 3 | | 2 | | 2 | |

She is the director of a gallery in Insa-dong (cell space N). Saturdays are the busiest day. Generally, she receives mobile calls rather than makes them.

- ***Sundays***

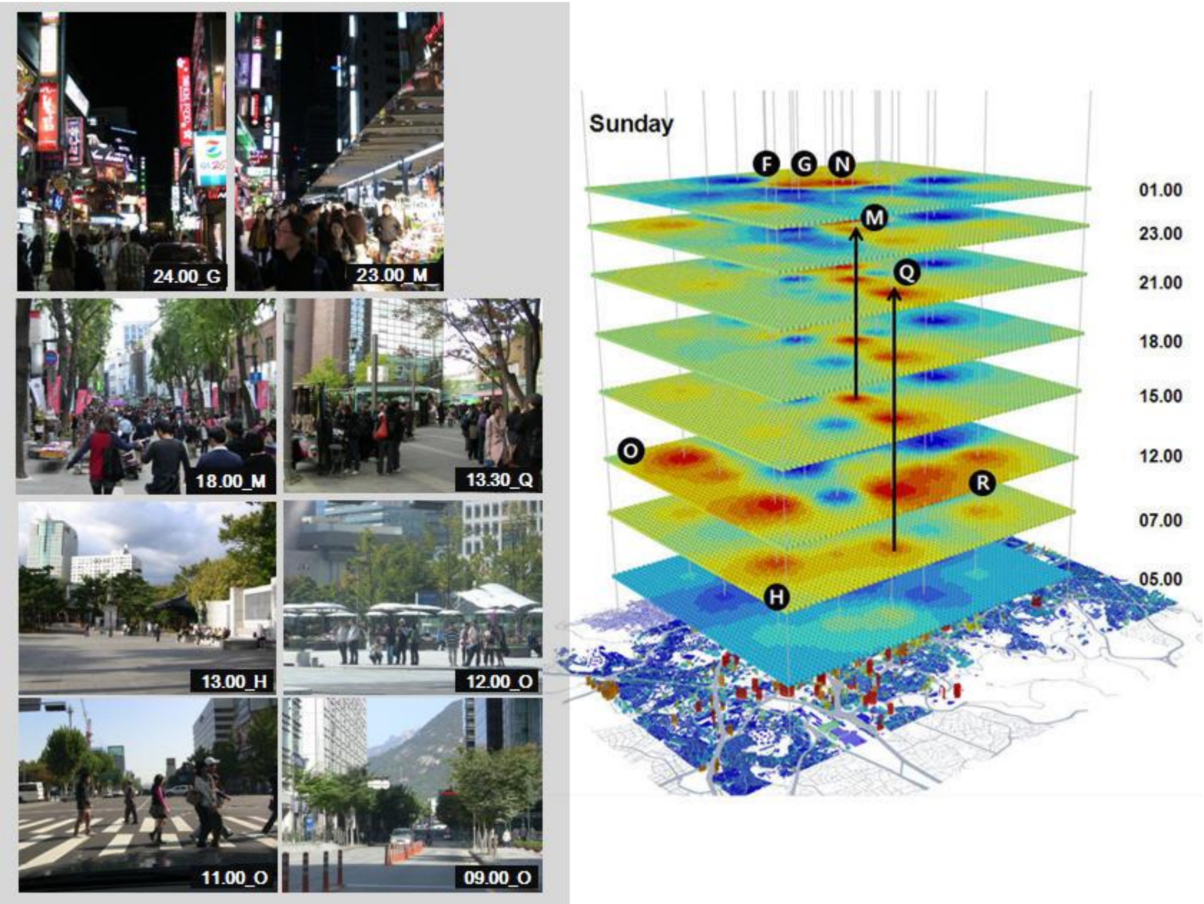


Figure C. Scenes observed by temporal trajectory on a Sunday and the interview points

**9:00 – 11:00 O (Juksun-dong)**

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for(A) calls |
|---|---|---|---|---|---|
| D.J. Park | F, 44 | 10:00 – 13:00 8hours | 0 | 7 | To family |
| J. J. Bae | F, 54 | 09:00 – 11:00 8hours | 1 | 3 | To family |

**12:00 – 21:00 M (Ulgee Ypgu), Q (Jungang)**

| Name of Interviewees | Gender and age | Time of stay in this area | (A) | (B) | The reason for(A) calls |
|---|---|---|---|---|---|
| S.J. Lee | F, 32 | 12:00 – 20:00 8hours | 3 | 15 | To family |
| J. M. Youn | F, 30 | 12:00 – 20:00 8hours | 4 | 17 | To family |
| K.C. Kwon | M, 23 | 15:00 – 22:00 7hours | 3 | 14 | To check where friends are.(2) To family (1) |
| S.Y. Kang | F, 19 | 15:00 – 22:00 7hours | 0 | 7 | |

(A): Number of phone calls made while staying this area
(B): Average number of phone calls made during the day before this interview

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