ABSTRACT

TOKER, Umut. Space for Innovation: Effects of Space on Innovation Processes in Basic Science and Research Settings. (Under the direction of Henry Sanoff, Professor of Architecture.)

In an era of fast-paced technological developments, innovation processes are critical for the evolution of societies through developing new technologies. University research centers are among the settings in which innovation processes take place. The numbers of university research centers and the workspaces provided for them have increased significantly in the second half of twentieth century. Innovation research has indicated that information consumption is the major resource for facilitating innovation. Among various information resources used for information consumption, face-to-face technical consultations are the most important information resources. Research in design disciplines has shown that spatial organization of workspaces can affect human encounters. However, how the spatial organization of workspaces in university research centers influence encounters among researchers and therefore innovation process outcomes have not been studied. This study is an inquiry into the effects of spatial organization on innovation process outcomes.

Within a multiple case study research design, six university research centers were selected to study the relationships between the spaces occupied, information consumption indicators, and innovation process outcomes. An activity log and a follow-up survey were the instruments used for data collection.

The results of the study indicated that the spatial organization of university research centers significantly affected patterns of space use for face-to-face technical consultation, technical consultation networks, information consumption patterns, and innovation process outcomes. Unprogrammed encounters among researchers were the highest utilized type of technical consultations. Configurational accessibility of spaces, shorter walking distances and informal common spaces facilitated unprogrammed encounters among researchers in the six selected university research centers. University research centers that had intact territories with shorter walking
distances had more connective technical consultation networks, in which researchers consulted with more colleagues, and reported more innovation process outcomes. Findings indicated that spatial organization affects face-to-face technical consultations and innovation process outcomes in university research centers, and that planning of these workspaces needs to be based on work processes that facilitate face-to-face technical consultations in order to facilitate innovation.
SPACE FOR INNOVATION: EFFECTS OF SPACE ON INNOVATION PROCESSES IN BASIC SCIENCE AND RESEARCH SETTINGS

by

UMUT TOKER

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APPROVED BY:

______________________________ ______________________________
Professor Henry Sanoff (Chair of Advisory Committee) Dr. Denis O. Gray

______________________________ ______________________________
Dr. Perver K. Baran Dr. Fatih A. Rifki
BIOGRAPHY OF THE AUTHOR

Umut Toker was born in Ankara, Turkey on August 08, 1974. After graduating from high school (T.E.D. Ankara Koleji) in 1992, he received his Bachelor of Architecture degree in 1996 from Middle East Technical University (METU) Department of Architecture in Ankara, Turkey. Later that year, he started pursuing a Master of Science degree in Urban Design Graduate Program at METU, where he served as a research assistant and participated in teaching graduate level urban design studios. In this period, he developed an interest in innovation processes and design implications for science and technology parks. He served as an architect and urban designer in the master planning and architectural design processes for Middle East Technical University Technopolis. After receiving his master’s degree in 1999, he started the PhD in Design Program, Community and Environmental Design Concentration at North Carolina State University (NCSU) College of Design.

During this period, the author developed an interest in architectural programming and user oriented architectural design. In this stage, Umut further developed his interest in innovation processes, and extended his research into spatial organization of university research centers, and its effects on innovation. He served as a research assistant in the College of Design PhD program for three years, and participated in teaching an architectural design studio at NCSU Department of Architecture. In the last year of his PhD education, Umut also served as a research assistant at NCSU Department of Psychology.

Umut Toker is a member of The Honor Society of Phi Kappa Phi and The Honor Society of Tau Sigma Delta in Architecture and Allied Arts. He received a first place student design award in 2001 Environmental Design Research Association (EDRA) 32nd Conference in Edinburgh, Scotland. In the same year, he was also awarded the 2000 – 2001 Architectural Research Centers Consortium (ARCC) King Student Medal For Excellence In Architectural + Environmental Design Research. Umut has a keen interest in historical developments in architecture, technology and music. He intends to continue his research and formal explorations into workspaces for knowledge-based industries.
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CHAPTER 1

INTRODUCTION

We are living in an era of technological developments, in which the development of societies and nations are dependent on innovation. Innovation processes, which are based on knowledge generation in basic science, foster not only technological developments, but also overall life quality of nations (Tornatzky and Fleischer, 1990). Consequently, the efforts to support and accelerate innovation processes are now an integral part of policies of nations, regions, cities, and business organizations (Castells and Hall, 1994; Castells, 1999). The question, however, is how innovation processes can be facilitated so as to nurture technological development.

The image of an individual scientist studying and “innovating” in a laboratory has remained a reflection of the past. Today, it has been realized that innovations are outcomes of processes in which researchers and scientists share an existing stock of knowledge, generate and accumulate new knowledge (Tornatzky and Fleischer, 1990). In this respect, providing increased access to existing knowledge, and accelerating efficient information flow among researchers and scientists have proven to be vital for innovation processes. For this purpose, contemporary innovation research focuses on many factors that affect innovation processes, and has generated a wide body of literature (Tornatzky and Fleischer, 1990; Castells and Hall, 1994). Innovation processes take place in organizations such as university research centers, laboratories, and high technology private firms, all of which are accommodated in workspaces. However, although a wide body of research exists about innovation processes in such settings, their workspaces have not really attracted attention in contemporary innovation research.

Physical space is the mold in which human behavior and encounters take place (Hall, 1966). Research in design disciplines investigates the relationships between human behavior, encounters, and space in a wide array of contexts such as workspaces, schools, houses and urban environments (Rapoport, 2000). Within this body of research, workspaces have formed a major focal point, where issues such as work pattern – workspace relationships have been studied within different work sectors. However, while innovation processes are accommodated within workspaces, and despite the existence of a wide body of research in workspaces, innovation processes, and the spaces within which they take place have not been studied.

This study therefore is an inquiry into the relationship between space and innovation processes. Essentially, it asks the question: how does spatial organization affect the outcomes of innovation processes? Can physical space be a variable in innovation processes?
1.1. INNOVATION AND TECHNOLOGY

In an era of fast-paced technological developments in which the words technology, innovation, knowledge and economy are among the most frequently mentioned, it is undeniable that innovation processes are critical for the evolution of societies. The image of the industrial revolution associated with coal mines, black smoke, and foundries has today transformed into an image of “foundries of knowledge” in buildings of concrete, glass, and steel, which is increasingly becoming common around the world (Castells and Hall, 1994). This is a transformation based on the processes of innovation, which are increasingly becoming more and more important.

Three main factors influence the increasing importance of innovation processes for contemporary societies: standard of living, quality of life, and skills and knowledge. By yielding new technologies, innovation and technological innovation processes increase the productivity of societies, which is eventually translated into a higher standard of living. It is undeniable that innovation and technological innovation processes directly and indirectly affect the quality of people’s lives in contemporary societies. Finally, the skill and knowledge levels in contemporary societies are increased through introduction and deployment of new technologies (Tornatzky and Fleischer, 1990). Evidently, in an “informational economy” where knowledge is the major commodity (Castells and Hall, 1994), understanding the processes of innovation is crucial for the progress of societies (Tornatzky and Fleischer, 1990). Understanding innovation is the reason for the currently extensive and continuously expanding research into the processes of innovation in many disciplines.

Consequently, support and expenditures for innovation and technological innovation processes have been continuously increasing since the second half of the twentieth century. The total amount of national research and development funding increased about 200 times between the years 1953 and 1998 in the United States (National Science Board, 2000). A similar trend has been observed in the international arena. The total amount of research and development expenditures of Canada, France, Germany, Italy, Japan, and the United Kingdom increased about two times from 1982 to 1997 (National Science Board, 2000).

1.2. SPACE AND INNOVATION

Among many settings, innovation processes mostly take place in private firms, government research laboratories, and university research centers (Tornatzky and Fleischer, 1990). While the roles of each of these settings vary, the efforts of universities in facilitating innovation processes have been increasingly important since the second half of the twentieth century. As settings of basic science research, universities have formed research centers, either through collaboration with other universities and organizations, or by their own efforts. In
the United States, the increasing amounts of government support have further helped university research centers to become more productive and larger in number. Consequently, the national research and development performance of universities have exceeded 20 billion dollars as of 2000, a number that has been reached through exponential increases since 1950’s (National Science Board, 2000). Today, university research centers as basic science and research settings form a core of knowledge generation. Therefore, university research centers as hot spots of innovation, are among the key contemporary organizations, which accommodate innovation processes and generate knowledge.

The increase in the number and productivity of university research centers has evidently brought an increasing need for their accommodation. Many of these university research centers (URCs) not only have offices, but also laboratory environments. Therefore, workspaces in these organizations are the places in which these processes take place. However, URC workspaces are quite different from conventional workspaces. The work patterns of URCs cause them to become new workspaces in which information flow, information consumption and an interactive environment are crucial. On the other hand, concerns about the spaces provided for URCs have been very different from providing an interactive environment. Many URCs have special research equipment that specify their handling and location. Consequently, such concerns have dominated space planning decisions for URCs since 1950’s (Watch, 2001; Haines, 1958). Moreover, high amounts of investment have been placed in such spaces due to the costly building techniques necessary for such environments (Watch, 2001). As a result of focusing on laboratory equipment, the work patterns of URCs have been neglected in many organizations. Some URCs discussed in this study form excellent examples of focusing only on laboratory equipment, where researchers of the same URCs have been located as far as 300 feet and several floors within a building. Such examples clearly indicate that considering only laboratory equipment have caused negligence for work patterns of URCs, although information flow, information consumption and an interactive environment for free flow of ideas are crucial for innovation.

Innovation research has indicated that information consumption is the key resource facilitating innovation (Kline and Rosenberg, 1986; Tornatzky and Fleischer, 1990; Castells and Hall, 1994; among others). Among numerous information resources, face-to-face consultations among researchers and scientists remain in the forefront as most efficient and most important information resource (Ancona, 1990; Kanter, 1988; Sonnenwald and Lievrouw, 1996; Allen, 1984). Facilitating information consumption through face-to-face consultation among researchers therefore supports innovation. Extensive environment – behavior research has shown that space affects encounters among humans in various settings (i.e. Hall, 1966; Osmond, 1959; Sommer, 1969; Rapoport, 1982; Hillier and Hanson, 1984; among numerous others). Among these, the effects of space on human encounters have been identified particularly in workspaces (i.e. Bechtel, 1977; Wineman, 1986; Becker and
Therefore, understanding how space can affect face-to-face consultations among researchers and scientists in innovation settings is a major step towards facilitating innovation through information consumption. However, the role of space in innovation processes has not been studied either in innovation research or in environment-behavior studies. Understanding the role of space in innovation processes is of major importance for three reasons:

1. Through utilization of such knowledge, work patterns of the settings in which innovation processes take place can be accommodated in workspaces that can facilitate information consumption and therefore innovation;

2. Products of architecture can be presented to cutting-edge research and development facilities as knowledge-based tools to utilize, and can be effective working tools produced through knowledge generation;

3. Knowledge generated through such spatial research can be a part of the overall effort for facilitating innovation and technological innovation that originates in design fields.

The objective of the current study has been understanding the “effects of space on innovation processes”. Among various settings in which innovation processes take place, basic science and research settings of university research centers have been selected as cases for this study. The effects of space on three information consumption indicators and innovation process outcomes have been studied in six university research centers within a multiple case study research strategy. Findings of the study have indicated that by affecting technical consultation networks, information consumption patterns and patterns of space use for face-to-face technical consultation, space can facilitate information consumption, therefore innovation process outcomes in university research centers.

The following chapter is a review of the existing literature in innovation research and environment-behavior studies, concluding with a conceptual model of space – innovation process outcomes relationships in university research centers. The third chapter introduces the purpose and research questions of the study. Chapter 4 describes the methodology used in the study with discussions of the context, research strategy, criteria for case selection, methods of data collection, and instrumentation. Data collection and data analyses procedures are defined and described in the fifth chapter of the study. Following data analyses procedures, findings of the study are presented in four phases. First, findings of cumulative data analyses are presented as indicators of overall findings. Second, findings from each individual case are presented. Third, repeating patterns of findings across cases are presented and integrated through pattern matching and explanation building strategies. Fourth,
comparisons of individual university research centers are conducted and discussed in terms of their spatial features and the effects of their spatial features on information consumption indicators and innovation process outcomes. The study concludes with a discussion of the findings and their implications, future prospects, and directions for further research.
CHAPTER 2

REVIEW OF PREVIOUS LITERATURE

Innovation processes are accommodated in various built environments such as office and laboratory buildings. Built environments define (contain) space and spatial relationships in which human behavior and encounters take place. Space has to be distinguished from the built environment. While built environment is composed of objects (i.e. buildings), space is defined (contained) by objects. Therefore, the relationships between space and human behavior, encounters and use of space are critical in understanding the influence of space on innovation processes.

2.1. SPACE

Space and its relationships to human behavior, encounters and use of space have been discussed extensively in environment-behavior studies. A review of these studies reveals the fact that human behavior, encounters and use of space can be affected by space and spatial relationships.

Using the term “proxemics”, Hall (1966) has observed human use of space at three levels of analysis: fixed-feature space, semi-fixed feature space and non-fixed feature space. Fixed-feature space is defined by the main building elements – walls, slabs, and so on. Movable or semi-movable objects in space define semi-fixed feature space. Non-fixed feature space is formed by human behavior according to the situation in each context. It is composed of certain boundaries of space maintained by human beings when encountering others. The essence of the idea of proxemics is that, fixed-feature space, semi-fixed feature space and non-fixed feature space co-act to form the visual world of man, which is not only composed of two-dimensional images, but also knowledge of the environment. Therefore, Hall (1966) proposes the idea that fixed-feature space, semi-fixed feature space and non-fixed feature space affect human behavior, encounters and space use through forming his / her visual world, and inducing responses. Hall’s (1966) proxemics framework has been effective in conceptualizing space and investigating its relationships to human behavior. Further research within environment – behavior research has built on one or more of the three levels of space – society relationships introduced by Hall’s proxemic framework.

2.1.1. Space and Society: Fixed-feature and Semi-fixed Feature Space

Based on observations of human use of space and encounters, Rapoport (1982) has argued that the built environment and space provides cues to people about what behavior is expected from them according to the context. The author has termed this the “nonverbal communication” of the built environment, and has
analyzed it according to the categorization introduced by Hall (1966). According to Rapoport, depending on how homogeneous a culture is (i.e. the presence of widely accepted rules, strong hierarchies), the cues communicated by the built environment through nonverbal communication are clear or ambiguous. In the case of preliterate or traditional (homogeneous) cultures, the author has shown that the built environment and space get a "mnemonic function", reminding people of what is expected from them. Rapoport argues that the mnemonic function is mainly carried by semi-fixed feature or non-fixed feature space in such cultures. However, the author has also shown that in the case of heterogeneous, contemporary cultures, the built environment and space loses its mnemonic function due to the lack of widely accepted rules and strong hierarchies. Rapoport argues that in such cases, nonverbal communication is carried on by fixed-feature and semi-fixed feature space to a higher extent, which brings the importance of spatial relationships and visibility as opposed to issues such as widely accepted rules or strong social hierarchies. Therefore, Rapoport (1982) has shown that fixed-feature, semi-fixed feature and non-fixed feature (informal) space have certain effects on human behavior, use of space, and encounters depending on the cultural context.

In the field of ecological psychology, Barker (1968), Bechtel (1977) and Wicker (1979) have observed human behavior extensively in various behavior settings at urban and building scale. Barker (1968) defined a behavior setting as a bounded system composed of human and non-human components where human behavior takes place. Extensive observations have revealed that among a high number of behavior settings, some are behavioral focal points, where larger quantities of human encounters (i.e. interactions) take place. Bechtel (1977) further studied the notion of behavioral focal points, and illustrated that in buildings and urban environments, centrally located spaces with maximum visibility form focal points of encounters – behavioral focal points. Therefore, the author has shown that spatial relationships and visibility are important factors in facilitating human encounters.

Structural analysis within environment – behavior research has examined space – society relationships by describing and/or explaining the systematic composition of objects (i.e. buildings) and events (i.e. human behavior) (Lawrence, 1987). A main distinction exists within structuralist approaches. While the area termed "global structuralism" deals only with descriptions of objects and events, "analytical structuralism" searches for explanations in addition to descriptions.

Within global structuralism, Glassie (1975) and Steadman (1983) analyzed the systematic composition of objects and spaces within the built environment at the level of fixed-feature space. Glassie (1975) has developed a complex descriptive system for traditional houses in Virginia. Similarly, Steadman (1983) has introduced the idea of architectural morphology, and developed a descriptive analysis method of spatial configurations (composition
of all spatial relationships in a system of spaces). Glassie’s (1975) system has remained at a descriptive level, and the author has not sought explanations for the set of relationships among building elements he has described. Steadman (1983) similarly has limited his study at a descriptive level. However, this author’s descriptive system has later been further developed and utilized for explanations (i.e. by Hillier and Hanson, 1984; Hillier, 1985; Hillier, Hanson and Graham, 1987). This line of structural analysis at the level of fixed-feature space has limited itself with descriptive accounts as opposed to investigating their explanations. Within analytical structuralism, cognitive approaches have focused on how the world is comprehended by human beings. Levi-Strauss (1963), a structural anthropologist, has studied space-society relationships in preliterate cultures. While the author has found significant relationships between space and social encounters, he has conceptualized space and spatial relationships as a direct reflection of culture. This approach has been widely criticized (i.e. by Lawrence, 1987; Hillier and Hanson, 1984), and it has been shown that such one-way effects on space by societies is not the case in contemporary societies, where space and society interact and affect each other.

Within structuralist approaches, theory and method of space syntax has sought an integration of global and analytical structuralism. Hillier and Hanson (1984), Peponis (1985), Peatross and Peponis (1995), Zimring and Peatross (1997), Penn (2001) and others have utilized the idea of architectural morphology to develop a method of description and analysis of spatial configurations. Building on Steadman’s (1983) research, and relying heavily on analytical structuralist approaches, these authors have sought explanations of their spatial descriptions and analyses of spatial configurations. The main idea of space syntax research is that the built environment has to be conceptualized as a series of spatial relationships (spatial configurations) in which human encounters and avoidance take place. Thus, this approach rejects the idea of conceptualizing the built environment as objects (i.e. buildings) and explicitly focuses on spatial configurations. In this approach, spatial configuration is defined as the relations among spaces in a system of spaces, taking into account all other spaces in the system. Based on these ideas, space syntax method describes space through a series of measurements developed based on the idea of architectural morphology. The results are then explained in a “syntactical theory of space” according to the social structure of the context under consideration. The measurements of space syntax method have been effective in understanding and predicting the form and quantities of human encounters. At the urban and building scales, correlations between syntactical measurements (i.e. “depth”, “integration”, “connectivity”, “intelligibility”) and human use of space (i.e. movement, co-presence) and human encounter and avoidance patterns (i.e. social interactions) have been found. Examples include hospitals, research laboratories, design schools, factories, small towns and neighborhoods. The explanation of these correlations has usually been based on structural analysis of societies or organizations under consideration. In a number of cases, space syntax method has been used to predict human movement at the urban scale, and configurational analysis has been used for prediction.
of human encounters in design processes (Penn, Hillier, Banister and Xu, 1998). Therefore, theory and method of space syntax has shown that spatial configuration is related to patterns of human encounter and avoidance.

Similar to Hillier and Hanson (1984), Lawrence (1987) has sought an integration of global and analytical structuralist approaches within the perspective he has termed “dialectical structuralism”. Lawrence (1987) has advocated the idea that the individual and the society, the built environment and human behavior, and changes in these due to time should be integrated within one inquiry, for description and explanation. Thus, within dialectical structuralism, the material characteristics of the built environment, the nonphysical world of ideas, rules, regulations are considered within the context of cultural, social, political, economic variables in the course of time. Although Lawrence has used the term “built environment”, he has essentially described and analyzed spatial relationships. Therefore, within dialectical structuralism, society and space are analyzed and explained within a larger context of cultural, social, political, economic variables, taking time into account.

2.1.2. Semi-fixed Feature and Non-fixed Feature (Informal) Space

At the level of semi-fixed and non-fixed feature (informal) space, Sommer (1969) inquired into observed human use of space. He observed that co-acting, conversing and cooperating behavior is related to semi-fixed feature space and informal space. Sommer described certain consistencies in such behavior and its relationship to space in various settings, such as cafeterias. At the level of semi-fixed feature space, Osmond (1959) introduced the notion of sociofugal and sociopetal spaces. He observed that while sociopetal spaces tend to bring people together (i.e. to converse, co-act, etc.) sociofugal spaces tend to keep people apart. Osmond and Sommer have been able to affect conversing behavior in a hospital setting by modifying semi-fixed feature space (by changing the arrangement of tables from a sociofugal arrangement to a sociopetal arrangement) (Sommer, 1969). They provide descriptions of semi-fixed feature space that would be likely to induce conversing behavior and facilitate human encounters in certain settings.

2.1.3. Space and Society: a Brief Summary

To summarize, research by Osmond (1959), Hall (1966), Barker (1968), Sommer (1969), Bechtel (1977), Rapoport (1982), Hillier and Hanson (1984) Peponis (1985) and Lawrence (1987) among others have shown that space and spatial relationships, as defined by the built environment (objects) at the levels of fixed-feature, semi-fixed feature and non-fixed feature space, form a framework in which human behavior, space use, and encounters take place, and are affected by it. Moreover, these authors have found certain levels of consistency in human behavior – space relationships in certain cultures and settings; and have shown that, in a clearly
defined context, and depending on the body of previous research, human behavior – space relationships are predictable to certain extents.

2.2. WORKSPACE

2.2.1. The Significance of Workspace Research for Design Disciplines

An extensive amount of research into workspaces in various sectors and their relationships to work practices exists in environment – behavior research. While research into the relationships between innovation processes and space requires consideration of specific concepts and factors within innovation processes, it is important to point out some of the key issues in workspace research in order to elaborate on the influence of space on innovation processes.

As in many other settings, environment – behavior research has also focused on the relationships between space and human behavior within various work practices and patterns. Among other social organizations, work organizations are those with the highest potential for relating to space. Consequently, workspaces have formed a major setting for research, and findings have been highly influential on organizations as well as individuals.

Two key points in underlining the importance of workspace research have been (i) the main objective of all work organizations – efficient production, and (ii) the key position of the human being in all work organizations. First, regardless of the work sector, the reason for existence of all work organizations is efficient production (Zuboff, 1986; Wineman, 1986; Becker and Steele, 1995; Duffy, 1997; Laing et al., 1998). No matter what their focus is, all organizations work for efficient production – ranging from goods to knowledge. Second, although the advances in various technologies have made automation possible in many areas of life, for all work organizations, human beings form the key resource for efficient production. Space stands as a key factor for achieving work objectives occupied by the key resource – the human being, and the work patterns themselves. Extensive research has shown that workspaces substantially influence outcomes of the practices of work organizations (Becker and Steele, 1995; Duffy, 1997).

The importance of space for work organizations has been shown in previous research. Two major studies effectively display the importance of space for work organizations. Duffy and his colleagues (Duffy, 1997; Laing et al., 1998) studied an extensive number of work organizations from different sectors and countries and illustrated that facilities costs (i.e. construction, maintenance, utilities, etc.) amount to 10%, whereas human costs (i.e. salaries) amount to 90% of all costs of an organization. A more recent study by Brill (2001) has shown that over a period of 10 years, operating and maintenance costs of a work organization remains close to 8%, whereas human costs remain close to an 85 – 90%. Then, the major expenditure of work organizations is for the
human being. Considering that the human being is the major resource for achieving the main objective of efficient production, the importance of design for increasing efficiency and satisfaction of employees and the organizations becomes clear. Accordingly, two main influences of space on work organizations are

(i) its relationship to workspace satisfaction and

(ii) its relationships to work patterns.

Both of these factors are related to the behaviors of individuals. Previous research into workspaces has originated from the idea of providing better workspaces to the human being as the major resource, and has proven to be effective. On the other hand, while both of the above factors have been studied extensively, recent research has shown that space – work pattern relationships are far more effective in yielding positive results when compared to the effects of increased workspace satisfaction.

2.2.2. Developments in Workspace Research 1: 1950s – 1980s

The issue of workspace satisfaction has been studied in the past four to five decades mainly through subjective evaluations of workspaces by employees. Marans and Spreckelmeyer (1986), for example, studied the ratings of employees in two organizations about their workspaces. Hedge (1986) and Ferguson and Weisman (1986) studied subjective expressions of satisfaction with office layouts. Similarly, Cherulnik (1993) studied subjective evaluations of employees to their workspaces. Common environmental attributes evaluated in these studies have covered satisfaction about issues such as environmental factors (i.e. lighting, air conditioning), and office layout (i.e. open layouts, privacy, etc.). Although results have indicated that satisfaction with workspace evaluated through such environmental attributes is related to job satisfaction and performance, these results have frequently proven to be subtle.

2.2.3. Developments in Workspace Research 2: Contemporary Research

Close to the end of 1990s, the contemporary line of workspace research turned its attention towards workspace – work pattern relationships. Instead of searching for factors of subjective evaluation and performance relationships, this line of research has mainly been concerned with issues of work patterns (i.e. work flow, information flow), and has sought the relationships between effectiveness and workspace through these issues. The major point of interest in this line of research is the spatial organization and its relationships to work patterns in various sectors. Examples of cutting-edge research into issues of workspace-work pattern relationships are studies by Becker and Steele (1995), Laing et al. (1998) and Brill (2001). The common point among these studies is that they deal with new work patterns (i.e. highly interactive, low – hierarchy organizations dependent
on knowledge) and their workspace requirements (i.e. the relationships between spatial organization and information flow, and resultant effects on the effectiveness of contemporary work patterns).

This line of research has shown that “subjective evaluations – based” workspace research of previous decades and its findings are far less significant than the contemporary issues of spatial organization – work pattern relationships. Brill’s (2001) recent study forms an effective example in this respect. Over a period of ten years, Brill and his colleagues found that ten workspace issues with the strongest effects on the productivity of organizations, when ranked from stronger to weaker, are as shown in Table 2.1.

<table>
<thead>
<tr>
<th></th>
<th>Ten workspace issues with the strongest effects on the productivity of organizations, ranked from stronger to weaker (Source: Brill, 2001).</th>
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<tbody>
<tr>
<td>1</td>
<td>Support for concentrated work</td>
</tr>
<tr>
<td>2</td>
<td>Support for impromptu interactions (both in one’s workspace and elsewhere)</td>
</tr>
<tr>
<td>3</td>
<td>Enough space for work tools</td>
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<tr>
<td>4</td>
<td>Support for meetings and undistracted group work</td>
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<tr>
<td>5</td>
<td>Support for side-by-side work and “dropping in to chat”</td>
</tr>
<tr>
<td>6</td>
<td>Located near or easily find co-workers</td>
</tr>
<tr>
<td>7</td>
<td>Provision of convenient places for breaks</td>
</tr>
<tr>
<td>8</td>
<td>Access to needed technology</td>
</tr>
<tr>
<td>9</td>
<td>Quality of lighting and access to day lighting</td>
</tr>
<tr>
<td>10</td>
<td>Temperature control and air quality</td>
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</tbody>
</table>

These findings of Brill (2001) and his colleagues support the idea that the spatial organization of the workspace and its support for the work pattern is becoming a more significant resource, and is more influential in terms of its findings when compared to issues of satisfaction with the workspace. A major resource in this line of research was that carried on in the last decade by Laing, Duffy and their colleagues.

“New Environments for Working: the Re-design of Offices and Environmental Systems for New Ways of Working” by Laing, A., Duffy, F, Jaunzens, D., Willis, S. (1998) is a basic inquiry into the influence of space on work processes, which reports the process and findings of a research program carried out in the UK, namely the “New Environments for Working (NEW)”. The main question of the study is, “what are the most effective ways of accommodating emerging working practices?” The study draws on the idea that new working practices are emerging, both in terms of the technological developments (and their impacts on work practices), and in terms of the work processes themselves. The study reports on the relationships between spatial organization and work processes for almost all sectors, through a conceptualization of work patterns. The study starts with a modeling
of “work patterns”. Then, a number of organizations are selected, which are assumed to represent each of these work patterns. In order to identify the work patterns, the authors have observed the way different organizations work. The main argument is that work patterns are changing and new ways of working are arising. According to the authors, new work patterns arise due to changes from: *routine processes to creative knowledge work; individual tasks to groups, teams, projects; and isolated work to interactive work* (Table 2.2).

<table>
<thead>
<tr>
<th>CONVENTIONAL WORK PATTERNS</th>
<th>NEW WORK PATTERNS</th>
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<tr>
<td>Routine processes</td>
<td>Creative knowledge work</td>
</tr>
<tr>
<td>Individual tasks</td>
<td>Groups, teams, projects</td>
</tr>
<tr>
<td>Work breakdown to small components</td>
<td>Collaborative and individual work</td>
</tr>
<tr>
<td>Work carried out by staff given precise instructions</td>
<td>Work process constantly redesigned</td>
</tr>
<tr>
<td>Precise timetable</td>
<td>Complex timetable</td>
</tr>
<tr>
<td>Full time occupancy of space</td>
<td>Task based occupancy of space</td>
</tr>
<tr>
<td>Individual space</td>
<td>Shared space</td>
</tr>
<tr>
<td>Alone or isolated work</td>
<td><em>Combined interactive and autonomous work</em></td>
</tr>
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</table>

Moreover, the authors argue that in conventional work patterns, information technologies are used for routine data processing; whereas in new work patterns, information technologies are used to support creative knowledge work. Following these observations, the authors conceptualize the work patterns in four major types: *individual process work, concentrated work, group process work, and transactional knowledge work* (Figure 2.1).

![Figure 2.1. Four work patterns, as conceptualized by Laing et al. (Based on Laing et al., 1998: 25).](image-url)

Following the conceptualization of work patterns, the authors then specify the spatial organization needs for each pattern, and arrive at four optimized types of spatial organizations. These are obtained through the
comparison of buildings and spatial organizations in which these organizations are accommodated, to the work patterns they employ. Therefore, named the “demand and supply model”, this research compares the spatial supplies of each organization to its demands, and comes up with four types of spatial organizations that could fit four types of work patterns. In doing so, they focus on two variables: interaction and autonomy. They ask each organization about their expected levels of autonomy and interaction, compare the results to existing spatial organizations, and optimize the four spatial organizations for each work pattern. In general, the matching of work patterns and spatial organizations give the following results. As organizations move from individual, concentrated and autonomous processing work towards interactive, creative, varied knowledge work, their spatial organizations get more complex (Laing et al., 1998). This implies a shift from the ‘conventional’ workstations (cubicles) and cellular offices towards a mixture of individual workstations, meeting spaces, and leisure areas (commons).

One of the findings of the authors is worth considering at this point. Laing and his colleagues introduce the notion of commons. Commons are those spaces used for such activities as leisure, coffee breaks, lunch, and relaxation. These spaces are mainly intended to accommodate non-work activities and interactions among building inhabitants (Laing et al., 1998). Therefore, according to the authors, as organizations move from conventional to new work patterns, not only their spaces deviate from conventional “workstation / cellular office” arrangements, but also accommodate spaces for facilitating interactive knowledge work. Thus, the notion of commons exists as one of the important space categories in contemporary workspace studies. Their availability, number and location within the overall spatial organization, as well as environmental qualities are highlighted as important points of concern by the authors.

2.2.4. Issues in Contemporary Workspace Research: an Overview

Laing and his colleagues’ (1998) research findings are parallel to those of Brill’s (2001), about the importance of workspace – work pattern relationship and the potential of the workspace in positively influencing the contemporary work organizations’ productivity and competitiveness. Based on this review of workspace research literature, the following major points are of concern to the present study:

- Employees constitute an organization’s most valuable resource.

- Workspace design can have a positive influence on the performance of this most valuable resource (users).
• As opposed to focusing on short-term investments of effort in workspace construction (i.e. minimizing construction costs), long-term investments into providing the appropriate spatial organization for supporting work patterns (i.e. focusing on information flow) have proven to be much more effective.

• The findings of previously conducted “subjective evaluations based” workspace research have remained subtle compared to the findings of contemporary line of spatial organization – work patterns research.

• Workspace research into the influence of space on improved productivity and competitiveness within various work patterns has to be based on these previous experiences.

Based on this review of workspace research, a vital point of concern is the attributes of the work pattern that is studied. As discussed in Laing and his colleagues’ (1998) research, different work organizations have different requirements to be provided by the workspace. For example, in Laing and his colleagues’ (1998) terminology, the spatial requirements of an organization doing extensive individual process work (i.e. an insurance company) should be different from an organization doing transactional knowledge work (i.e. a software research and development company). While efforts for facilitating information flow through spatial organization might be advantageous for a research and development organization, the same effort might be undermining the work of another organization requiring concentrated work. **Therefore, research into the influence of space in different organizations requires knowledge of key issues and a clear conceptualization of the work patterns carried out by the specific sector studied.** Thus, the key point for studying workspaces provided for innovation processes is to clearly conceptualize the key issues and work patterns in organizations within innovation processes. **Then, what are the dynamics of innovation processes?**

2.3. INNOVATION

2.3.1. Innovation, Technology and Technological Innovation

**Innovation**, derived from the Latin word “novus”, refers to “the introduction of something new or a new idea, method or device” (Tornatzky and Fleischer, 1990). The term “technological innovation”, on the other hand, is used extensively in the literature, and is referred to as a ‘sub-construct’ by Bamberger (1991). “**Technology**” refers to tools or tool systems derived from human knowledge, by which human beings transform parts of their environment. Then, “**technological innovation**” refers to the development and introduction of knowledge-derived tools by which human beings transform parts of their environment (Tornatzky and Fleischer, 1990). “Technological innovation” and “innovation” are used usually interchangeably in literature.
In order to clarify these terms, one has to look at the characterization of the “process”. Two generally agreed upon innovation process models exist, which are referred to as “technological innovation”. The first model uses an analogy of a “room with houses”, with the “rooms” of research, development, deployment, adoption, implementation and routinization (Figure 2.2) (Tornatzky and Fleischer, 1990).

The second model is termed “the chain-linked model of technological innovation”, which includes the rings of the “chain” as research, analytic design, detailed design, production, distribution and marketing (Figure 2.3) (Kline and Rosenberg, 1986). In both of these models, the process does not proceed linearly and sequentially – i.e. from “research” towards “implementation”. On the contrary, the proceeding of events is non-linear – i.e. feedback loops operate back-and-forth among the “rooms” or “rings”.

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**Figure 2.2.** Processes of technological innovation as proposed by Tornatzky and Fleischer (Based on Tornatzky and Fleischer, 1990: 32).
Therefore, the innovation process is not a linear one. The interchangeable use of both terms “innovation” and “technological innovation” in literature basically refers this non-linear process. Then, the use of these terms covers not only research, but also development, adoption and implementation of its results. However, although some authors also consider the accomplishments in research as “innovation”, others argue that a development has to be considered an “innovation” only if it is adopted and implemented (Bamberger, 1991).

2.3.2. Scientific Breakthroughs

Tornatzky and Fleischer (1990) mention that basic science and research is mainly conducted in institutions such as major research universities, government research centers, government laboratories and university research centers; and its main objective is “generation of new knowledge” – scientific breakthrough. In their definition of basic science and research, these authors rely on Kuhn’s definition of “normal” science, which:

“...means research firmly based upon one or more past scientific achievements, achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice (Kuhn, 1996: 10).”

However, applied research and development, according to the authors, is mainly conducted in private and large firms, and its main objective is to develop products that satisfy a felt problem or need. If we visualize basic
science and research and its accomplishments within the two innovation models discussed previously, it can be associated with the “research room / ring”. Then, the use of the term “innovation” in the sense of applied research and development, its adoption and implementation, and the use of the same term in the sense of basic science and research and its accomplishments, have to be distinguished. Bamberger (1991) points out that the use of the term “innovation” for both is a problem of terminology within the innovation literature.

The three commonly used terms, then, are “scientific breakthrough”, “innovation” and “technological innovation”. In innovation literature, the terms “innovation” and “technological innovation” are usually associated with the whole process (including adoption and implementation). On the other hand, the common point of these terms is the introduction of new ideas, methods or tools, which coincides with the original meaning of the term “innovation”. Since this study is an inquiry into the influence of space on innovation processes, adoption and implementation of “new ideas, methods and devices” remain outside the scope. As a result of the terminology problem mentioned, the term “innovation” will be used here within the limits of the definition provided by Tornatzky and Fleischer (1990), referring to “the introduction of a new idea, method or device”, without including their adoption and implementation. However, the use of the term in this sense is only for the purposes of dealing with space, and with an awareness of the fact that “innovation” is also used for the whole process from research to routinization. Therefore, the influence of space has to be considered within the question of how a new method, idea or device is introduced, and what the effective factors are.

2.3.3. Issues in Contemporary Innovation Research: an Overview

2.3.3.1. “Measuring” Innovation

Bamberger (1991) has provided a framework of different approaches to operationalization of innovation. Two main approaches to operationalization of innovation are based on “judgmental ratings” and “nonjudgmental ratings”. In the first approach, measurement of innovation is based on the subjective impressions of either those involved in the innovation processes (insiders), or those who are not actually involved with the process, but have a certain level of knowledge and expertise to rate the process (outsiders/experts). In some cases, both measures are applied. The subjective impressions of insiders and outsiders are utilized for an evaluation of the innovation processes, and outcomes (Bamberger, 1991). The second approach, which is based on nonjudgmental ratings, operationalizes innovation through the number of ‘items’ as outputs, which are believed to be innovations. These ‘items’ are, “knowledge outputs”, such as the number of books, articles, and papers, and, “application outputs”, such as the number of patents, new applications, algorithms, blueprints and reports.
2.3.3.2. Factors Influencing Innovation Processes 1: Units of Analysis

Six units of analysis have been proposed by Tornatzky and Fleischer (1990) for understanding the factors influencing innovation processes.

*Characteristics of individuals.* These include personal characteristics of those involved in innovation processes, regardless of their social roles in the organizations considered. Examples include consideration of demographic characteristics, psychological traits, job skills or personalities of individuals through the use of questionnaires. Although this range of individual characteristics exist in innovation literature, Tornatzky and Fleischer (1990) assert that psychological traits, job skills or personalities of individuals have not proven to be effective on innovations in organizations, primarily because innovation processes are not composed of “an individual star-scientist or researcher”, working isolated in a room, “innovating”. On the contrary, innovation processes are interactive. Therefore, demographic characteristics such as experience and level of education in the considered technical area have proven much more effective as factors influencing innovation processes, particularly for achieving a general understanding of the organizational context considered (Tornatzky and Fleischer, 1990).

*Individuals as Role Holders.* The most widely discussed roles are those of gatekeepers or key communicators, and product champions. *Gatekeepers or key communicators* are those people who serve as important sources of technical information in the organization, who also facilitate information flow (Allen, 1984). *Product champions* are those people who facilitate decision making by such activities as arguing for change and finding resources. Gatekeepers, key communicators, and product champions support innovation processes through facilitating information flow and providing access to knowledge (i.e. in Allen, 1984; Sonnenwald, 1999). Social network analysis has been implemented to identify the presence and number of such individuals in previous innovation literature (i.e. Sonnenwald and Lievrouw, 1996).

*Groups.* These include formally defined groups (i.e. project teams) and informal social groups (i.e. those based on social relationships such as having lunch or meeting at weekends). Intra-group and inter-group interactions have been considered as facilitative factors in innovation processes. Both information flow within and among formal groups through various channels (i.e. face-to-face interactions) and information flow through informal social groups are facilitative of innovation processes (Allen, 1984; Sonnenwald, 1996, 1999, Keller, 1994). Similar to studies of individual roles, social network analysis has been used for identification of information flow within and among formal and informal groups.

*Organizations.* These include organizational structure of various kinds, defined through constructs such as “bureaucratic” vs. “nonbureaucratic”, “mechanistic” vs. “organic” organizations. Formalization (number of levels
of hierarchy), complexity (degree of professionalization and number of professional groups in the organization),
level of interdependence among researchers / research teams, and available resources (funds) are examples of
measures used to analyze organizations. Organizational complexity, decreased formalization, increased
interdependence are among factors that facilitate innovation (Tornatzky and Fleischer, 1990).

Economic Environment. This consists of the larger economic environment within which organizations operate.
The specific industry within which the organization operates, market characteristics, economic opportunities and
government policies such as patent policies and tax incentives are factors that influence innovation processes
for commercial institutions (Tornatzky and Fleischer, 1990).

Interorganizational and Environmental Interactions. These include exchange of, or dependence on common
resources, based on the voluntary activity of two or more organizations. Information flows among organizations
through informal work-related interactions or formal coordination are influential on innovation processes (Allen,
1984).

Tornatzky and Fleischer (1990) mention that the last two large-scale factors have been studies either from an
economic or a social perspective, and considering innovation, their impacts have not been well understood, or
have been unclear. Moreover, these last two units of analysis in this framework are related to economic and
social environments in macro-scale, and therefore related more to the whole process of technological innovation,
which includes adoption and implementation. However, the initial four units of analysis have been points of
reference in micro-scale analysis of the innovation process. Therefore, for an inquiry into the influence of space
on innovation processes, the first four units of analysis (individual characteristics, roles of individuals, groups and
organizational context) remain relevant. Then, what are the influential factors for innovation processes at these
four relevant units of analysis?

2.3.3.3. Factors Influencing Innovation Processes 2: Information Horizons and Information Resources

A review of literature at the four mentioned units of analysis reveals that the knowledge base of an innovation
process is the major resource. There is a wide range agreement on the facilitating role of increased access to
information in innovation processes (i.e. Allen, 1984; Kline and Rosenberg, 1986; Kanter, 1988; Tornatzky and
Fleischer, 1990; Sonnenwald and Lievrouw, 1996; among others).

Sonnenwald (1999) provides a conceptual framework of “access to information”. According to the author, human
information seeking behavior is induced upon the perception of a lack of knowledge. When this is perceived,
humans seek information among a number of information resources available to them within their context. The
available information resources form their information horizons. For example, Sonnenwald (1999) has
identified five main information resources within the information horizon of a typical engineer in a R&D group in a private firm: members of the group, literature (including books, journals and electronic resources), subject matter experts, project and vendor documentation, and personal experimentation and observation. Evidently, such a list of information resources is subject to change according to the organizational context of the individual. Then, wider information horizons provide increased access to information resources, which is of major importance to the innovation process.

2.3.3.4. Accessing Information for Innovation: Previous Research

In innovation literature, communication of information through face-to-face interaction is mentioned as a significant information resource among others:

“Open communication serves a very important function for the potential innovator. Information and ideas flow freely and are accessible; technical data and alternative points of view can be gathered with greater ease… (Kanter, 1988: 189).”

Several studies support this idea through their findings. One example is Allen’s study (1984). This study essentially reports the results of a research project conducted over a period of ten years, between 1963 and 1973. The author defines the topic of the study as the problem of communication in research and development. Allen’s study is composed of two parts. The first part looks at the information consumption patterns of research and development projects. The author also has made an inquiry into the influence of space on information consumption in the second part of this study. For the purposes of the current study, the first part of Allen’s research will be discussed at this point.

The main concern of Allen’s study is to determine the information consumption patterns of research and development projects. The main question, therefore, is how information consumption patterns influence the outcomes of research and development projects, in terms of what the author defines as “research and development effectiveness”. The main research strategy was measuring the information consumption patterns in research and development projects, and then relating them to “research and development effectiveness”. Projects, which were similar in terms of scope and content, were selected for comparison of their information consumption patterns and R&D effectiveness. Since all of the projects were assigned to firms by the government, the “R&D effectiveness” was operationalized through subjective evaluations (judgmental ratings) of government’s technical monitors.

The study reports on different patterns of information consumption – i.e. use of literature, communications within the organizations, organizational impacts. Time spent consulting with organization members, the number and quality of ideas obtained in this way, and the degree to which consulting with members of the project was used
were measured, and related to R&D efficiency. The results indicate that for higher-rated projects, the “percent of total time allocated to consulting” and “total number of communications with members of the organization” was higher than lower-rated projects. For higher-rated solutions, idea-generating messages obtained from the organization members were higher than lower-rated solutions. For high performers, the total number of communications with organization members (that were not assigned to the project) was very high. Similarly, for high performers, the mean number of communicated organization members (that were not assigned to the project) was about three times more than the low performers. For high R&D performers, inter-group interaction levels were higher than intra-group interaction levels.

Therefore the study reports empirical evidence to support the idea that improved intra-group and inter-group communication of information will increase R&D effectiveness. The author states that face-to-face technical interactions within and among groups have positive impacts on R&D effectiveness. In general, the study confirms Kanter's (1988) idea that face-to-face technical interaction among the members of the organization has a positive impact on innovation. Allen’s findings are important for the purposes of the present study. The study supports the idea that face-to-face technical interaction among organization members facilitates innovation as an information resource. Moreover, its focus on similar projects gives insights about selecting cases, methodology and analysis.

Sonnenwald and Lievrouw (1996) inquired into the impact of communication among organization members on project performance in an engineering design project. This small group case study describes how communication and information behavior affects project performance. The authors report that data was collected from one project team in a high technology firm in California. The team was composed of 14 members, whose goal was to create a product related to telephone systems. Data about communication among team members was collected by a sociometric survey, which asked individuals to identify and record their interactions (work-related consultations) about the project with other team members. The approximate duration of consultation and the medium used (face-to-face, e-mail, fax, telephone) for consultation were also included in this sociometric survey.

Project performance was based on judgmental ratings of team members. Team members were asked to assess their team’s performance and other members’ performance and contributions to the project using five-point likert scale statements. Social network analysis was used to analyze data from sociometric surveys. The consultations among team members were represented using sociograms. Also, a sociomatrix of team member consultations was constructed. Consultations were quantified using the measures of connectivity and centrality. Communication behavior was measured for each team member by the number of consultations and centrality.
The results indicate that communication behavior significantly correlate with individual effectiveness as perceived by team members. The number of consultations and centrality of team members significantly correlated with their effectiveness ratings. Thus, the study emphasizes the importance of communication of information through consultations in knowledge based processes, which, in this case, is an engineering design problem.

Sonnenwald and Lievrouw (1996) illustrate how social network analysis can be used to quantify communication of information through consultation among organization members as a variable. The study parallels previously discussed studies indicating that increasing the access to information through communication is advantageous for knowledge-based work. While Allen’s (1984) study provided results about the positive effects of inter-group and intra-group interactions on “R&D effectiveness”, Sonnenwald and Lievrouw’s (1996) study provided results about the positive effects of intra-group consultations on “individual effectiveness as perceived by team members”. Both inter-group and intra-group consultations facilitate performance and effectiveness for groups.

Ancona and Caldwell (1992) studied the performance of two sets of 38 and 45 product development teams in high-technology companies respectively. With the objective of examining the inter-group work-related consultations and their impacts on performance, the authors have focused on inter-group consultations of product development teams in high-technology companies. A multi-method approach was used. For the first set, semi-structured interviews with all team managers and activity logs from two teams were used. For the second set, questionnaires were used to gather data about inter-group communications of teams. Two important results of this study are, first, inter-group consultations are positively associated with team performance, and second, “isolationism” (low levels of inter-group consultations) is negatively associated with team performance. Therefore, the results of this study parallel previously discussed studies.

In another study, Ancona (1990) found similar positive effects of communication of information through face-to-face consultations on team performance, as perceived by the team members and superintendents. The author studied the effects of inter-group communications on the performance of five consulting teams in a state education department. Although the context of this study does not overlap innovation processes, it is one of the most frequently cited and discussed studies in innovation literature, and it provides relevant information at the level of inter-group consultations. Ancona (1990) explains that the main objective of her study was examining the inter-group consultations and their impacts on the performance of five consulting teams. This exploratory study was based on monitoring the activities of these five teams organized to work toward the department’s goals as set by the commissioner of the department. The teams were composed of six to ten consultants. A multi-method approach was used in the study, where inter-group consultations were monitored using questionnaires, logs,
interviews and observation. Process outcomes were assessed by insiders and outsiders of teams. Insider ratings were judgmental, which included assessments of “satisfaction being a member of the team”, and “team effectiveness at meeting group member needs”. Outsider ratings were also judgmental, and included rankings of the commissioner, superintendents and human resources manager of the department, about team effectiveness.

The results of the study revealed a typology of teams based on their strategies towards inter-group consultations. Ancona (1990) proposes that three types of teams exist: informing teams are those that are isolated from their environment, parading teams are those that have high levels of passive observation of other teams, and probing teams “revise their knowledge of the environment through external contact, initiate programs with outsiders, and promote their team’s achievements within their organization (Ancona, 1990: 334).” The author states that “probing” teams, which had the highest levels of inter-group consultations were rated as highest performers among the teams. As a result, Ancona (1990) argues that inter-group consultations are better predictors of “team performance” than intra-group consultations. This study indicates that higher levels of consultation facilitate team performance. This parallels Allen’s (1984) results, who, in addition found that intra-group consultations also facilitate team performance. Therefore, also taking Sonnenwald and Lievrouw’s (1996) study into account, these studies indicate that sharing information through intra-group and inter-group consultation have a high potential of facilitating innovation. Therefore, among other resources, communication of information through face-to-face consultation is a significant information resource in widening information horizons, which facilitates innovation.

2.3.4. Summary

Literature review of innovation processes reveals that at the organizational, group and individual levels of analysis, certain variables affect innovation. At the organizational level, formalization, complexity and available resources affect innovation processes. At the group and individual levels, two factors exist as important variables. First, individuals as role holders are effective on innovation processes. The presence of individuals that have such roles as key communicator facilitate innovation. This is connected to the second factor: information as the basis of innovation processes. Each individual in an innovation process has a certain “information horizon” composed of various “information resources”. These information resources range from literature to personal experimentation, previous research, and information from “outsiders” – i.e. project vendors. One important information resource is communication of information through face-to-face consultation (work-related interactions). Consultations may take place through various media, such as face-to-face consultation, telephone, e-mail, fax or other networking tools. The impact of information technologies on face-to-face consultation remains at a low level, indicating that face-to-face consultation is still an important consultation
medium for facilitating innovation. Formal and informal consultation networks are particularly important in this sense. Increased access to information resources, that is, support of information behavior facilitates innovation. Therefore, increased face-to-face consultation supports innovation. The role of key communicators provides increased access to information resources. Inter-group and intra-group consultations are positively associated with innovation. Finally, at the individual level, demographic characteristics of individuals in innovation processes support innovation to a certain extent. These include variables such as previous experience and level of education. Operationalization of process outcomes is possible making use of judgmental and nonjudgmental measures. Review of literature indicates that triangulation is advantageous in operationalization of innovation.

As a result, enriched information horizons, specifically, increased communication of information through face-to-face consultation (work-related interaction) is an important precursor of innovation. Then, what about the relationship of innovation process, information horizons and space?

2.4. INNOVATION PROCESSES IN SPACE: SPACE FOR INNOVATION

Communication of information through face-to-face consultation, as an important precursor of innovation, requires co-presence and co-action in space. Can space provide the preconditions for co-presence and co-action for individuals involved with the innovation process? In innovation literature, this point has been addressed by Kanter (1988), who acknowledges the importance of face-to-face consultation in innovation process, and points out “integrating and isolating” characteristics of the physical work environment, which can be advantageous for organizations by facilitating information flow and free exchange of ideas. Such statements can be found scattered in innovation literature from time to time, but the issue of space and its influence on information flow has not been studied empirically, and its discussion has been very limited within this body of literature.

Although the number of studies that have focused on space - innovation relationships within environment – behavior studies are quite limited, some have addressed the relationships between space and face-to-face interaction as a precursor of innovation, with references to innovation literature (especially to Allen’s 1984 study). However, although such references to innovation processes have been addressed in some cases, the context of these studies has been outside the innovation settings. The frequent contexts of research in these studies have been workspaces of organizations that are not directly involved in basic science and research activities. Moreover, these studies have also been limited to an analysis of space at a single level.

One study that looks at space as a variable in the processes of innovation has been conducted by Hiller and Penn (1991) and further discussed by Hiller (1996). This study explores the relationships between spatial
configuration and interaction patterns, and examines their effect on the innovation processes. The rationale of this study is based on the theory and method of space syntax. According to Hillier (1996), in the case of complex, contemporary social organizations, the behavior of inhabitants will be closer to “probabilistic”, rather than depending on social interventions. Taking Allen’s study as a base, and drawing upon the idea that levels of interaction and communication have considerable effects of the processes of innovation, Hillier argues that *increasing the probability of unprogrammed encounters in space can increase levels of communication of information through face-to-face interaction, thus can affect the innovation processes positively.*

The design of this study was based on Allen’s research. Twenty-four floors were sampled from eight research laboratories throughout the UK. The study included observation of space use patterns, and a questionnaire survey to determine the communication networks. These sets of data were compared to spatial configuration of buildings. Axial analysis was based on the “open space structure of buildings”, which took fixed featured space into account. The author states that open space structure of buildings were obtained by plotting all moveable space on plans, and then drawing axial maps. After configurational analysis through space syntax method, observations of space use patterns were made, plotting down the patterns. Finally, the questionnaire was employed, which listed all the people in the survey area, and asked respondents to score on a five-point scale the frequency of contact they had with each name on the list. It also asked the respondents whether they found that name useful in their work. Findings were then compared. First, the use density of spaces highly correlated with their local integration values. Second, the mean rate of inter-group contacts among individuals on a floor correlated with the mean degree of global integration of spaces on that floor. Third, the rates of useful contacts in overall layout of buildings correlated with the overall mean degrees of spatial integration of buildings. To summarize, the results implied that higher local and global spatial integration of spaces tended to support the levels of useful work-related inter-group interactions. Therefore, this study provides an important connection between innovation and space. *However, this study does not relate innovation process outcomes to space.*

Penn, Desyllas and Vaughan’s study (1999) goes into a more detailed investigation of these issues. The authors start with a discussion of the recent developments in work organizations, and particularly the ‘organizations of innovation’. Penn and his colleagues’ is basically a single case study of a multidisciplinary advertising and marketing agency, and the spaces it occupies. The authors state that this company is unique among its competitors, due to its attempts to maximize “innovative solutions” through the degree of unscheduled face-to-face interaction among employees. Thus, although some ‘departments’ exist in the company, projects are not assigned to individual departments, in order to maximize interaction and facilitate the generation of innovative solutions. The design of the case study is very similar to Hillier and Penn’s study (1991). First, visible patterns of space use were observed and recorded. Then, configurational analysis was done using the space syntax
method. Last, a questionnaire survey for investigating the interaction patterns was utilized. The results come from a comparison of these three.

The visible patterns of space use are summarized in a plan view of the space occupied. These include moving, seated, standing and talking people. The first comparison is made between the total movement and mean global integration of spaces. For this, a series of notional gates were selected as measurement points. The global integration values of lines passing through these notional gates were then compared to the number of people that have passed through them. There was a positive correlation between total movement and global integration. Second, the number of talking, seated, standing and moving people were compared to the depth of each space from main entrance. The number of seated people positively correlated with depth, meaning that seated (possibly concentrated working) people were mostly in ‘deeper’ spaces. However, the number of moving and standing people decreased as depth increased. Finally, the number of talking people reached a peak in the medium-depth spaces. The mean number of moving people and talking people were positively correlated, indicating that movement is a possible resource to start interaction. Another comparison was made between the number of talking, seated, standing and moving people in spaces, and the sum of global integration values of lines entering these spaces, which indicated that the number of people in a space is positively correlated to global and local integration of that space.

Following the results of the questionnaire, the authors report two additional comparisons. It was seen that the number of useful citations and mean frequency of contact were positively correlated. When the mean usefulness of people was compared to the mean global and local integration values of the zones they occupied, it was seen that mean local and global integration of zones had a positive correlation with mean usefulness of people occupying it. Overall, these comparisons have implications about the possible positive influence of spatial configuration on the levels of interaction, which can be influential in innovation processes. These effects are basically due to the increased probability of encounters by space. In other words, if one can increase the probability of bumping into each other spatially, then he/she creates an opportunity for people to interact in an unprogrammed way, which may lead to work-related information flow. This study is significant for the purposes of the current study since it not only provides the relationships between spatial configuration and interaction, but also makes an initial attempt to relate this data to perceived “usefulness” of individuals in the organization.

At this point, an important question can be posed: Is observing the number and place of talking, moving, standing and seated people sufficient for making inferences about consultation? Backhouse and Drew’s (1992) research attempts to look for the answers to this question. This study looks at the form of the interactions that
take place in a work setting, which makes it different from the quantitative approach of Hillier (1996) and Penn, Desyllas and Vaughan (1999).

The authors have selected to study an architectural office, which had been studied by Hillier and Grajewski in 1990. One of the objectives here was to compare the results of a qualitative approach to the quantitative approach of ‘space syntax methods’. The authors thus offer a microanalysis of interaction and communication patterns which were investigated previously by the space syntax methods. The methodology of the study consists of a combination of video recording and ethnographic research techniques. One full week was spent in the space of this firm, making video recordings and interviews with the employees. The employees were asked questions about how they perceived their workspace, in relation to their work styles and tasks. The authors state that movement pathways, meeting points, the manner in which meetings were initiated, initiation rituals, and the interactional sequences were identified and transcribed. Specifically, the focus was on movement that resulted in initiation of an interaction.

The results of the study not only support the quantitative approaches of space syntax methods, but also complement them through a series of explanations. First of all, Backhouse, and Drew’s (1992) study supports the findings of space syntax methods, by acknowledging that the interactions take place in the locally and globally integrated areas / divisions. The authors state that the ‘hot-spots’ of interaction identified by space syntax methods were indeed the gravitational centers of interaction. The patterns of interaction suggested that work-related interactions were usually the product of opportunity or chance created by an \textit{incidental proximity}. This result supports the proposal about increasing the probability of ‘bumping into each other’ and facilitating interaction, mentioned in previous sections. The authors conceptualize the work organization of individuals through two kinds of spheres of task orientation. The first of these is named the \textit{task of immediate occupation}, which can be understood as a task in which an individual is engaged at any moment. This implies a concentrated, autonomous work. However, since most tasks need interaction with others, the individual has to leave his/her place at some instances, to make interactions. This is the significant instance in which the individual becomes available to a second form of task. According to the authors, when an individual is away from his/her place, he/she is understood by others to be available to ‘recruitment’. This availability explains the second sphere, named \textit{the task of recruitment}. In this sphere, the individual is recruited by another, and re-routes himself/herself. The authors state that this sequence of recruitment and re-routing has formed a pattern in the course of research. As one individual moves into the ‘vicinity’ of another, \textit{he/she is recruited, his/her task orientation is altered from planned to the contingent, and the prior task moves into a ‘pending’ position}. This pattern essentially causes the formation of ‘recruitment grounds’, the spaces which are more likely to form
scenes to such incidents. Therefore, the authors mention that these ‘recruitment grounds’ overlapped ‘spatially integrated spaces’.

As mentioned earlier, Allen (1984) has considered the influence of space on innovation processes. Allen states that in addition to the importance of communication and interaction among individuals of innovative organizations, other factors that affect the pattern of communications that develop in an organization have to be considered. Therefore, the author has made an inquiry into the influence of space on the processes of innovation within seven research and development laboratories. In Allen’s study, the only variable used for operationalization of space is the distance between locations of individuals within the organization. Allen’s methodology can be summarized as follows. First, communication patterns of the seven selected research and development laboratories were measured through asking scientists and researchers in these organizations about to which of their organizational colleagues they communicated once a week or more. In this process, the emphasis was on communications about “scientific and technical matters”. The instrument was a questionnaire that listed the names of all scientists and engineers, and asked the respondents to indicate to which people in the list they communicated about scientific and technical matters on a day. Allen mentions that these questionnaires were distributed at the end of each workday. The author states that walking distances between individuals were measured through the floor plans and maps provided by these organizations. Each individual was considered as a focal person, and the walking distance from his / her desk to other individuals was measured. For each three-meter interval of this distance, the ratio of number of communicated individuals in that interval to the total number of available people was computed. Thus, an index of communication was computed for each interval.

Based on the computed communication ratios, Allen has plotted the aggregate ratios for all respondents as “the probability that two people will communicate about a scientific or technical subject matter (Allen, 1984: 236).” It was seen that within an interval of 0-100 meters, the probability of communication decreased significantly as distance increased. Thus, distance was found to be an important influence on the communication patterns of individuals in research and development laboratories.

Allen’s findings (1984) are important for the purposes of the present study. The study integrates two lines of inquiry: one that looks at the role of communication and interaction in innovation processes, and one that looks at the role of space in innovation processes. Although the author does not explicitly link the results of these two lines of inquiry, that is, he does not mention the relationship between “research and development effectiveness” and influence of space, this study still is a supportive one considering the purpose and questions of the present study. Finally, Allen’s study is also informative in the sense that it introduces a methodology for considering the
influence of distance, which is different than space syntax method. Distance, in this example is evidently an important variable.

A number of points have to be highlighted at this point. While all these studies refer to innovation literature, and show some relationships between space and human encounters, they (i) usually deviate from actual settings of innovation and (ii) usually deal with space only at the level of fixed-feature space. Penn, Desyllas and Vaughan’s (1999) study is a case in this sense. Although the authors have shown some relationship between spatial configuration and face-to-face interaction as a precursor of innovation, the context of the study is an advertising agency. Hillier and Penn (1991), and Hillier (1996) on the other hand, have studied the relationship between syntactical properties of spatial configuration and co-presence and interaction in space, within eight research laboratories (innovation settings). However, these authors have dealt with space only at the level of fixed-feature space, and have not shown a direct connection to innovation process outcomes. Space – face-to-face interaction relationship has also been confirmed by Backhouse and Drew (1992), but within the context of an architectural office. Then, the studies of space – innovation relationships have strong implications about the relationship of spatial configuration and face-to-face interaction as a precursor of innovation. However, these studies have been limited in number, have analyzed space only through fixed-feature space (i.e. spatial configuration or distance), and usually have taken place in settings other than those of innovation. In addition, whether these interactions are work-related consultations or not is another remaining question. Moreover, these studies have not considered the recently introduced notion of commons and their influence in terms of availability, number and environmental qualities. Finally, environmental qualities of studied spaces as perceived by their inhabitants have been lacking in all of these studies.

2.4.1. Innovation, its Precursors and Space

This review of literature reveals four important points.

1. Within innovation literature, research has confirmed that increased communication of information through face-to-face consultation is a major precursor of innovation. Sonnenwald and Lievrouw (1996), Ancona and Caldwell (1992) and Ancona (1990) among others have found that increased intra-group and inter-group face-to-face consultation facilitates innovation, which was assessed through perceived personal or team performance. Moreover, other authors also subscribe to the idea that increased face-to-face consultation facilitates innovation (i.e. Kanter, 1988; Dougherty, 1996). However, despite the confirmed potential of fixed feature, semi-fixed feature and non-fixed feature space in facilitating face-to-face interaction in environment and behavior studies, space has not been considered as a variable in innovation literature.
2. Within environment – behavior studies, research has confirmed that, space can affect face-to-face interaction, which is a precursor of innovation. Penn, Desyllas and Vaughan (1999), Hillier and Penn (1991) and Backhouse and Drew (1992) have shown that fixed feature space (to be more specific, spatial configuration) can affect face-to-face interaction. However, first, a low number of such studies have explicitly dealt with innovation settings (i.e. research laboratories), and second, even when studying innovation settings, space has been considered at a single level of analysis (i.e. only spatial configuration, which is a concern at the level of fixed-feature space). Moreover, these studies have only focused on the quantity of interactions, as opposed to the nature of these interactions, such as whether these are work-related consultations or not.

3. Within innovation literature, research has also shown that organizational context affects innovation process outcomes (i.e. Allen, 1984).

4. Based on the reviewed literature, it is possible to represent the relationship of space to innovation process outcomes with a conceptual model that takes the effects of space, information consumption and organizational context on innovation process outcomes. This conceptual model represents the effects of space and organizational context on information consumption and its effects on innovation process outcomes (Figure 2.4).
Figure 2.4. Conceptual model representing the relationships between space, organizational context, information consumption and innovation process outcomes.

2.4.2. Summary

The studies that exist in innovation and environment – behavior literature exhibit diverse approaches in terms of the variables considered, as well as their measurements. If one groups these variables into general terms, they would exist as “space”, “interaction” and “innovation” in short. Therefore, the main points that come out of this section are fourfold.

1. In innovation literature, consultation exists as a precursor of innovation, and research has shown that increased consultation facilitates innovation (which has been measured in various ways).
2. In environment – behavior literature, the relationships between space and interaction has been studied in various settings. Research has shown that space can influence face-to-face interaction at three levels of analysis (fixed-feature, semi-fixed feature and non-fixed feature space) in different settings.

3. In environment – behavior literature, studies of space – interaction relationships specifically in innovation settings have remained at the level of fixed-feature space. Although semi-fixed feature space and non-fixed feature space has been shown to be effective on interaction in settings other than innovation, studies in innovation settings have not analyzed space at these levels. Moreover, the contemporary notion of commons and its influence, as well as environmental qualities as perceived by inhabitants have not been considered in these studies. In addition, these studies have focused on quantities of observed face-to-face interactions rather than actual work-related consultations.

4. In environment – behavior literature, studies of space – interaction relationships specifically in innovation settings have considered only the quantities of face-to-face interaction, but not the nature of these interactions. On the other hand, innovation literature indicates that the quality of these interactions are important, and, whether the interaction is about technical matters or not, whether the interaction is coincidental, prescheduled, inter-team or intra-team is an important issue.

5. Within the existing innovation and environment – behavior literature, the entire chain of relationships among space, interaction and innovation has not been inquired in a single study, where work-related consultations are considered rather than only quantities of observed interactions or quantities of movement.

Therefore, the entire space – consultation – innovation chain has to be studied. This would be only possible by connecting the chain in a comparative study – that is, by looking at space-consultation-innovation chain in a number of cases at the same time and comparing a number of cases – and by looking at space at the three mentioned levels of analysis. Such a study is lacking in the existing literature.
CHAPTER 3

PURPOSE OF THE STUDY

The main purpose of this study is to understand the relationships between space and innovation process outcomes within basic science and research settings. The context of the study is university research centers, which are defined as basic science and research settings in the innovation literature.

3.1. THE CONCEPTUAL MODEL

A review of existing innovation literature (i.e. Tornatzky and Fleischer, 1990; Sonnenwald and Lievrouw, 1996; Allen, 1984; Kline and Rosenberg, 1986; Kanter, 1988) has indicated that organizational context and information consumption are two major factors that influence innovation process outcomes in basic science and research settings. In this framework, information consumption through face-to-face technical consultation is a major precursor of innovation. Review of existing environment and behavior research has indicated that space is related to human encounters (i.e. face-to-face interactions) at proxemic levels of fixed, semi-fixed and non-fixed feature space (i.e. Osmond, 1959; Hall, 1966; Bechtel, 1977; Wicker, 1979 Hiller and Hanson, 1984; Peponis, 1985 among others) in various contexts in heterogeneous cultures (Rapoport, 1982). Therefore, based on the reviewed literature, space, organizational context and information consumption are the three variables that affect innovation process outcomes.

The relationships between space and the information consumption exist within the organizational contexts of university research centers. Throughout the literature review, a number of authors have indicated that organizational context influences innovation process outcomes. These relationships were organized within a conceptual model of relationships among variables in Chapter 2 (Figure 2.5). In order to focus explicitly on the effects of space on innovation process outcomes, it is vital to understand and differentiate the effects of organizational context clearly. In this respect, space – innovation process outcomes relationships have to be represented within each organizational context. When more than one organizational contexts are considered, the effects of organizational context have to be “constant” in order to understand the effects of space on innovation process outcomes.

Then, in an inquiry into the relationships between space and innovation process outcomes within basic science and research settings, a conceptual model can be constructed through space, information consumption and innovation process outcomes relationships. Three indicators of information consumption are utilized to form the conceptual model of relationships between space and innovation process outcomes: information
consumption patterns, technical consultation networks of researchers, and patterns of space use for face-to-face technical consultation.

Therefore, within the organizational context of university research centers, the relationships between space and innovation process outcomes are examined through the relationship of space to information consumption patterns, technical consultation networks, and patterns of space use for face-to-face technical consultation.

The variables are defined as follows. Innovation process outcomes are defined as the dependent variable. Space is defined as the independent variable. Three indicators of information consumption, defined as information consumption patterns, technical consultation networks and patterns of space use for face-to-face technical consultation are defined as mediating variables. The conceptual model for this study and its variables are described in Figure 3.1.

![Figure 3.1. Conceptual model of the study.](image-url)
3.2. RESEARCH QUESTIONS

The main research question of this study is:

“How does space affect innovation process outcomes in basic science and research settings?”

In order to answer this question, an initial point of inquiry exists as space – information consumption relationships. Based on the conceptual model constructed, three indicators of information consumption are: information consumption patterns, technical consultation networks, and patterns of space use for face-to-face technical consultation.

The immediate relationship of space to information consumption is at the level of space – patterns of space use for face-to-face technical consultation relationships. Since face-to-face technical consultation is a significant resource, whether space affects patterns of space use for face-to-face technical consultation constitutes a starting point. Thus, the first research question of this study is:

**RESEARCH QUESTION 1.** What is the effect of space on patterns of space use for face-to-face technical consultation?

This study defines space at three proxemic levels: fixed-feature space, semi-fixed feature space and non-fixed feature space. Therefore, research question 1 has to be answered through these three proxemic levels.

**RESEARCH QUESTION 1.A.** What are the relationships between fixed-feature space and patterns of space use for face-to-face technical consultation?

Fixed-feature space was described by spatial configuration (syntactical properties of space), and distance (metric and geometric properties of space). Thus, the relationships between fixed-feature space and patterns of space use for face-to-face technical consultation have to be examined through these spatial properties.

**RESEARCH QUESTION 1.A.1.** What are the relationships between spatial configuration in fixed-feature space and patterns of space use for face-to-face technical consultation?

**RESEARCH QUESTION 1.A.2.** Which syntactical properties of fixed-feature space affect patterns of space use for face-to-face technical consultation?

**RESEARCH QUESTION 1.A.3.** What are the relationships between walking distances and patterns of space use for face-to-face technical consultation?
Answers to research question 1 also have to be sought at the level of semi-fixed and non-fixed feature space:

**RESEARCH QUESTION 1.B. What are the relationships between semi-fixed feature and non-fixed feature space and patterns of space use for face-to-face technical consultation?**

At the level of semi-fixed and non-fixed feature space, the main concern of the study is to understand which semi-fixed and non-fixed feature elements are related to patterns of space use for face-to-face technical consultation. Then, where face-to-face technical consultations take place, and where they are most likely to take place have to be inquired. Face-to-face technical consultations take place in spaces where researchers indicate that they most frequently meet others. They are also most likely to take place in spaces where researchers most frequently go when they leave their space.

In this respect, semi-fixed and non-fixed feature elements of those spaces where researchers most frequently meet others, and those spaces where researchers most frequently go when they leave their offices gain importance. The semi-fixed and non-fixed feature elements of such spaces are inquired through their positive and negative environmental qualities as perceived by researchers, and researchers’ reasons for their use:

**RESEARCH QUESTION 1.B.1. What are the environmental qualities of those spaces where researchers most frequently meet others throughout their work?**

**RESEARCH QUESTION 1.B.2. What are the environmental qualities of those spaces where researchers go when they leave their space within the building / research center they work in? What are the reasons for the researchers to use those spaces?**

Once the patterns of space use for face-to-face technical consultation in different university research centers are determined, technical consultation networks can be examined based on the findings of analyses for answering the first question. *Technical consultation networks* form the second indicator of information consumption, whose relationships to space are sought. Technical consultation networks indicate regular patterns of technical consultation among researchers. Therefore, how they are formed in university research centers with different spatial features is important in understanding space and innovation relationships:

**RESEARCH QUESTION 2. What is the effect of space on technical consultation networks of researchers?**

Based on the findings of analyses for answering the first two research questions, information consumption patterns can be examined. The last information consumption indicator, whose relationship to space is inquired, is *information consumption patterns*. It is possible for researchers to select from a number of information
resources in university research centers: face-to-face or non-face-to-face technical consultations, or other information resources such as literature, experimentation, etc. In this respect, how much different information resources are selected / preferred in university research centers with different spatial features gains importance:

**RESEARCH QUESTION 3. What is the effect of space on researchers’ information consumption patterns?**

Another point of interest of this study is patterns of information consumption through face-to-face technical consultation, and how this varies in university research centers with different spatial features. Therefore, within information consumption patterns, the following question is also pursued:

**RESEARCH QUESTION 3.A. What is the effect of space on information consumption through face-to-face technical consultation?**

Through explanation building based on the findings and discussions about these research questions, space – information consumption relationships in different university research centers with varying spatial features can be identified. At this point, the question is to compare university research centers regarding their spatial features, information consumption, and innovation process outcomes. Therefore, the main research question of the study can be answered with a discussion of the following question:

**RESEARCH QUESTION 4. What is the effect of space, at three levels of analysis (fixed-feature, semi-fixed feature and non-fixed feature space), on information consumption and innovation process outcomes in basic science and research settings?**

3.3. DEFINITION OF TERMS

3.3.1. Innovation Process Outcomes

“INNOVATION” refers to the processes of developing and introducing a new idea, device or method within basic science and research settings of university research centers (Tornatzky and Fleischer, 1990).

“BASIC SCIENCE AND RESEARCH SETTINGS” refers to university research centers conducting basic science and research activities. “BASIC SCIENCE AND RESEARCH” refers to research mainly conducted in university research centers with the objective of “generation of new knowledge” – scientific breakthrough (Tornatzky and Fleischer, 1990).

“INNOVATION PROCESS OUTCOMES” refers to the researchers’ judgmental and nonjudgmental ratings of the research process in university research centers (Bamberger, 1991). By “JUDGMENTAL RATINGS”, researchers’
subjective evaluations of the process are addressed. By “NONJUDGMENTAL RATINGS”, objective knowledge and application outputs of the process are addressed (Bamberger, 1991).

3.3.2. Space

“SPACE” is defined by (contained by) the main building elements (such as walls and slabs) and any other object (such as furniture). Therefore, “space” should be distinguished from physical building elements as objects. In this study, space is categorized into three units of analysis as fixed-feature space, semi-fixed feature space and non-fixed feature space (Hall, 1966).

“FIXED-FEATURE SPACE” is defined by the main building elements (such as walls and slabs) (Hall, 1966). Spatial configuration and distance are descriptors of fixed-feature space.

“SPATIAL CONFIGURATION” refers to the non-metric, non-geometric relationships between a space and another, or between more than two spaces, taking into account all other spaces in the whole system (Hillier and Hanson, 1984). Spatial configuration is described by the syntactical properties of space. “SYNTACTICAL PROPERTIES OF SPACE” refers to those spatial properties termed as depth, integration (RRA), control value, connectivity, intelligibility, and visibility in systems of spaces that are analyzed by utilizing the space syntax method (Hillier and Hanson, 1984). Detailed definitions and operationalization of these terms are provided in the methodology of the study. DISTANCE refers to the metric property of proximity between two spaces.

“SEMI-FIXED FEATURE SPACE” refers to space defined by any object other than main building elements (such as furniture) (Hall, 1966).

“NON-FIXED FEATURE SPACE” refers to space defined by human behavior according to the situation in each context. It is composed of certain boundaries of space maintained by human beings when encountering others (Hall, 1966; Sommer, 1969).

Perceived environmental qualities of space and reasons for space use are descriptors of semi-fixed and non-fixed feature space. “ENVIRONMENTAL QUALITIES OF SPACE” refers to qualities of the studied spaces as perceived by their users. “REASONS FOR SPACE USE” refers to the reasons for use of the studied spaces as stated by their users.

3.3.3. Organizational Context

“ORGANIZATIONAL CONTEXT” refers to organizational characteristics of university research centers and individual characteristics of researchers (Tornatzky and Fleischer, 1990).
3.3.4. Information Consumption

“INFORMATION CONSUMPTION” refers to utilization of information resources for research purposes (Sonnenwald, 1999). Three indicators of information consumption are defined in this study.

“INFORMATION CONSUMPTION PATTERNS” refers to researchers’ overall amounts of information consumption through face-to-face or non-face-to-face technical consultations and priorities of other information resources as stated by researchers (Sonnenwald, 1999). “INFORMATION RESOURCE” refers to face-to-face or non-face-to-face technical consultations, as well as literature, vendors, customers, external sources, previously conducted research, experimentation and personal experience used as information resources upon researchers’ recognition of lack of knowledge (Sonnenwald, 1999). “TECHNICAL CONSULTATION” refers to all research-related knowledge and information exchange among researchers upon recognition of lack of knowledge (Allen, 1984). This covers information consumption through various media, such as face-to-face technical consultations, or technical consultations through e-mail, telephone, fax and other information technologies, and excludes non-research related discussions among researchers.


“PATTERNS OF SPACE USE FOR FACE-TO-FACE TECHNICAL CONSULTATION” refers to the amount of face-to-face technical consultations for each space in the entire system of spaces.
CHAPTER 4

METHODOLOGY

4.1. CONTEXT

University research centers constitute the context for the study, where basic science and research is conducted with the main objective of knowledge generation.

4.2. RESEARCH STRATEGY

This study utilized a multiple-case study research design with multiple units of analysis. While there is extensive discussion in the literature on case study as a research strategy, a definition for case study has been provided as follows:

“A case study is an empirical inquiry that (i) investigates a contemporary phenomenon within its real-life context; when (ii) the boundaries between phenomenon and context are not clearly evident, and in which (iii) multiple sources of evidence are used (Yin, 1984: 23).”

The term case study is used here as a field research strategy as opposed to a teaching strategy based merely on literature search. A multiple case study is analogous to multiple experiments in the sense that, each case is treated as a single experiment. Accordingly, the group of cases selected and studied is not treated as a sample from a larger population for the case study research design. Thus, the results of single case studies are not held subject to statistical analysis across cases. A replication logic is followed in the analysis of findings, as opposed to a sampling logic.

Two main strategies in the replication logic are pattern matching and replication seeking. In pattern matching, findings are compared across cases (or compared to a proposition) in order to find and display results forming patterns throughout the course of the study. In replication seeking, repeating patterns across cases are sought and displayed as evidence. As a result, instead of “statistical generalization” by treating each case like a sample from a larger population, analytic generalization is made in case study as a research strategy, by utilizing an analogy of multiple experiments and treating each individual case analogous to a single experiment. Generalization to a proposition is made as opposed to generalizing to a population (Yin, 1984).

Accordingly, six university research centers were selected as individual cases within a multiple case study research design. In the following sections, the case study design, case selection criteria used, operationalization of variables, data collection methods and instrumentation will be explained.
4.2.1. Starting Up: Case Selection

In order to focus on the influence of space on innovation process outcomes, two sets of case selection criteria were identified: criteria about the spaces occupied by URCs, and criteria about the organizational context URCs.

The first set of criteria focused on selection of cases with different spatial features. Based on a spatial categorization of URC plans, this set of criteria provided a group of cases with clearly identifiable spatial differences.

The second set of criteria focused on selection of cases with similar organizational contexts. In doing so, the potential “noise” due to differing organizational contexts could be avoided, and special focus on space and its influence could be maintained in order to ensure internal validity.

Cases were selected by the following procedure.

4.2.2. Criteria for Case Selection 1: Spatial Categorization of University Research Centers

In order to sustain the systematic nature of the inquiry in terms of the spaces occupied by basic science and research settings, an extensive number of URC floor plans were analyzed and categorized according to their spatial configurations. The floor plan analysis for this categorization comprised fifty URC plans from the literature (AIA, 1996), which included URCs across the United States, as well as National Science Foundation Science and Technology Centers (NSF-STCs) and North Carolina State University, Ohio State University, University of California Santa Cruz, University of North Carolina – Charlotte, University of North Carolina – Chapel Hill URC plans.

The major objective for such a categorization was to form a series of graphical representations of functions and functional interrelationships that exist in contemporary URCs. Three spatial categories were identified according to this analysis. The URCs were selected according to this spatial categorization. Within a multiple case study research strategy, the objective was to select two URCs in each of the three spatial categories, so that the varying spatial configurations existing in contemporary URCs could be sufficiently represented.

4.2.2.1. “Territory” of a URC

The categorization of university research centers according to their spatial configurations was based on the spaces occupied by each center. In this categorization, the term “territory” will be used for the total of all those spaces occupied exclusively by a URC. Therefore, the territory of a university research center includes all convex spaces designated only for use of that particular university research center. In this respect, for example,
a room shared by more than one university research center, remains outside the territories of all those URCs that share that room. Those convex spaces designated only for use of a particular URC constitute **territorial convex spaces** for that URC. All other spaces that are not designated only for use of a particular URC constitute **non-territorial convex spaces** for that URC.

The territory of a URC may be **intact** or **non-intact** based on the locations of its territorial convex spaces relative to each other. **An intact URC territory** is composed of a number of territorial convex spaces, where people do not have to move through any non-territorial convex spaces to reach from one territorial convex space to another. **A non-intact URC territory** is composed of a number of territorial convex spaces, where people may have to move through non-territorial convex spaces to reach from one territorial convex space to another.

Each of the analyzed URCs displayed at least two of four functions in their territories. The four basic functions that were observed in university research centers were the **office core**, the **office**, the **laboratory** and the **laboratory support space**. The **primary circulation**, although not being a part of a URC territory, will be defined along with the four basic functions for a clear categorization.

**Primary Circulation (PR):** *Primary circulation* represents those convex spaces where people pass through before entering the territory of a URC. There were two situations in which PR was formed by different convex spaces. **Situation 1.** Throughout the analysis of URC floor plans, it was observed that many URCs were in buildings that accommodated more than one URC. In such buildings, in order to enter a URC territory, individuals pass through a series of convex spaces that are shared by all URCs in the building. This series of convex spaces are formed by spaces such as entrance halls, corridors, or stairs that are not specifically in the territory of one URC, but are shared by all URCs as means of circulation. Therefore, corridors or a similar series of circulation spaces form the primary circulation. **Situation 2.** In rare instances, if the center under consideration occupies a building exclusively designated for its use, the last open space before entering the building (i.e. a sidewalk, a parking lot, etc.) constitutes the primary circulation. The relationships between a URC territory and primary circulation in these two situations are shown in two abstracted permeability graphs in Figure 4.1.
The basic functions of URCs were defined as follows.

1. **Office Core (OC):** The office core is shared by all individuals affiliated with a URC. It is composed of at least one, but in most cases more than one convex space. The convex spaces may form a series of corridors, as well as central spaces where width to length ratio is larger than a corridor. In most cases, the majority of offices, and in some cases, a laboratory is directly connected to the office core. The office core may also accommodate open offices. In some examples, it was observed that the office core accommodated shared equipment such as fax machines or printers.

2. **Offices (O):** Offices are either single convex spaces with at least four walls reaching the ceiling and a door (cellular offices), or single convex spaces with at least one enclosing partition, which rarely reach a height of six feet (open offices). They are mainly intended for concentrated work. Cellular offices may be occupied by single individuals (cellular individual offices) or shared by a number of individuals (cellular shared offices). Cellular offices have a high level of privacy and usually a low level of visibility. Open offices, on the other hand, are configurationally different than cellular offices, although used with the intention of concentrated work. Commonly referred to as a “cubicles”, open offices are always grouped together, and usually accommodated in office cores. They have a low level of privacy, and usually high levels of visibility.

3. **Laboratory (L):** In university research centers that have laboratories, a laboratory is composed of a series of convex spaces that accommodate counters and shelves. Individual or shared working spaces
are provided on counters. In some cases, the laboratory may be connected to a primary circulation (PR), where the relationship between the office core and the laboratory is an indirect connection. In other cases, the laboratory is always directly connected to the office core. The laboratory may rarely form a “home base” (i.e. function similar to an office) to certain individuals in university research centers, based on the research conducted. Also, in some rare cases, a small number of offices (less than 5% of the total number of offices) may be connected directly to the laboratory.

4. Laboratory Support Spaces (S): These spaces accommodate special equipment for specifically defined processes (i.e. DNA sequencing). A laboratory support space is in most cases composed of a single convex space. If one or more of sensitive substances, sensitive equipment, sensitive processes, hazardous or toxic materials are accommodated, at least four walls and a door define the convex space. In these instances, the laboratory support spaces are also sealed with special doors and/or wall materials. In other rare instances such as dish washing, a door may not exist; the convex space may be defined by three walls, or may be connected to another convex laboratory support space. Whether the laboratory support space is sealed or not, it is always directly connected to the laboratory. Due to safety reasons, in URCs where the laboratory is directly connected to primary circulation (PR), the number of support spaces tends to increase.

The analysis of the interrelationships among these four basic functions and primary circulation yielded three major categories according to the architectural program and spatial configuration of university research center territories.

4.2.2.2. Category 1 URCs

Category 1 URCs accommodate both offices and laboratories in their territories. The functional interrelationships within Category 1 URCs are composed of an office core (OC), offices (O), a laboratory (L) and laboratory support spaces (S). These URCs have an intact territory: there is no need to pass through a primary circulation (PR) while navigating the URC territory. Consequently, the laboratory is directly connected to the office core. The spatial configuration of Category 1 URCs is defined as follows.

1. There is an office core (OC), offices (O), a laboratory (L) and laboratory support spaces (S). The primary circulation (PR) is directly connected to the office core, which constitutes the major circulation core.

2. Offices, either open or cellular, are directly connected to the office core. In rare cases, an insignificant number of offices (below 5%) may be connected directly to the laboratory.
3. The laboratory is directly connected the office core.

4. Laboratory support spaces are directly connected to the laboratory.

In this spatial configuration, the office core becomes the main circulation carrier within the center. Consequently, the relationship of all other spaces in the system to the primary circulation (PR) is through the office core, which makes all other spaces one step deeper from the primary circulation. Category 1 URCs are graphically represented with the abstracted permeability graph in Figure 4.2.

![Figure 4.2. Abstracted permeability graph for Category 1 URCs.](image)

4.2.2.3. Category 2 URCs

Category 2 URCs accommodate both offices and laboratories in their territories. The functional interrelationships within Category 2 URCs are composed of one or more office cores (OC), offices (O), one or more laboratories (L) and laboratory support spaces (S). These URCs have a non-intact territory. The URC territory is divided into two or more sectors. When navigating the URC territory, people pass through the primary circulation (PR) in order to move from one sector to another.

There are two types of sectors in Category 2 URCs. The **office sector** is composed of an office core and offices (OC + O), whereas the **laboratory sector** is composed of a laboratory and laboratory support spaces (L + S). In category 2 URCs, there are at least two sectors separated by primary circulation. At least one **office sector** and one **laboratory sector** always exist in Category 2 URC territories.

The spatial configuration of Category 2 URCs is defined as follows.
1. There is at least one office core (OC), offices (O), at least one laboratory (L) and laboratory support spaces (S). There are at least two sectors, one with an office core and offices (OC + O = office sector), and one with a laboratory and laboratory support spaces (L + LS = laboratory sector), separated by primary circulation (PR).

2. The primary circulation (PR) is directly connected to the office core of office sectors, and to the laboratory of laboratory sectors. Therefore, in order to reach from one sector to another, one has to pass through primary circulation.

3. Offices, either open or cellular, are directly connected to the office core. In rare cases, an insignificant number of offices (below 5%) may be connected directly to the laboratory.

4. The laboratory is directly connected the office core.

5. Laboratory support spaces are directly connected to the laboratories.

Category 2 URCs are graphically represented with the abstracted permeability graph in Figure 4.3.

![Figure 4.3. Abstracted permeability graph for Category 2 URCs.](image)

4.2.2.4. Category 3 URCs

Category 3 URCs accommodate offices, but no laboratories in their territories. The functional interrelationships within Category 3 URCs are composed of two office cores (OC) and offices (O). Although it is possible that single office core URCs with only offices exist, such examples were not encountered in analyses of URC floor plans. Due to the requirements of their data collection and research processes, Category 3 URCs do not accommodate laboratories. Category 3 URCs have intact territories: there is no need to pass through a
primary circulation (PR) while navigating the URC territory. The spatial configuration of Category 3 URCs is defined as follows.

1. The spatial configuration is composed of two office cores (OC) and offices (O).

2. The primary circulation (PR) is directly connected to an office core, which constitutes the major circulation carrier within the territory either by itself or with another office core.

3. Offices, either open or cellular, are directly connected to an office core.

In this spatial configuration, the office cores form the main circulation carrier within the center. Consequently, the relationship of all other spaces in the system to the primary circulation (PR) is only through office cores, which makes all other spaces one step deeper from the primary circulation. Category 3 URCs are graphically represented with the abstracted permeability graph in Figure 4.4.

![Abstracted Permeability Graph for Category 3 URCs](image)

**Figure 4.4.** Abstracted permeability graph for Category 3 URCs.

4.2.2.5. Summary

The categorization of URCs according to their spatial configurations indicated that although all URCs accommodate offices and at least one office core, laboratories and laboratory support spaces might not be present in some URCs. Depending on their research areas, analyzed URCs either had only offices, or both offices and laboratories at the same time. The first group was composed of those URCs whose data collection and research process is based on computerized processes (i.e. simulations). The second group, on the other
hand, was composed of those URCs whose data collection and research process required laboratory work and related special equipment (i.e. DNA sequencing, autoclave, studies with various solvents).

This difference between the two groups is significant, due to the fact that it affects work patterns (i.e. a certain amount of work time is spent in laboratories by researchers in those URCs in the second group, as opposed to spending more work time in offices by researchers in those URCs in the first group), and as a result, patterns of information flow through face-to-face technical consultation.

In order to reach a set of cases that is representative of contemporary URCs, at least two URCs that correspond to each of these three spatial categories were selected.

4.2.3. Criteria for Case Selection 2: Organizational Context of University Research Centers

The second set of case selection criteria required that the selected university research centers had to be similar in terms of their organizational contexts (Table 4.1). Organizational contexts were measured in terms of:

- Formalization (number of levels of hierarchy)
- Complexity (degree of professionalization and number of professional groups in the organization)
- Available resources (number of funds)
- Level of interdependence among researchers / research teams
- Coherence on a research agenda
- Close alignment to a strategic plan
- Number of projects carried on,

And,

- Individual characteristics of researchers.
Table 4.1. Organizational context of university research centers.

<table>
<thead>
<tr>
<th>ORGANIZATIONAL CONTEXT</th>
<th>INDIVIDUAL CHARACTERISTICS (Personal characteristics of individuals)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formalization (number of levels of hierarchy)</td>
<td>Number of years of technical experience in the specific field in which the individual is currently engaged</td>
</tr>
<tr>
<td>Complexity (degree of professionalization and number of professional groups in the organization)</td>
<td>Number of years the individual has been working for that research center</td>
</tr>
<tr>
<td>Available resources (number of funds)</td>
<td>The individuals’ level of education</td>
</tr>
<tr>
<td>Level of interdependence among researchers / research teams</td>
<td></td>
</tr>
<tr>
<td>Coherence on a research agenda</td>
<td></td>
</tr>
<tr>
<td>Close alignment to a strategic plan</td>
<td></td>
</tr>
<tr>
<td>Number of projects carried on</td>
<td></td>
</tr>
</tbody>
</table>

This set of case selection criteria was utilized in order to select organizationally similar URCs, so that a clear focus on the effects of space could be achieved, and the potential “noise” due to varying organizational contexts could be eliminated. In this respect, this set of criteria ensured the internal validity of the study.

The information about organizational contexts of contacted URCs was gathered by conducting structured interviews with URC directors. A series of questions were asked to the URC directors about organizational contexts of the URCs they were directing.

The structured interview with URC directors was composed of two parts: subjective information and objective information. In the first part, URC directors were asked to rate (i) the coherence of the research center on the research agenda, (ii) the level of interdependence among researchers / research teams, (iii) the extent to which the research carried on by individuals / teams depended upon other individuals / teams, and (iv) the extent to which research carried on in the research center was closely aligned to a strategic plan. In the second part, the URC directors were asked to report the number of researchers affiliated with the URC, the number of currently active funding resources, whether those funds supported the whole URC or particular projects, and number of research projects carried on in the URC.

4.2.4. Summary

Upon gathering information about organizational contexts of URCs, and associating them with one of the three spatial categories, individual cases were selected according to the case selection criteria. By selecting individual
cases according to these two sets of criteria, those URCs with similar organizational contexts but different spatial configurations were selected, and a clear focus on the effects of space could be achieved.

4.3. OPERATIONALIZATION OF VARIABLES

Innovation process outcomes as the dependent variable, space as the independent variable and information consumption indicators as mediating variables were operationalized based on the definitions provided in Chapter 3. The relationships among these variables were then represented in a detailed conceptual model based on the previously introduced series of relationships among variables.

4.3.1. Innovation Process Outcomes

Innovation process outcomes were defined as the dependent variable, and were operationalized through judgmental and nonjudgmental ratings of those researchers participating in the research process. Judgmental ratings of innovation process outcomes were based on subjective evaluations of the research process by the researchers. Nonjudgmental ratings of innovation process outcomes were based on the actual number of knowledge and application outputs of individuals (Table 4.2).

Table 4.2. Innovation process outcomes.

<table>
<thead>
<tr>
<th>INNOVATION PROCESS OUTCOMES</th>
<th>NONJUDGMENTAL RATINGS (Number of outputs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>JUDGMENTAL RATINGS</td>
<td>KNOWLEDGE OUTPUTS</td>
</tr>
<tr>
<td>Perceived creativity and innovativeness of research conducted in the center</td>
<td>Books</td>
</tr>
<tr>
<td>Perceived level of the center’s overall contribution to the field</td>
<td>Articles</td>
</tr>
<tr>
<td>Perceived level of recognition / reputation of center</td>
<td>Papers</td>
</tr>
<tr>
<td>Overall satisfaction with the research processes that take place in the center</td>
<td>Project proposals</td>
</tr>
<tr>
<td></td>
<td>Conference papers</td>
</tr>
<tr>
<td></td>
<td>Technical manuscripts</td>
</tr>
</tbody>
</table>
4.3.2. Space

Space was defined as an independent variable through three units of analysis: fixed-feature space, semi-fixed feature space and non-fixed feature space.

4.3.2.1. Fixed-Feature Space

Fixed-feature space was analyzed based on spatial configuration and distance. Spatial configuration of research centers was analyzed utilizing space syntax method. Distances between the origin and destination of technical consultations were measured using floor plans of research centers. The spatial variables (syntactical features of space) that were measured through space syntax analysis, their definitions and operationalizations are provided below.

The Space Syntax Method: Basic Definitions And Algorithms In Configurational Analysis. Given a sample spatial configuration (Figure 4.5.a), the whole system of spaces is first divided into the fewest number of convex spaces. One convex space is defined for each cellular space (i.e. a room with four walls) in a system (Hillier and Hanson, 1984). When there are spaces that are not clearly defined by a number of walls (i.e. corridors, spaces defined by less than four walls), one convex space is defined for each space with width to length ratio closest to 1. The objective is to cover the entire system with the fewest number of convex spaces with width to length ratios closest to 1 (Hillier and Hanson, 1984). By analogy, an entire system of spaces is covered by a minimum number of “fattest” convex spaces.

The relationships of all convex spaces in the configuration can then be represented by substituting each convex space with a circle, and each connection among convex spaces (i.e. doors or virtual passages between convex spaces) with a line (Figures 4.5.a and 4.5.b) (Hillier and Hanson, 1984).
These series of circles and lines representing convex space relationships are then “justified” according to a pre-selected “origin”. The “justification” is based on the number of “steps” (i.e. number of connections) that need to be taken in order to reach each space from the “origin”. In space syntax terminology, the “origin” is termed as the “carrier”, and is represented with a cross, superimposed on a circle (see Figure 4.5.b).

For the sample spatial configuration in Figure 4.5.a., when the entrance point is selected as the “carrier”, the “justified permeability graph” of the system can be constructed as shown in Figure 4.5.c.
Figure 4.5.c. The “justified permeability graph” of the sample spatial configuration in Figure 4.5.a. The entrance point is the “carrier”. Each of the remaining convex spaces is justified according to the number of steps need to be taken to reach from the carrier (Based on Hillier and Hanson, 1984: 150).

Each justified permeability graph has one “carrier”. All convex spaces in the system can be selected as the carrier, and permeability graphs can be justified accordingly. However, usually the entrance point to the system is selected for this purpose. In Figure 4.5.c, convex space “A” is 1 step deep from the carrier, convex spaces “2, E, 4, 5, 6” are 2 steps deep from the carrier, and convex spaces “B” and “C” are 3 steps deep from the carrier.

The advantage of representing spatial configurations with “justified permeability graphs” is that, this representation provides the relationships of all convex spaces to each other. Therefore, non-metric and non-geometric properties of spatial configurations are represented. This representation focuses on the spatial interrelationships in a system, rather than the area or shape of convex spaces. In this respect, seemingly very “similar” floor plans can be clearly differentiated from each other by means of examining spatial interrelationships.

A good example for this can be provided by another sample configuration. When metric and geometric properties (size and shape) are considered, the sample spatial configuration in Figure 4.6.a is very “similar” to Figure 4.5.a. However, when spatial interrelationships are considered, the differences between the two spatial configurations can be exhibited by looking at non-metric and non-geometric properties (Figure 4.6.b.) through a justified permeability graph (Figure 4.6.c.).
The syntactical properties of individual spaces and entire systems of spaces are based on these non-metric and non-geometric properties of spatial configuration. The operationalizations of syntactical properties of space are as follows.

**Point Depth (PD).** The *point depth* of a given convex space “A” from another convex space “B” is calculated by the number of convex spaces that is necessary to pass to move from “B” to “A” through the shortest route possible (Hillier and Hanson, 1984). Point depth can be calculated for each convex space with respect to another. In the sample justified permeability graph of Figure 4.5.b., the point depth of convex space “C” is 2 from convex space “A”, or 3 from convex space “E”.

**Mean depth (MD).** *Mean depth* is one derivative of depth, which can be calculated both for individual convex spaces and the whole system.

The mean depth of a convex space “A” in a justified permeability graph is calculated by first assigning depth values to all convex spaces from an original convex space (in this case, “A”), second, adding them up, and third, dividing this sum by the total number of convex spaces in the system minus one (the original space): $[MD_a = \frac{\sum D_{a, bi}}{k-1}]$ where $D_{a, bi}$ = depth of each convex space from the origin, $k$ = number of convex spaces in the system (Peponis, 1985). Thus, the mean depth can be calculated for any individual convex space in the system, including the carrier.
Mean depth of a system “S” is calculated by dividing the sum of mean depths for all individual spaces (a1, a2,…, ai) by the total number of spaces: \[ MD(S) = \frac{\sum MD_{ai}}{k} \] where MD_{ai} = mean depth of each convex space in the system, k = number of spaces in the system (Peponis, 1985).

Relative Asymmetry (RA). This measurement is also named integration, and is a derivative of depth. Relative asymmetry (RA) generalizes depth by comparing how deep the system is from an original convex space (usually the carrier) with how deep it theoretically could be (i.e. if all convex spaces were lined up, adding one level of depth each) (Hillier and Hanson, 1984). This is a measurement of the distribution of integration. RA for a convex space “A” is calculated as follows: \[ RA_{A} = \frac{2(MD_{A} - 1)}{(k - 2)} \] where MD_{A} = mean depth of convex space “A”, k = number of convex spaces in the system (Hillier and Hanson, 1984). Here, low values indicate that the system is shallow from the convex space considered, “A”, that is, the convex space is integrated. Higher values indicate that the system is deep from the space considered, “A”, that is, the space is segregated.

When the whole system is considered, the mean RA is calculated from all points in the system by dividing the sum of RA values of all convex spaces by the number of convex spaces in the system. Thus, RA of a system “S” is calculated by: \[ RA(S) = \frac{\sum RA_{ai}}{k} \] where RA_{ai} = RA of each space in the system, and k = the number of spaces (Hillier and Hanson, 1984).

Global Real Relative Asymmetry (RRAn – Global integration). When systems with significantly different numbers of convex spaces are considered for comparison, a transformation on the RA values is required, in order to eliminate the possible effect of size on the level of RA values. Thus, Real relative asymmetry (RRA) is the transformed form of RA, to be used for comparisons of two systems with significantly different numbers of convex spaces (Hillier and Hanson, 1984).

The RRAn value for a convex space “A” in a system is calculated by dividing its RA with a “D-value”. The D-value is calculated by a formula based on graph theory, and is not calculated by hand each time – usually it is an integral part of the calculations of related software. However, the D-value formula will be introduced here only for illustrative purposes. RRAn of a convex space “A” in a system is calculated by: \[ RRAn_{A} = \frac{RA_{A}}{D_{k}} \] where RA_{A} = RA of the convex space “A”, and D_{k} = D-value for a system of k number of convex spaces (Hillier and Hanson, 1984). The D-value of a system with k convex spaces is calculated by: \[ D_{k} = \frac{6.644k \cdot \log_{10}(k + 2) - 3.17k + 2}{(k^{2} - 3k + 2)} \] where k = the number of convex spaces in the system (Hillier and Hanson, 1984). Lower RRAn values for convex spaces indicate that they are segregated, while higher values indicate that they are integrated.

When the whole system is considered, RRAn of a system “S” is calculated by dividing the sum of RRAn values for all convex spaces by the total number of spaces: \[ RRAn(S) = \frac{\sum RRAn_{ai}}{k} \] where k = the number of convex
spaces in the system (Hillier and Hanson, 1984). Lower RRA_n values for systems indicate that they are segregated, while higher values indicate that they are integrated.

**Local Real Relative Asymmetry (RRA^3 – Local integration).** In space syntax method, the *local real relative asymmetry* of a convex space can be calculated according to the desired numbers of convex spaces around it. RRA^3 is a local measure of integration according to (n) numbers of convex spaces around the convex space under consideration. Since it is usually calculated for a “radius” of 3 (local integration according to three convex spaces around the space under consideration), it is termed RRA^3. However, it can be calculated for any radius by substituting the total number of convex spaces in the system (k) by “n”. Therefore, local integration of a convex space “A” according to a radius “n” can be calculated by: [RRA_n = RA_a / D_n] where RA_a = RA of the convex space “A”, and D_n = D-value for a system of (n) number of convex spaces (Hillier and Hanson, 1984). When RRA^3 is calculated, “n” equals 3. Lower RRA^3 values for individual convex spaces indicate that they are locally segregated, while higher values indicate that they are locally integrated.

**Control Value (CV).** Control value represents the level of control that a convex space “a” has on its neighbors for permeability to them. Each convex space in the system has n number of immediate neighbors. Then, each convex space “a” with i number of immediate neighbors, b_1, b_2, …b_i, receives 1/n from b_1, 1/n^2 from b_2, until 1/n^i from b_i (Hillier and Hanson, 1984; Peponis, 1985). The control value of a convex space “a” is the sum of control received from each of its immediate neighbors: {CV_a = Σ[1/ Val(b_i)]} where Val(b_i) = the number of immediate neighbors of convex space “b”, which are immediate neighbors of the convex space under consideration – “a” (Hillier and Hanson, 1984; Peponis, 1985). Control value can be calculated for each convex space in a system (Hillier and Hanson, 1984). Higher CV values for individual convex spaces indicate higher control, while lower values indicate lower control.

**Connectivity (CONN).** Connectivity of a convex space in a system is the number of all other spaces directly linked to it (accessed with no change of direction) (Hillier and Hanson, 1984).

**Intelligibility (I).** Intelligibility is the degree to which convex spaces with high levels of connectivity also have high values of integration. Higher integration and higher connectivity makes a convex space intelligible, which means that the convex space gives a good idea about the navigation of the entire system, since the number of convex spaces that are directly accessible and the degree of global integration is high. Intelligibility of a convex space “a”, can be calculated by: [I_a = Connectivity_a / RRA_a] where Connectivity_a is the connectivity of convex space “a”, and RRA_a is the real relative asymmetry of the convex space “a” (Hillier, 1996).
The intelligibility of a whole system is also calculated. For this, a regression analysis of connectivity and RRA of all convex spaces in the whole system is made. In this case, the correlation coefficient “r” (based on Pearson’s test) gives the intelligibility of the whole system. High positive correlations indicate high intelligibility of a system (-1<r<1) (Hillier, 1996).

**Visibility (iso).** Visibility is the total set of all points (isovist) that can be seen from a selected point in a spatial configuration. For any “vantage point” x in a spatial configuration D, V_x is the set of points v, such that all v are visible from x. Therefore, V_x is termed the visible set or isovist at “vantage point” x (Figure 4.7): “V_x = {v ∈ D : v is visible from x}” (Benedikt, 1979: 49).

Based on these three components of the boundary of an isovist, the measure of visibility is then defined as the area of the isovist, A_x = A(V_x), which measures how much space can be seen from x in terms of area (Benedikt, 1979).

![Figure 4.7](image.png)

**Figure 4.7.** The visibility of a selected point “x” in a spatial configuration: an isovist. Illuminated areas represent V_x (Based on Benedikt, 1979: 50).

The **mean isovist (MEANiso)** of an individual space is calculated by first, superimposing a high resolution grid on its floor plan; second, calculating the isovists of each square of the grid; third, taking the mean value of all isovists of this grid (Benedikt, 1979). The resolution of the grid is selected by the researcher, where higher resolutions yield more accurate MEANiso values.
4.3.2.2. Semi-fixed and Non-fixed Feature Space

Semi-fixed and non-fixed feature space was analyzed by respondents’ perceived environmental qualities of those spaces (i) where they most frequently meet others throughout their work, and (ii) where they go when they leave their space within the building / research center they work in. The reasons for the respondents to use those spaces where they go when they leave their space within the building / research center they work in was also analyzed as an aspect of semi-fixed and non-fixed feature space.

Operationalization of space is summarized in Table 4.3.

<table>
<thead>
<tr>
<th>SPACE</th>
<th>FIXED FEATURE SPACE</th>
<th>SEMI-FIXED FEATURE AND NON-FIXED FEATURE SPACE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL CONFIGURATION</td>
<td>DISTANCE</td>
<td>PERCEIVED ENVIRONMENTAL QUALITIES</td>
</tr>
<tr>
<td>Depth (PD) (for individual spaces)</td>
<td>Distance between the origin and destination of technical consultations</td>
<td>Of those spaces where respondents most frequently meet others throughout their work</td>
</tr>
<tr>
<td>Mean depth (MD) (for individual spaces and the entire system)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Real relative asymmetry (RRAn) (for individual spaces and the entire system)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local Real Relative Asymmetry (RRA3) (for individual spaces)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control value (CV) (for individual spaces)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connectivity (CONN) (for individual spaces)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intelligibility (I) (for individual spaces and the entire system)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visibility (MEANiso) (for individual spaces)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.3.3. Information Consumption Indicators: Information consumption patterns, technical consultation networks and patterns of space use for face-to-face technical consultation

Information consumption patterns, technical consultation networks and patterns of space use for face-to-face technical consultation were defined as mediating variables.
4.3.3.1. Information consumption patterns

*Information consumption patterns* were conceptualized through the notion of “information horizons”, which are composed of information resources. The main concern at this point was to understand (i) which information resources were utilized the most, and (ii) how different information resources were prioritized by researchers. Considering the information resources available for researchers, patterns of information consumption were operationalized as follows. Information resources were divided into two main areas: technical consultations and other information resources. Technical consultations consist of face-to-face technical consultations and technical consultations through e-media. The total number of different types of technical consultations, and their percentages of the aggregate number of technical consultations were considered. Other information resources were considered in terms of their priority for researchers as illustrated in table 4.4.

**Table 4.4. Information consumption patterns.**

<table>
<thead>
<tr>
<th>INFORMATION CONSUMPTION PATTERNS</th>
<th>OTHER INFORMATION RESOURCES (priority)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TECHNICAL CONSULTATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>FACE-TO-FACE TECHNICAL CONSULTATIONS</td>
<td>TECHNICAL CONSULTATIONS THROUGH E-MEDIA</td>
</tr>
<tr>
<td>Pre-scheduled office visits</td>
<td>e-mail</td>
</tr>
<tr>
<td>Unscheduled office visits</td>
<td>Telephone</td>
</tr>
<tr>
<td>Pre-scheduled group meetings</td>
<td>Fax</td>
</tr>
<tr>
<td>Unscheduled group meetings</td>
<td>Through other networking tools (netmeeting, conference calls…)</td>
</tr>
<tr>
<td>Coincidental consultations</td>
<td></td>
</tr>
</tbody>
</table>

| “Total number of” and “Percentage of the aggregate numbers of all consultations” |
| Literature                                                                      |
| Vendors                                                                         |
| Customers                                                                       |
| External sources                                                               |
| Previous research conducted in the research center                             |
| Personal experience                                                             |
| Experimentation                                                                 |
| Face-to-face technical consultation                                             |

4.3.3.2. Technical Consultation Networks

Technical consultation networks were operationalized through connectivity of networks at the network level, and centrality of individuals at the individual level. Two measures of social network analysis were utilized in this study: *social connectivity of entire networks* and *social centrality of individuals*. The key communicators were identified by the level of researchers’ social centrality. In addition, number of citations for individuals for
discussions about research was considered as a secondary proof about their role as key communicators (Table 4.5).

**Table 4.5. Technical consultation networks.**

<table>
<thead>
<tr>
<th>TECHNICAL CONSULTATION NETWORKS</th>
<th>INDIVIDUAL LEVEL (Individuals as role holders)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NETWORK LEVEL</td>
<td>Social connectivity of formal networks</td>
</tr>
<tr>
<td>Social connectivity of formal networks</td>
<td>Social centrality of individuals</td>
</tr>
</tbody>
</table>

Detailed definitions and operationalization of measures of social networks are provided below.

**Social Network Analysis: Basic Definitions And Algorithms.** Social network analysis is composed of methods that focus on social entities and analyze their relationship patterns and implications of these relationships.

In social network analysis, the presence of regular patterns of relationships among social entities is termed *structure* (Wasserman and Faust, 1994). The quantities that measure structure are termed *structural variables*.

In social network analysis, social entities are referred to as *actors*. Any kind of relationship between a pair of actors is termed a *relational tie*. Therefore, a *social network* consists of a finite set of actors and their relational ties (Wasserman and Faust, 1994).

For the purposes of this study, the social network of a basic science and research setting was characterized as consisting of researchers. In this respect, each researcher formed an “actor”, as used in social network analysis terminology. The relational tie was defined as communication of information through technical consultation between researchers.

A *graph theoric notation system* was used to operationalize technical consultation networks in this study.

**Graph theoric notation in social network analysis.** Graph theoric notation focuses on the relations among a set of actors, but does not quantify those relations. The relations between a pair of actors are dichotomous: they are either present or not. When they are present, the quantity of those relations does not matter (i.e. the presence of a technical consultation matters, but number of technical consultations does not) (Wasserman and Faust, 1994). Graph theoric notation in social network analysis is as follows.

In a set of actors (*N*) there are “*g*” number of actors, and the actors are named {*n*<sub>1</sub>, *n*<sub>2</sub>, *n*<sub>3</sub>… *n*<sub>g</sub>}. Therefore, *N*={*n*<sub>1</sub>, *n*<sub>2</sub>, *n*<sub>3</sub>… *n*<sub>g</sub>}. When there is a directional tie between two actors *n*<sub>i</sub> and *n*<sub>j</sub>, the relationship is represented as: *n*<sub>i</sub> →
Then, in a group of “g” number of actors, there may be a maximum of \( g(g - 1) \) relationships, and a minimum of zero relationships. Each relational tie is represented by “/”. When there is a non-directional tie, the relationship is represented as: \( n_i - n_j \). In such a case, in a group of “g” number of actors, there may be a maximum of \( g(g - 1)/2 \) relationships, and a minimum of zero relationships (Wasserman and Faust, 1994).

**Measures in social network analysis.** For the purposes of this study, directional relational ties were considered among researchers within each URC. Therefore, the numbers of relational ties for all researchers were identified. Specifically, if a researcher “A” had reported technical consultations with “x” number of other researchers, and “y” number of other researchers had reported technical consultations with researcher “A”, then his/her number of relational ties was considered to be “x + y”. The number of relational ties of each researcher was then utilized in two algorithms for measuring the connectivity of each URC social network, and centrality of each researcher in these URCs.

Social connectivity was calculated for URC social networks, yielding a single social connectivity value for each URC. **Social connectivity of a URC social network** was calculated by dividing the actual sum of researchers’ number of relational ties among researchers by the total number of possible ties (Wasserman and Faust, 1994).

\[
\text{Social connectivity of a social network} = \frac{l}{g(g - 1)}, \text{where } l = \text{total number of actual relational ties}, g = \text{number of actors (researchers) in the network (Wasserman and Faust, 1994).}
\]

Therefore, one social connectivity value was calculated for each URC’s social network.

Social centrality was calculated for each network actor (researcher). **Social centrality of a researcher** was calculated by dividing the number of his / her relational ties by the number of all possible ties that he / she could have (Wasserman and Faust, 1994).

\[
\text{Social centrality of an actor in a social network (a researcher in a URC)} = \frac{l_i}{(g - 1)}, \text{where } l_i = \text{the number of } i^{th} \text{ actor’s ties}, g = \text{number of actors in the network (Wasserman and Faust, 1994).}
\]

Therefore, two researchers with the highest level of centrality were identified as key communicators in each URC.

**4.3.3.3. Patterns of space use for face-to-face technical consultation**

Patterns of space use for face-to-face technical consultation were operationalized by the number of face-to-face technical consultations reported for all spaces. In addition, the numbers of citations for individual spaces as spaces where respondents most frequently meet others, and where respondents most frequently visit when they leave their own spaces were calculated (Table 4.6).
Table 4.6. Patterns of space use for face-to-face technical consultation.

<table>
<thead>
<tr>
<th>PATTERNS OF SPACE USE FOR FACE-TO-FACE TECHNICAL CONSULTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of face-to-face technical consultations reported for all spaces</td>
</tr>
<tr>
<td>Number of citations for individual spaces as spaces where respondents most frequently meet others</td>
</tr>
<tr>
<td>Number of citations for individual spaces as spaces where respondents most frequently visit when they leave their own spaces</td>
</tr>
</tbody>
</table>

4.3.4. The Detailed Conceptual Model

The conceptual model for the study was detailed based on the definition and operationalization of variables as in Figure 4.8.
Figure 4.8. The detailed conceptual model for the study.
4.4. METHODS OF DATA COLLECTION AND INSTRUMENTATION

Two instruments were utilized for data collection in this study: an activity log and a follow-up survey.

Instrument 1: The Activity Log. This instrument was designed to gather data from all researchers in the selected URCs. The “activity log” was used to gather data about information consumption patterns, technical consultation networks, and patterns of space use for face-to-face technical consultations.

The “activity log” was composed of an instructions page and five additional pages for each day of a typical week. This instrument was designed to collect data from each respondent about his / her research-related technical consultations throughout a typical week. The activity log was designed in the form of a booklet, with an instructions page and five additional pages for collecting data. On each left hand page of the activity log, the floor plan(s) of the research center under consideration was displayed.

This floor plan was divided into convex spaces for a clear indication of technical consultation locations. On each right hand page of the activity log, a technical consultations matrix was displayed, which included types of technical consultation (unscheduled office visits, coincidental consultations, prescheduled group meetings, unscheduled group meetings, prescheduled office visits, e-mails, telephone calls and technical consultations via other networking tools such as videoconferencing), location and time on its columns.

The instrument requested the respondents to indicate the type, location and time spent (in minutes) for research-related technical consultations, by first identifying their locations on the floor plans provided, and then recording them on the technical consultations matrix. In order to avoid double counting of technical consultations reported by researcher, the researchers were specifically requested to record only those consultations they initiated. Therefore, the researchers recorded a consultation whenever they started a conversation or interaction about a research related subject.

The activity log was tested in departments of Electrical Engineering and Industrial Engineering of NCSU, to ensure the reliability of the instrument. Researchers from both departments were asked to complete the activity log for five business days, and their comments about the instrument were noted. Based on the comments of the researchers, a number of minor changes were made in the layout of technical consultations matrix for clarity of the instrument. A sample of the final form of the activity log is provided in Appendix A.

Instrument 2: the Follow-up Survey. This instrument was designed to gather data from all researchers in the selected URCs. The “follow-up survey” was utilized after completion of activity logs. This instrument was designed to collect data about individual characteristics of researchers, semi-fixed and non-fixed feature space,
judgmental and non-judgmental ratings of innovation process outcomes, and part of the technical information networks data.

The follow-up survey was composed of three parts. The first part of the follow-up survey was composed of the plan(s) of the research center studied, and an evaluations page. In this part of the survey, respondents were asked to specify on the plan(s) (i) where they most frequently meet others throughout their work, and (ii) where they go when they leave their space within the building / research center they work in. Three open-ended questions also asked the respondents to write down their perceptions of environmental quality and reasons for using those spaces.

In the second and third parts of the follow-up survey, the respondents were asked to respond to a series of questions phrased for gathering data about priority of information resources, judgmental and non-judgmental ratings of innovation process outcomes, personal characteristics of respondents, formal and informal social networks within the organization. A sample follow-up survey is provided in Appendix B. Table 4.7. summarizes the variables, operationalization of variables and methods of data collection and analysis utilized in this study.
<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>TYPE OF VARIABLE</th>
<th>UNITS OF ANALYSIS</th>
<th>LEVELS</th>
<th>OPERATIONALIZATION</th>
<th>METHODS OF DATA COLLECTION AND ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPATIAL CONFIGURATION</td>
<td>FIXED FEATURE SPACE</td>
<td>SYNTACTICAL PROPERTIES OF SPACE</td>
<td>SPACE syntax analysis of URC floor plans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISTANCE</td>
<td></td>
<td>DISTANCE BETWEEN THE ORIGIN AND DESTINATION OF TECHNICAL CONSULTATIONS</td>
<td>METRIC MEASUREMENTS ON URC FLOOR PLANS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERCEIVED ENVIRONMENTAL QUALITIES</td>
<td>SEMI-FIXED AND NON-FIXED FEATURE SPACE</td>
<td>OF THOSE SPACES WHERE RESPONDENTS MOST FREQUENTLY MEET OTHERS THROUGHOUT THEIR WORK</td>
<td>FOLLOW-UP SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REASONS FOR USE</td>
<td></td>
<td>OF THOSE SPACES WHERE RESPONDENTS GO WHEN THEY LEAVE THEIR SPACE WITHIN THE BUILDING / RESEARCH CENTER THEY WORK IN</td>
<td>FOLLOW-UP SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDEPENDENT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FACET-TO-FACE CONSULTATIONS</td>
<td>INFORMATION CONSUMPTION PATTERNS</td>
<td>AMOUNT AND PERCENTAGE OF AGGREGATE</td>
<td>ACTIVITY LOG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSULTATIONS THROUGH OTHER MEDIA</td>
<td></td>
<td>AMOUNT AND PERCENTAGE OF AGGREGATE</td>
<td>ACTIVITY LOG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER INFORMATION RESOURCES</td>
<td></td>
<td>PRIORITY OF INFORMATION RESOURCES</td>
<td>FOLLOW-UP SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INDIVIDUAL AND GROUP</td>
<td>MEDIATING</td>
<td>NETWORK LEVEL</td>
<td>CONNECTIVITY</td>
<td>SOCIAL NETWORK ANALYSIS BASED ON THE DATA FROM ACTIVITY LOGS</td>
<td></td>
</tr>
<tr>
<td>INDIVIDUAL AND GROUP</td>
<td>MEDIATING</td>
<td>INDIVIDUAL LEVEL</td>
<td>CENTRALITY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TECHNICAL CONSULTATION NETWORKS</td>
<td>MEDIATING</td>
<td>NUMBER OF CITATIONS FOR DISCUSSIONS ABOUT RESEARCH</td>
<td>FUTURE SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PATTERNS OF SPACE USE FOR FTF</td>
<td>MEDIATING</td>
<td>NUMBER OF TECHNICAL CONSULTATIONS REPORTED FOR ALL SPACES</td>
<td>ACTIVITY LOG</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PATTERNS OF SPACE USE FOR FTF</td>
<td>MEDIATING</td>
<td>NUMBER OF CITATIONS FOR EACH SPACE FOR USE FREQUENTLY</td>
<td>FOLLOW-UP SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PATTERNS OF SPACE USE FOR FTF</td>
<td>MEDIATING</td>
<td>NUMBER OF CITATIONS FOR EACH SPACE FOR MEETING OTHERS FREQUENTLY</td>
<td>FOLLOW-UP SURVEY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNOVATION PROCESS OUTCOMES</td>
<td>DEPENDENT</td>
<td>JUDGMENTAL RATINGS</td>
<td>SUBJECTIVE RATINGS OF THE CENTER AND PROCESSES ON A 7-POINT LIKERT SCALE</td>
<td>FUTURE SURVEY</td>
<td></td>
</tr>
<tr>
<td>INNOVATION PROCESS OUTCOMES</td>
<td>DEPENDENT</td>
<td>NONJUDGMENTAL RATINGS</td>
<td>KNOWLEDGE OUTPUTS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.7. Variables, units of analysis, operationalization, methods of data collection and analysis.
4.5. CASE STUDY SELECTION PROCESS: UNIVERSITY RESEARCH CENTERS

Upon definition of a methodology and case study protocol, an initial pool of university research centers (URCs) was selected from North Carolina State University (NCSU) research centers and National Science Foundation Science and Technology Centers (NSF-STCs), which are URCs funded by NSF.

The initial pool comprised fifty-eight URCs. After a survey of NCSU Centers, Institutes and Laboratories (CILS) through the data provided by the NCSU website (“Centers, Institutes & Labs”, n.d.), and NSF-STCs, the number of URCs were reduced to forty. With the final list of forty URCs, the contacting, meeting and selecting process began. First, each of the directors of forty URCs was contacted by telephone. The rationale and objectives of the study were briefly described, and a meeting was requested for further discussion.

The initial contacts with this group of URCs yielded conclusions as to whether they satisfied the study’s case selection criteria, as well as to their availability for participating in the study. Based on telephone conversations with URC directors, the following initial results were obtained. The directors of twenty-three of the URCs were interested in participating, and accepted the proposal for an initial meeting. Seventeen URCs declined participation in the study, due to one or more reasons that are listed in Table 4.8.

Table 4.8. Reasons for not participating mentioned by the directors of those university research centers that did not participate in the study.

<table>
<thead>
<tr>
<th>REASONS FOR NOT PARTICIPATING (R)</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>The URC did not fit the study’s selection criteria because of space constraints (it was extremely scattered among different buildings, campuses or universities with no rationale for coherence).</td>
</tr>
<tr>
<td>R2</td>
<td>The URC did not fit the study’s selection criteria because of the low number of researchers and incoherent structure.</td>
</tr>
<tr>
<td>R3</td>
<td>The URC did not fit the study’s selection criteria because it was no longer active (but it was active before).</td>
</tr>
<tr>
<td>R4</td>
<td>The URC did not fit the study’s selection criteria because it was not conducting research (focusing on non-research projects).</td>
</tr>
<tr>
<td>R5</td>
<td>The URC did not fit the study’s selection criteria because it was a virtual center (that it had a name and paper-based appearance, but was not actually coherently active).</td>
</tr>
<tr>
<td>R6</td>
<td>The URC was not interested in participating in the study because of time constraints and/or workload.</td>
</tr>
<tr>
<td>R7</td>
<td>The URC was simply not interested in participating in the study.</td>
</tr>
<tr>
<td>R8</td>
<td>The URC director would be interested in participating and encouraging participation, but the researchers would not (based on a general incoherence in the center).</td>
</tr>
</tbody>
</table>
Meetings were conducted with the remaining twenty-three URCs’ directors, where the study was described in detail, with precise explanations of time investment and participation requirements. The structured interview, designed to ensure the validity of the study, was conducted with each of the directors, in order to understand whether the centers satisfied the study’s criteria about organizational context.

A walk-through of the spaces occupied by the centers was also conducted in each center to determine the accuracy of each URC’s floor plans, to ensure that the URCs accurately coincided with spatial categories, therefore to maintain the validity of the study.

Meetings with URC directors concluded with the acceptance of nine URCs, which also fitted the study’s case selection criteria in terms of the organizational context and spaces occupied. The remaining fourteen URC directors chose not to participate in the study because of one or more of the reasons listed in Table 4.8; therefore, the contacts with these URCs were not pursued further. As a result of these series of telephone calls and following meetings with URC directors, nine URCs remained in the pool.

With these results, nine out of forty URCs, which satisfied the study’s case selection criteria, were selected for proceeding with data collection.

4.6. DATA COLLECTION PROCEDURE

A meeting with each remaining URC was arranged for seeking participation of their researchers. The participation of all researchers (faculty and graduate students) was requested in these meetings.

The meetings with the selected URCs began with a brief presentation of the rationale, content and objectives of the study. Both instruments were introduced, with an orientation exercise for becoming familiar with floor plans. The time investment and participation requirements of the study were explained in detail. Participation of all researchers was requested, by making it clear that this request was on a voluntary basis. In all nine URCs selected, no objections to participation were raised after the presentations.

Consequently, in consultation with the researchers, a period of five consecutive weekdays identified in each center for completing the activity logs. These five-day periods were selected by asking researchers if any extraordinary events would take place in the targeted period. Any period with a potential of extraordinary activities (i.e. group attendances to conferences, travels by high numbers of researchers, examination periods, etc.) were avoided, so that the selected periods would reflect the regular research activities, information consumption and face-to-face technical consultation patterns. As a result, an appropriate five-day period was selected for each URC.
Upon agreement of researchers for participation, the activity logs were distributed on the selected five-weekday periods in each university research center. The completed activity logs were then collected from each center in the week following their five-weekday periods. After the collection of completed activity logs, response rates in each participating URC were checked.

Of the nine participating URCs, three had response rates that were below 10%, and 6 had response rates above 75% for activity logs. Through a following discussion with the directors of those URCs with low response rates, it was understood that it would not be possible to make another effort for increasing these response rates. Therefore, the data collection process was stopped in these URCs, and the follow-up surveys were not distributed.

As a result, the activity log data collected from six of nine URCs were taken into consideration in data analysis, since low response rates were achieved in the remaining three URCs. The response rates for activity logs in URCs that participated in the study are illustrated in Table 4.9.

Table 4.9. Response rates in participating university research centers.

<table>
<thead>
<tr>
<th>PARTICIPATING UNIVERSITY RESEARCH CENTERS</th>
<th>NUMBER OF COMPLETED ACTIVITY LOGS</th>
<th>TOTAL NUMBER OF RESEARCHERS</th>
<th>RESPONSE RATE FOR ACTIVITY LOGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. URC1</td>
<td>12</td>
<td>16</td>
<td>75%</td>
</tr>
<tr>
<td>2. URC2</td>
<td>9</td>
<td>12</td>
<td>75%</td>
</tr>
<tr>
<td>3. URC3</td>
<td>16</td>
<td>20</td>
<td>75%</td>
</tr>
<tr>
<td>4. URC4</td>
<td>15</td>
<td>19</td>
<td>&gt;75%</td>
</tr>
<tr>
<td>5. URC5</td>
<td>17</td>
<td>21</td>
<td>&gt;75%</td>
</tr>
<tr>
<td>6. URC6</td>
<td>16</td>
<td>16</td>
<td>100%</td>
</tr>
<tr>
<td>7. URC7</td>
<td>3</td>
<td>18</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>8. URC8</td>
<td>2</td>
<td>14</td>
<td>&lt;20%</td>
</tr>
<tr>
<td>9. URC9</td>
<td>4</td>
<td>22</td>
<td>&lt;20%</td>
</tr>
</tbody>
</table>
In the next step, secondary meetings were arranged with researchers of six URCs with activity log response rates of at least 75%. In these secondary meetings, the follow-up surveys were introduced and distributed. Researchers were requested to complete the follow-up surveys. Upon completion, the follow-up surveys were either collected, or returned by mail in instances where the participating center was geographically distant. This process finalized the data collection process, with six individual cases that satisfied the study’s case selection criteria, and yielded at least 75% response rate.
CHAPTER 5

DATA ANALYSIS

Yin (1984) proposes a general data analysis strategy for multiple case studies, which is composed of an initial analysis within cases followed by cross-case analysis. The author also emphasizes the replication-seeking and pattern-matching procedures, based on the idea of treating multiple cases as a series of experiments, as opposed to treating them as a sample from a larger population. The current study utilized the general data analysis strategy proposed by Yin (1984). Based on this strategy, a pattern-matching and replication-seeking strategy was followed. Statistical generalization was avoided since analyses of six cases would have provided six data points. Rather than statistical generalization, repeating results and matching patterns of findings across cases were sought. Since statistical generalization was avoided in this strategy, a systematic method for analyzing findings within cases, and then comparing them across cases was necessary. For this, Miles and Huberman (1984) have recommended a number of strategies:

- Putting information into different arrays;
- Making a matrix of categories and placing evidence within such categories;
- Creating data displays – flow charts and other devices – for examining the data;
- Tabulating frequency of different events;
- Examining the complexity of such tabulations and their relationships by calculating second-order numbers such as means and variances.

Following these strategies, initially, in each individual case, relationships between spatial variables and technical consultations were sought. Findings in each individual case were tabulated by utilizing matrices, tables and charts. Repeating patterns of the findings from each individual case were then sought across cases. Finally, individual cases were compared to each other. Data analysis was composed of two main phases: in-case analysis and cross-case analysis and comparison. Data gathered from the activity log, follow-up survey, space syntax analysis and social network analysis were analyzed according to the conceptual research model (see Figure 4.8) with the following procedure.
5.1. IN-CASE ANALYSIS

In the first phase of data analysis, each individual case was analyzed and interpreted, where matrices were prepared for display and analysis of collected data, following the strategies proposed by Miles and Huberman (1984).

In-case analysis started with an inquiry into the relationships between space and patterns of space use for face-to-face technical consultation. Three matrices were prepared for data analysis according to research question 1.


Matrix 1 was prepared for display and analysis of data based on research questions 1.A.1 and 1.A.2. The main objective at this point was to see the relationships between spatial configuration and patterns of space use for face-to-face technical consultation. For each URC, reported numbers of different types of face-to-face technical consultation for each space (in the activity logs) were compared to syntactical properties of those spaces. Within this analysis, syntactical properties of origins of technical consultations through e-media were also identified. Each empty cell in Matrix 1 represents a bivariate analysis of the corresponding variables on X and Y axis (Table 5.1).
Table 5.1. Data analysis matrix 1 for research questions 1.A.1 and 1.A.2. Each empty cell represents a bivariate analysis (scatterplot and correlation coefficient) of the corresponding variables on X and Y axes.

**RESEARCH QUESTION 1.A.1.** What are the relationships between spatial configuration in fixed-feature space and patterns of space use for face-to-face technical consultation?

**RESEARCH QUESTION 1.A.2.** Which syntactical properties of fixed-feature space affect patterns of space use for face-to-face technical consultation?

<table>
<thead>
<tr>
<th>PATTERNS OF SPACE USE FOR FACE-TO-FACE TECHNICAL CONSULTATION (numbers reported in the activity logs)</th>
<th>SPATIAL CONFIGURATION (syntactical features measured through space syntax analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRAn</td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td></td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td></td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td></td>
</tr>
<tr>
<td>PRESCHEDULED OFFICE VISITS</td>
<td></td>
</tr>
<tr>
<td>PRESCHEDULED GROUP MEETINGS</td>
<td></td>
</tr>
<tr>
<td>E-MAILS</td>
<td></td>
</tr>
<tr>
<td>TELEPHONE CALLS</td>
<td></td>
</tr>
<tr>
<td>CONSULTATIONS VIA OTHER NETWORKING TOOLS</td>
<td></td>
</tr>
</tbody>
</table>

Matrix 2 was prepared for display and analysis of data based on research question 1.A.3. By making use of Matrix 2, the distances between origin and destination of face-to-face technical consultations were compared to the number of reported face-to-face technical consultations (in the activity logs) for each URC. Each empty cell in Matrix 2 represents a bivariate analysis of “the metric distance between origin and destination of technical consultations” and number of consultations that took place within each metric distance (Table 5.2).
Table 5.2. Data analysis matrix 2 for research question 1.A.3. Each empty cell in Matrix 2 represents a bivariate analysis (scatterplot and correlation coefficient) of “the metric distance between origin and destination of technical consultations” and number of consultations that took place for each metric distance.

**RESEARCH QUESTION 1.A.3. What are the relationships between walking distances and patterns of space use for face-to-face technical consultation?**

<table>
<thead>
<tr>
<th>METRIC DISTANCE BETWEEN ORIGIN AND DESTINATION OF CONSULTATIONS (measured through floor plans)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
</tr>
<tr>
<td>PROGRAMMED ENCOUNTERS</td>
</tr>
<tr>
<td>PRESCHEDULED OFFICE VISITS</td>
</tr>
<tr>
<td>PRESCHEDULED GROUP MEETINGS</td>
</tr>
<tr>
<td>E-MAILS</td>
</tr>
<tr>
<td>TELEPHONE CALLS</td>
</tr>
<tr>
<td>CONSULTATIONS VIA OTHER NETWORKING TOOLS</td>
</tr>
</tbody>
</table>

Matrix 3 was prepared for display and analysis of data based on research questions 1.B.1. and 1.B.2. For each URC, perceived environmental qualities and reported reasons for use (in the follow-up surveys) were associated with those spaces where researchers most frequently meet others throughout their work, and those spaces where researchers go when they leave their space. In addition, reported locations of technical consultations (in the activity logs) were also associated with the environmental qualities reported in the follow-up survey. Each empty cell in Matrix 3 represents a content analysis (list of predictors of face-to-face technical consultations) of the variables corresponding to X and Y axis (Table 5.3).
Table 5.3. Data analysis matrix 3 for research questions 1.B.1. and 1.B.2. Each empty cell in Matrix 3 represents a content analysis (list of predictors of face-to-face technical consultations) of the variables corresponding to X and Y axis.

**RESEARCH QUESTION 1.B.1.** What are the environmental qualities of those spaces where researchers most frequently meet others throughout their work?

**RESEARCH QUESTION 1.B.2.** What are the environmental qualities of those spaces where researchers go when they leave their space within the building / research center they work in? What are the reasons for the researchers to use those spaces?

<table>
<thead>
<tr>
<th>PATTERNS OF SPACE USE FOR FACE-TO-FACE TECHNICAL CONSULTATION (reported in the follow-up surveys)</th>
<th>Environmental qualities (reported in the follow-up surveys)</th>
<th>Reasons for use (reported in the follow-up surveys)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citations of individual spaces where researchers most frequently meet others throughout their work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Citations of individual spaces where researchers go when they leave their space within the building / research center they work in</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Matrices 1, 2 and 3 were then used in each in-case analysis for explanation building in order to answer research question 1.A.

5.1.2. Answering Research Question 1.A.

**RESEARCH QUESTION 1.A.** What are the relationships between fixed-feature space and patterns of space use for face-to-face technical consultation?

Matrix 1, while answering research questions 1.A.1 and 1.A.2, provided information about syntactical features of space and their relationships to patterns of space use for face-to-face technical consultation. In this respect, matrix 1 provided part of the information about fixed-feature space for answering upper-level research question 1.A. Similarly, Matrix 2 provided information about the relationships between walking distances and patterns of space use for face-to-face technical consultation. This matrix completed the information about fixed-feature space for answering upper-level research question 1.A. Therefore, by making use of these two matrices, a list of “best predictors of patterns of space use for face-to-face technical consultation at the level of fixed-feature space” was prepared for each URC as a response to Research Question 1.A.

5.1.3. Answering Research Question 1.B.

**RESEARCH QUESTION 1.B.** What are the relationships between semi-fixed feature and non-fixed feature space and patterns of space use for face-to-face technical consultation?
Matrix 3 was utilized to answer research questions 1.B.1. and 1.B.2. In doing so, information about semi-fixed and non-fixed feature space and their relationships to patterns of space use for face-to-face technical consultation was provided. Therefore, by making use of Matrix 3, a list of “best predictors of patterns of space use for face-to-face technical consultation at the level of semi-fixed and non-fixed feature space” was prepared for each URC as a response to Research Question 1.B.

5.1.4. Answering Research Question 1.

RESEARCH QUESTION 1. What is the effect of space on patterns of space use for face-to-face technical consultation?

By making use of Matrices 1, 2 and 3, a list of “best predictors of patterns of space use for face-to-face technical consultation” was prepared for each URC through explanation building. Therefore, Research Question 1, and the issues pointed in its sub-questions were answered individually for each URC. This process is graphically represented in Figure 5.1.

![Figure 5.1. Answering RESEARCH QUESTION 1 through explanation building by making use of matrices for data analysis at the level of sub-questions. (RQ = RESEARCH QUESTION)](image)

Technical consultation networks were operationalized at individual and social network levels. Therefore, at the individual level, part of the answer for this question was built during the in-case analysis phase. Space – technical consultation network relationships were inquired through centrality of individuals within in-case
analysis. These relationships were inquired through the connectivity of entire social networks within cross-case analysis.

Initially, the centrality of each researcher was calculated in all six URCs. Consequently, key communicators were identified for each URC. Regarding research question 1 and its sub-questions, each of the correlations in Matrix 1 was repeated by omitting key communicators. In this way, by looking at the “average communicators”, personal effects of key communicators on the patterns of space use for face-to-face consultation were screened. Therefore, this reconsideration ensured internal validity, and provided further proof about the findings of research question 1 and its sub-questions.

Finally, connectivity of technical consultation networks were calculated via social network analysis for each URC. This analysis yielded the founding information for answering research question 2 at the level of cross-case analysis.

5.1.5. First Step of Answering Research Questions 3 and 4

Research Questions 3 and 4 were essentially answered through cross-case analyses. However, in order to provide the data for cross-case analyses for these questions, a number of analyses procedures were carried on for each individual case.

For Research Question 3, information consumption patterns were calculated in terms of percentage of aggregate number of consultations for each URC. In addition, reported priorities of information resources were tabulated through frequencies of preference within each URC. For Research Question 4, innovation process outcomes were calculated and tabulated in terms of number of outcomes per researcher per unit time, and mean judgmental ratings of outcomes. These raw data calculations provided the bases for answering these questions in cross-case analysis.

5.2. CROSS-CASE ANALYSIS

Pattern matching, replication seeking and explanation building formed the main strategy throughout the cross-case analysis phase. Similar to the in-case analysis, a number of matrices were built and utilized. At this level, answers to the first question were sought initially.
5.2.1. Answering Research Question 1

Research Question 1 and its sub-questions were answered for each individual case during in-case analysis. The main strategies for answering this question at the cross-case analysis phase were pattern matching, replication seeking and explanation building.

For Research Question 1.A and its sub-questions, matching patterns of findings across cases about syntactical features of space, distance and their relationships to patterns of information consumption through face-to-face technical consultation were sought by superimposing matrices 1 and 2 from each individual case. Those findings that continuously repeated across cases, and formed patterns were then noted. As a result, a list of “best predictors of patterns of space use for face-to-face technical consultation” at the level of fixed-feature space was prepared based on findings that repeated across cases.

With a similar approach, for Research Question 1.B and its sub-questions, matching patterns of findings across cases were sought. For this purpose, those environmental qualities and reasons for use gathered from Matrix 3 of each individual case were categorized into “upper-level subject headings” upon content analysis. For ensuring reliability, a colleague was asked to conduct content analysis and categorize cited environmental qualities and reasons for use into “upper-level subject headings”. The original categorization of citations into upper level headings was reorganized taking the colleague’s content analysis into consideration. Then, repeating findings across cases were noted. As a result, a list of “best predictors of patterns of space use for face-to-face technical consultation” at the levels of semi-fixed and non-fixed feature space was prepared based on findings that repeated across cases.

Finally, a list of “best predictors of patterns of space use for face-to-face technical consultation” at all proxemic levels of space was prepared based on findings that repeated across cases.

5.2.2. Answering Research Question 2

RESEARCH QUESTION 2. What is the effect of space on technical consultation networks of researchers?

Research Question 2 formed the first step of cross-case analysis. In this step, calculated technical consultation network connectivity values were listed in Matrix 4 according to spatial categories of URCs (Table 5.4).
Table 5.4. Data analysis matrix 4 for research question 2. Each empty cell in Matrix 4 represents calculated values (social connectivity values) corresponding to X and Y axis.

<table>
<thead>
<tr>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>TECHNICAL CONSULTATION NETWORKS OF RESEARCHERS (FORMAL)</td>
<td>CONNECTIVITY OF SOCIAL NETWORKS</td>
<td></td>
</tr>
</tbody>
</table>

This procedure resulted in a comparison of technical consultation networks of the six URCs both among themselves and across the three spatial categories.

5.2.3. Answering Research Question 3 and 3.A.

RESEARCH QUESTION 3. What is the effect of space on researchers’ information consumption patterns?

RESEARCH QUESTION 3.A. What is the effect of space on information consumption through face-to-face technical consultation?

For answering research question 3, information consumption patterns of each URC were initially tabulated both in terms of percentage of aggregate numbers of information consumption and priority of information resources during the in-case analysis phase. This information was then compared across cases and across spatial categories during the cross-case analysis phase according to Matrix 5 (Table 5.5). This procedure provided comparison of URCs about information consumption patterns both among themselves and across spatial categories.
Table 5.5. Data analysis matrix 5 for research question 3. Each empty cell in Matrix 5 represents calculated values of the variables corresponding to X and Y axis.

<table>
<thead>
<tr>
<th>INFORMATION RESOURCES</th>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACE-TO-FACE TECHNICAL CONSULTATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LITERATURE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VENDORS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CUSTOMERS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXTERNAL SOURCES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREVIOUS RESEARCH CONDUCTED IN THE URC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PERSONAL EXPERIENCE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EXPERIMENTATION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESCHEDULED OFFICE VISITS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-MAILS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TELEPHONE CALLS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSULTATIONS VIA OTHER NETWORKING TOOLS</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For answering research question 3.A., information consumption through face-to-face technical consultation was extracted from Matrix 5. This procedure essentially highlighted the information related to research question 3.A., which was available in Matrix 5. Matrix 6 was prepared for this process (Table 5.6).
Table 5.6. Data analysis matrix 6 for research question 3.

Each empty cell in Matrix 6 represents calculated values (percentage of aggregate number of consultations) of the variables corresponding to X and Y axis.

<table>
<thead>
<tr>
<th>INFORMATION CONSUMPTION THROUGH FACE-TO-FACE TECHNICAL CONSULTATION (PERCENTAGE OF AGGREGATE)</th>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNPROGRAMMED ENCOUNTERS</td>
<td>UNSCHEDULED OFFICE VISITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>COINCIDENTAL CONSULTATIONS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROGRAMMED ENCOUNTERS</td>
<td>PRESCHEDULED OFFICE VISITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PRESCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AGGREGATE</td>
<td>FACE-TO-FACE CONSULTATIONS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This procedure provided a comparison of URCs among themselves and across spatial categories based on information consumption through face-to-face technical consultation. A particular point of interest at this point was to examine the variation of aggregate numbers of face-to-face technical consultations per researcher across cases and spatial categories.

5.2.4. Answering Research Question 4

**RESEARCH QUESTION 4.** What is the effect of space, at three levels of analysis (fixed-feature, semi-fixed feature and non-fixed feature space), on information consumption and innovation process outcomes in basic science and research settings?

Answering research questions 1, 2, 3 and their sub-questions provided detailed information about space and information consumption relationships within and across cases, as well as across categories. This information was then connected to information about innovation process outcomes via Matrix 7, which provided a comparison of URCs across cases and across categories (Table 5.7). At this final stage, innovation process outcomes based on non-judgmental ratings were calculated by the average number of outcomes per researcher.
per unit work time (months) in each URC. This information included those outcomes that were produced in the
time span in which researchers had been working with their current URCs, therefore, outcomes that were
produced prior to working with the URCs that participated in the study were not reported. Innovation process
outcomes based on judgmental ratings were calculated based on mean ratings of predefined categories by all
researchers in each URC.

Table 5.7. Data analysis matrix 7 for research question 4. Each empty cell in Matrix 7 represents
calculated values (innovation process outcomes measurements) of the variables corresponding to X
and Y axis.

<table>
<thead>
<tr>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>INNOVATION PROCESS OUTCOMES (based on judgmental ratings)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>INNOVATION PROCESS OUTCOMES (based on non-judgmental ratings)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This procedure essentially provided the answer to the main research question of the study, where answers to
each research question was based on the previous questions. Through this step-by-step data analysis
procedure, each of the answers was based on matching patterns, repeating findings and explanation building.

5.3. SUMMARY

The data analysis procedure described in this chapter outlines the standardized steps taken for explanation
building. Therefore, it must be noted that none of the questions had a “single answer”, but a series of
explanations and discussions. Moreover, this procedure yielded findings that were interconnected across
research questions. Thus, explanation building forms the driving force behind all data analysis and findings.
Detailed discussions of the findings from individual cases and cross-case analysis will be discussed in the
following chapters.
CHAPTER 6

FINDINGS: INDIVIDUAL CASES

Six URCs that participated in the study included URC1, URC2, URC3, URC4, URC5 and URC6. URC1, URC2, URC3, and URC5 share one building. URC4 shares one building with an educational organization. URC6 has its own building.

This chapter is composed of three sections. Section 1 will initially describe the territories of the six URCs and the buildings they occupy. Second, the organizational context and territories of each URC, and their correspondence with the spatial categories introduced in Chapter 4 will be discussed. In section 2, relationship patterns between technical consultations and syntactical properties of space will be presented across cases. In section 3, individual case study reports will be presented for each URC with explanations of the findings. Section 4 will be a summary of the findings from individual case study reports.

6.1. INDIVIDUAL CASES: ORGANIZATIONAL CONTEXT AND TERRITORIES

The URCs that participated in the study occupied a total of three buildings: Building 1, Building 2 and Building 3.

Building 1 is shared by URC1, URC2, URC3, and URC5. One other URC and a number of private sector research and development units also share this building. Building 1 was designed and built as a “shell structure” with non-partitioned floors. The building was subsequently occupied by five URCs and a number of private sector research and development units according to tenant space requirements.

Building 1 accommodates two common spaces that are shared by all URCs and private sector R&D units in the building. These are an informal common space named the “lobby” on the second floor, and a formal common space named the “conference room” on the third floor. The second floor “lobby”, furnished with a number of tables, two vending machines, and a microwave oven, is a lunchroom shared by all tenants. The tenants of Building 1 share the third floor “conference room”, each for their own prescheduled group meetings.

URC1 and URC2 have their own intact territories on the second floor of Building 1. URC3 does not have an intact territory, and consists of one office sector on the first floor and two laboratory sectors on the second and third floors respectively. URC5 has its own intact territory on the first floor. The other tenants of Building 1 use the remaining spaces on the third floor. The territories of URC1, URC2, URC3, and URC5 are displayed on the floor plans of Building 1 in Figure 6.1.1.
Figure 6.1.1. The territories of URC1 (dark blue), URC2 (light blue), URC3 (yellow) and URC5 (green) on the floor plans of Building 1.
URC4, shares **Building 2** with an educational organization. Building 2 was originally designed exclusively for URC4 with three stories. However, due to URC4’s lack of necessary funds, the original design was later converted to a four-story building to be shared by an educational organization. Therefore, although Building 2 is not a “shell structure”, URC4 is not the only organization occupying it. Consequently, URC4 does not have an intact territory, and is composed of office sectors and laboratory sectors on each of the first, second, and third floors. Half of the third floor and the entire fourth floor are occupied by the educational organization. The territory of URC4 is displayed on the floor plans of Building 2 in Figure 6.1.2.
Figure 6.1.2. The territory of URC4 (yellow) on the floor plans of Building 2.
Building 3 was designed and built exclusively for the use of URC6. Therefore, URC6 has its own intact territory within Building 3. The territory of URC6 is displayed on the floor plans of Building 3 in Figure 6.1.3.

Figure 6.1.3. The territory of URC6 (green) on the floor plans of Building 3.
6.1.1. URC1

6.1.1.1. Organizational Context

URC1 is a single-site URC located in Building 1. URC1’s studies focus on molecular genetics and forestry. The purpose of URC1 is stated by the director as “promoting innovation in basic science to advance the application of molecular genetics to forest trees”. URC1 researchers work on the identification of genes that determine the major features of wood properties. This feature of URC1’s work makes this URC significant, since it has the potential of leading to genetic modifications with significant economic benefits. There are currently six major faculty, four research scientists, and six graduate students, totaling sixteen researchers working with URC1.

The structured interview conducted with URC1 director indicated the following results about URC1’s organizational context. URC1 researchers (especially graduate students), although responsible for reporting to major faculty, do not belong to a specific hierarchical reporting system. Therefore, the number of levels of hierarchy in the organizational chart of URC1 was two, which indicated the presence of a flattened hierarchy. URC1 obtains support from a variety of sources. At the time of data collection, the total number of funding resources was six. These sources fund URC1 as whole, rather than individual projects.

A high level of coherence in URC1 was indicated in the results of the structured interview conducted with the director. In the structured interview, the director rated the organizational focus and the level of interdependence among researchers of URC1 as 6 on a 7-point Likert scale. Similarly, the extent to which the research carried on by individuals depended upon other individuals, as well as the alignment of URC1’s research to a strategic plan, was rated 6 by the director on a 7-point Likert scale.

As a result, the overall organizational context of URC1 reflects high coherence, close alignment to a strategic plan, and high levels of interdependence among researchers.

6.1.1.2. Territory and Architectural Program

URC1 territory accommodates both offices and laboratories, and is intact with an office core, offices, laboratory, laboratory support spaces, and commons (Figure 6.1.1.1).
The office core is composed of 4 convex spaces (B01, B02, B04, B05). There are thirteen cellular offices (2506, 2514, 2516, 2524, 2526, 2528, 2530, 2513, 2515, 2517, 2518, 2519, 2520) available in URC1, which are connected directly to the office core. Another room directly connected to the office core, originally intended for use as a laboratory (2501), is currently used as a shared office because its equipment was relocated to the major laboratory (2529). Therefore, room 2501, although intended as a laboratory, is actually used as a shared office and mostly as a storage space for laboratory supplies. There were no researchers assigned to work in room number 2501 at the time of data collection. Also connected directly to the office core is an eight-person conference room (2504), an open and shared computer workstation for three people (B03), an open office for reception (URC1-R), and an informal common space (FR). The office core is directly connected to the primary circulation.

The laboratory (2529) covers almost half of the area occupied by URC1 (BL01, BL02, BL03, BL04, BL05, BL06, BL07, BL08, BL09). Five counters with shelves and drawers are present in the laboratory to function as shared laboratory work environments. There are eight laboratory support spaces directly connected to the laboratory (2531, 2533, 2535, 2537, 2539, 2539A, 2552, 2554), two of which are sealed (2552, 2554).

The laboratory is directly connected to the office core with only one door through convex space BL01. Although it has a door opening directly to the primary circulation, this door is permanently sealed for safety reasons. Therefore, the office core, with its direct connection to the primary circulation through convex spaces B01 and B05, is the only available direct contact of URC1 to outside its territory.
An informal common space, named the “family room” (FR), is a unique feature of URC1 territory. The term itself and the idea of a “family room” were introduced by the URC1 director. This space is intended to accommodate informal activities, to act literally as a “family room” for researchers of URC1, and to house formal and informal group meetings, and activities such as coffee breaks, reading, relaxing. The family room is furnished with two sofas, upholstered chairs, coffee tables, bookshelves and a chalkboard. During the walkthrough, the director mentioned that weekly informal “coffee hours” are held in this space. A kitchen (URC1-K), with coffee and espresso machines, a microwave oven, and a refrigerator is directly connected to the family room. The data collection meetings with URC1 were held in the family room. URC1 director explained the rationale behind this setting as an effort to facilitate information flow and idea generation among researchers by informal face-to-face interactions, group meetings in a relaxed, friendly environment. The furnishings of this space, as well as shared equipment such as the coffee machine, according to the director, were all selected and utilized deliberately for this purpose. In this respect, the “family room” of URC1 is a space created by the efforts of URC1 director, and represents a unique effort among other contacted URCs for this study.

URC1 territory also accommodates a formal common space, named the “conference room” (2504). Although designated for such use, the director reported that this space was rarely used for meetings, and mostly used by himself because “it made him more accessible and visible” to URC1 researchers. The reason behind this was “the better connection of this room” than the room designated for his use (2506). This situation can be clearly observed on the floor plan of URC1, which makes clear that room 2506 is indirectly connected to the office core through the reception area (URC1-R), while room 2504 has a direct connection.

Another feature introduced by the director was about cellular individual and group offices in URC1 territory. In order to eliminate the feeling of a hierarchical organizational context, the designers were specifically requested to provide offices with equal floor areas, oriented to the same direction. Therefore, whether graduate student or faculty member; each researcher occupies an office “equal to his or her colleague” in URC1. During the walkthrough and the structured interview, the director made it clear that he was the generator of the architectural program and ideas for spatial organization, and communicated these ideas to the designers for implementation.

6.1.1.3. Spatial Configuration

The spatial configuration of URC1 territory forms a justified permeability graph in which the spaces get deeper as one navigates from the office core towards the laboratory. The office core is connected to the primary circulation at two convex spaces, B01 and B05. The conference room, the family room, the reception, and all offices except three are one step deep from the office core. The kitchen and offices 2506, 2528, and 2530 are two steps deep from the office core. The laboratory convex spaces are at least one step deep from the office core. All laboratory
support spaces are at least one step deep from one of the laboratory convex spaces. The spatial configuration of URC1 territory is represented with the justified permeability graph in Figure 6.1.1.2, where the starting point is the primary circulation (PR).

![Figure 6.1.1.2. The spatial configuration of URC1 territory: justified permeability graph with the starting point as primary circulation.](image)

6.1.1.4. Correspondence of URC1 with a Spatial Category

In the justified permeability graph of URC1 territory, all four basic functions introduced in Chapter 4 can be observed: an office core, offices, a laboratory, and laboratory support spaces connected to the primary circulation through the office core. When the interrelationships of convex spaces that constitute these functions are observed on URC1 floor plan and justified permeability graph, the scheme becomes clear for categorizing URC1. The primary circulation is directly connected to the office core (PR ↔ OC), offices are directly connected to the office core (OC ↔ O), the laboratory is directly connected to the office core (OC ↔ L), and laboratory support spaces are directly connected to laboratory convex spaces (L ↔ S). The two cellular individual offices connected directly to the laboratory form an exception to these interrelationships. This situation was explained by URC1 director as follows. The initial objective was to connect these two offices directly to office core convex space B04, as other cellular individual offices. However, unexpectedly, these two offices were
left out of the office core by the designers in the actual project. Therefore, the locations of these two offices have no specific rationale in the overall configuration.

These spatial interrelationships can be represented as:

\[ \begin{array}{c}
O \\
\uparrow
\end{array} \quad \begin{array}{c}
\text{PR}
\end{array} \quad \begin{array}{c}
\downarrow
\end{array} \quad \begin{array}{c}
\text{OC}
\end{array} \quad \begin{array}{c}
L
\end{array} \quad \begin{array}{c}
S
\end{array} \]

Therefore, this series of convex space interrelationships form a spatial configuration that corresponds to a category 1 URC. As a result, URC1 was categorized as a **Category 1 University Research Center** according to its spatial configuration.

### 6.1.2. URC2

#### 6.1.2.1. Organizational Context

URC2 is a single site URC located in Building 1. URC2’s studies focus on genomics. The term *genome* refers to the sum total of an organism’s genetic code. The purpose of URC2 is to determine these genetic codes. URC2 is a significant URC in its research area, since it studies “sequencing entire genomes, which has not been possible or economically feasible until recently”. This feature of URC2’s studies is referred to as “a revolutionary development in biotechnology”.

There are currently six research scientists and six graduate students affiliated with URC2, however, there are no faculty members among this group. All researchers are responsible for reporting their work to the director. URC2 is funded by its parent university, although research centers that request certain analyses from URC2 pay for this service. Therefore, the number of funding sources can be identified as two. URC2 exhibits a high organizational focus in terms of coherence. In the structured interview with the director, coherence of the research center on the research agenda, level of interdependence among researchers, and alignment to a strategic plan was rated 5 on a 7-point Likert scale. As a result, the organizational context of URC2 exhibits a certain level of coherence.

#### 6.1.2.2. Territory and Architectural Program

URC2 has an **intact territory** that accommodates both offices and laboratories. The territory accommodates an office core, offices, a laboratory, and laboratory support spaces (Figure 6.1.2.1).
Figure 6.1.2.1. The floor plan of URC2.

The office core is composed of six convex spaces (G01, G02, G03, G04, G05, G06) as shown on figure 6.6. There is one cellular individual office, which is currently used by the director (2105). Another cellular but shared office is used by all URC2 researchers (2104). Eight open and shared offices are located with direct connection to convex office core spaces G04 and G06. The open offices are not assigned to any particular researcher. An open office for reception (URC2-R) and a conference room for formal meetings (2103) are directly connected to the office core.

The laboratory (2109) covers more than half of the territory of URC2. It is composed of nine convex spaces (GL01, GL02, GL03, GL04, GL05, GL06, GL07, GL08, GL12). Six counters in the laboratory, with shelves and drawers, provide shared working environments to URC2 researchers. The laboratory is densely occupied with a high number of equipment. Seven laboratory support spaces are available, six of which are directly connected to laboratory convex spaces (GL09, GL10, GL11, 2108, 2110, 2112). Room 2109A accommodates special equipment; therefore, it is one step deeper from laboratory convex spaces than other laboratory support spaces.

The laboratory is directly connected to the office core at three convex spaces (GL01, GL02, GL08). Although the laboratory has a direct connection to the primary circulation with a door through convex space GL12, this door is permanently sealed for safety reasons. Therefore, the only direct connection of URC2 territory to primary circulation is through the office core convex space G01. This brief description also points to a difference between URC2 territory and URC1. While the connection of URC1 territory to the primary circulation is
through two convex spaces (two doors), URC2 territory is connected to the primary circulation through only one convex space (one door).

URC2 territory does not provide any informal **common spaces**. The only common space, the “conference room”, is designated for formal meetings, such as prescheduled or unscheduled group meetings. This is another significant difference of URC2 territory from URC1, which has the “family room” designated for such uses.

The formation of an architectural program and spatial organization in URC2 territory was similar to URC1. The requirements of URC2 were defined by the director and advisory faculty members from various academic departments. Similar to URC1, the designers’ role was confined to implementation of these ideas.

**6.1.2.3. Spatial Configuration**

The spatial configuration of URC2 territory is represented with the justified permeability graph in Figure 6.1.2.2, where the starting point is the primary circulation. One feature of URC2 spatial configuration reflected in the justified permeability graph is that, the office core and laboratory are much more integrated than URC1, due to the ringy structure in URC2.

![Figure 6.1.2.2. The spatial configuration of URC2 territory: justified permeability graph with the starting point as primary circulation.](image-url)
URC2 spatial configuration exhibits a justified permeability graph in which the office core convex spaces and laboratory convex spaces are close in terms of depth from primary circulation. The office core and laboratory convex spaces form two rings rather than a tree structure, due to their connection at three points. In this respect, URC2 spatial configuration is different from URC1, which exhibits a much more tree-like structure, where laboratory convex spaces are much more deeper than office core convex spaces in terms of depth from primary circulation. Hence, while the depths of laboratory convex spaces and office core convex spaces are very close in URC2 spatial configuration, laboratory convex spaces are much deeper than office core convex spaces in URC1 spatial configuration. However, in URC2 configuration, the ringy structure provides that URC2 offices are much deeper than URC1 offices. The total number of steps for reaching the deepest convex space is seven in both URCs.

6.1.2.4. Correspondence of URC2 with a Spatial Category

In the justified permeability graph of URC2 territory, all four basic functions introduced in Chapter 4 can be observed: an office core, offices, a laboratory, and laboratory support spaces connected to the primary circulation through the office core. The primary circulation is directly connected to the office core (PR $\leftrightarrow$ OC), offices are directly connected to the office core (OC $\leftrightarrow$ O), the laboratory is directly connected to the office core (OC $\leftrightarrow$ L), and laboratory support spaces are directly connected to laboratory convex spaces (L $\leftrightarrow$ S).

These spatial interrelationships can be represented as:

```
PR
↑
O $\leftrightarrow$ OC $\leftrightarrow$ L $\leftrightarrow$ S
```

This series of convex space interrelationships form a spatial configuration that corresponds to a category 1 URC. As a result, URC2 was categorized as a **Category 1 University Research Center** according to its spatial configuration.

6.1.3. URC3

6.1.3.1. Organizational Context

URC3 is a single site URC located in Building 1. URC3 research focuses on genetic codes (genomes) of economically important fungi. The purpose of URC3 is “to discover and analyze the function of genes from economically important fungi”.

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URC3 is a significant URC in its research area, since the knowledge generated by URC3 “provides new insights into cellular processes and development as well as leads to the development of novel plant protection and other fungal based products”. URC3’s significance in its research area is reflected by the high amount of funding attracted from several sources in the recent years.

There are twenty researchers in URC3, including ten research scientists, two of whom are also faculty members, five post-doctoral fellows and five graduate students.

The highly coherent organizational context of URC3 was revealed in the director’s responses to the questions of the structured interview. The director rated the organizational focus of URC3 as 6 on a 7-point Likert scale. Both the level of interdependence among researchers, and the extent to which the research carried on by individuals / teams depended upon other individuals / teams were rated 4 on a 7-point Likert scale. The director explained his rating of these two scales by referring to 10 projects carried on in the center at the time of data collection. According to the director, URC3 research was highly aligned to a strategic plan, which he rated 7 on a 7-point Likert scale.

6.1.3.2. Territory and Architectural Program

URC3 territory accommodates both offices and laboratories, but is divided into three sectors, one on each floor of Building 1. An office sector is located on the first floor, while two laboratory sectors are located on second and third floors respectively (Figure 6.1.3.1). Although URC3 is a single site URC, its territory is non-intact. In order to reach one sector from another, one has to pass through several primary circulation spaces. During the walk-through of URC3 territory, the director explained that there were two reasons for this situation. First, URC3 was the last URC to settle in Building 1. Despite objections by researchers and administration, URC3 had to settle in the existing territory, composed of the remaining unused spaces. The second reason for a non-intact territory was the availability of technical resources for laboratories. At the time of data collection, laboratory infrastructure was available on second and third floors. Therefore, the office sector of URC3 had to be placed on the first floor, while two laboratory sectors had to be separated to the two remaining spaces on second and third floors.
Figure 6.1.3.1. The floor plan of URC3.
At the time of data collection, there was a vacant space available on the first floor, across URC3’s office sector. Since the director was concerned with interaction problems among URC3 researchers located on different floors, his intention was to request that the two laboratory sectors should be relocated to this available space. One of the reasons for URC3’s participation in this study was that the director and researchers thought the results of this study would form empirical evidence for their claims and relocation request.

**URC3 office sector** is composed of an office core, individual and shared offices, and common spaces. The **office core** is composed of six convex spaces (F01, F02, F03, F04, F05, F06). There are six cellular individual offices (1204, 1203, 1205, 1208, 1210, 1212), two individual open offices (1207, 1209), and four open and shared offices in convex spaces F07 and F08. An open office close to the entrance is designated for reception (URC3-R) and a conference room is available for accommodating ten people. Shared office equipment (a printer and fax) is available in convex space F06. The office core is connected to the primary circulation with two doors through convex spaces F01 and F03.

The **second floor laboratory sector** is composed of nine laboratory convex spaces (FL01, FL02, FL03, FL04, FL05, FL06, FL07, FL08, FL09), which accommodate four counters providing shared workspaces. Six laboratory support spaces (2301, 2303, 2304, 2306, 2307, 2309) are directly connected to laboratory convex spaces. There are three shared offices directly connected to laboratory convex spaces. These shared offices provide a home base to those researchers who spend significant amounts of time in this laboratory sector, due to the distance to the actual office sector. The second floor laboratory sector is connected directly to the primary circulation with a door through convex space FL01.

The **third floor laboratory sector** is composed of four laboratory convex spaces (FL 10, FL11, FL13, FL14), an individual cellular office (3900A), and a convex space that is used for laboratory support (FL12). At the time of data collection there was only one research scientist and one graduate student assigned to work in this laboratory sector, because of the problems of distance. The third floor laboratory sector is connected to the primary circulation with one door through laboratory convex space FL10.

At the time of data collection and walk-through, researchers indicated that the distance between these three sectors caused interaction problems among researchers. The distance between the three sectors is not only vertically increased by different floors, but also horizontally because of the relative location of each sector on each floor plan.

The only available **common space** provided in URC3 territory is the conference room on the first floor office core. This space is mainly designated for formal meetings, such as prescheduled group meetings. Therefore
there are no informal common spaces provided for casual conversation or relaxation. The formal conference room is equipped with a coffee machine and a microwave oven.

In the meetings, the researchers mentioned that the formal conference room was rarely used for formal meetings, because it was too small to accommodate the number of researchers in URC3. In addition, it was mentioned that the formal conference room was mostly used for getting coffee or heating lunch. As a result, the formal group meetings of URC3 are mainly held at the third floor conference room (3002), which is shared by all tenants of the building. In fact, the meetings for participation in this study were held at room number 3002. In general, problems of distance between the three sectors, and lack of common spaces for formal or informal encounters were clearly expressed by the director and researchers during the introductory meetings, prior to data collection. With these features, URC3 is an interesting case for this study, as a significant URC in its research area with problems related to its territory clearly expressed even before data collection.

6.1.3.3. Spatial Configuration

The spatial configuration of URC3 territory exhibits a segregated picture by merely examining the justified permeability graph. The separation of the territory into three sectors adds additional steps in configuration for reaching laboratory sectors on second and third floors. While the deepest spaces in URC1 and URC2, which had intact territories, were seven steps deep from the primary circulation, the deepest spaces of second floor laboratory sector reach twelve, and the deepest spaces of third floor laboratory sector reach sixteen steps from the first floor primary circulation. Therefore, the separation of the territory into three sectors not only increases metric horizontal and vertical distance, but also configurational depth between sectors.

When the whole system of spaces is considered, URC3 offices and laboratories are much more segregated from each other compared to those of URC1 and URC2. While in the first two URCs discussed, the laboratory had at least one direct connection to the office core, in the spatial configuration of URC3 territory, these connections, even between the two laboratory sectors, are indirect.

The spatial configuration within sectors, however, resemble those of URC1 and URC2 office cores and laboratories. In the office sector, all offices, whether individual, shared, cellular or open, are one step deep from office core convex spaces. Similarly, in both laboratory sectors, laboratory support spaces and offices are one step deep from laboratory convex spaces. The spatial configuration of URC3 territory is represented with the justified permeability graph in Figure 6.1.3.2, where the starting point is the primary circulation on first floor.
Figure 6.1.3.2. The spatial configuration of URC3 territory: justified permeability graph with the starting point as primary circulation on first floor.

6.1.3.4. Correspondence of URC3 with a Spatial Category

In the justified permeability graph of URC3 territory, all five basic functions introduced in Chapter 4 can be observed: an office core, offices, two laboratories, and laboratory support spaces. When the interrelationships of
convex spaces constituting these functions are considered, the scheme becomes clear for categorizing URC3. First, URC3 territory is separated into three sectors: an office sector with an office core and offices (OC + O), and two laboratory sectors each with a laboratory, and several laboratory support spaces (L + S). Second, these three sectors are indirectly connected to each other through several primary circulation spaces. Starting with the primary circulation, which is directly connected to the office sector (PR \(\rightarrow\) [OC + O]), offices are directly connected to the office core (OC \(\leftrightarrow\) O), laboratory sectors are directly connected to the primary circulation (PR \(\leftrightarrow\) [L + S]), and laboratory support spaces are directly connected to laboratory convex spaces (L \(\leftrightarrow\) S). These spatial interrelationships can be represented as:

\[\text{[OC + O]} \leftrightarrow \text{PR} \leftrightarrow \text{[L + S]},\]

which in fact is an extended form of the configuration described for Category 2 URCs in Chapter 4:

\[\text{[OFFICE SECTOR]} \leftrightarrow \text{[PRIMARY CIRCULATION]} \leftrightarrow \text{[LABORATORY SECTOR]}.\]

Therefore, this series of convex space interrelationships form a spatial configuration corresponding to a category 2 URC. As a result, URC3 was categorized as a **Category 2 University Research Center** according to its spatial configuration.

### 6.1.4. URC4

#### 6.1.4.1. Organizational Context

URC4 is a single-site URC, which occupies part of Building 2. URC4 research focuses on coastal natural resources and environments, including fisheries, fish habitat, water quality, marine environmental toxicology, aquatic veterinary medicine, aquatic food products, and instrumentation for gathering behavioral and physiological data from fish and crabs.

The mission of URC4 is to improve the coordination of research programs necessary to understand the complex coastal ecological land, water, and atmospheric system; to promote the development of improved technology related to use of coastal resources and industries; and to serve those who value natural coastal resources by fostering research designed to improve understanding of coastal natural resources. The goal of URC4 is to bring together research scientists, and specialists into a cohesive unit. URC4 is a significant URC in its research area. The number of full-time researchers at URC4 is nineteen, with ten faculty and nine graduate students.

The structured interview with URC4 director revealed a highly coherent organizational context. The director rated the organizational focus of URC4 as 6 on a 7-point Likert scale. The level of interdependence among
researchers was rated 5, and the extent to which the research carried on by individuals / teams depended upon other individuals / teams was rated 4 on a 7-point Likert scale. URC4 is mainly funded by its parent university, with occasional additional funding from other sources. These funds are mainly used for the whole center, rather than individual projects, especially because of the need for special equipment required by the research undertaken. There were a total of seven research projects carried on in URC4 at the time of data collection, with an addition of one extension project. According to the director, URC4 research was highly aligned to a strategic plan based on the URC4 Charter, which he rated as 7 on a 7-point Likert scale.

6.1.4.2. Territory and Architectural Program

URC4 territory accommodates both offices and laboratories. However, it is divided into three office sectors and three laboratory sectors, with one office sector and one laboratory sector located on each of the three floors of Building 2. The remaining areas of the building are used by an educational organization. URC4 is a single-site URC; however, because it is composed of three office and three laboratory sectors, its territory is non-intact. In order to move one sector from another, one has to pass through primary circulation spaces, either on the same floor or across floors.

Building 2 was originally designed for URC4 with three floors only. Because of lack of funds, however, the original design was changed to a four-story building, where half of the third floor and the fourth floor were designated for an educational organization’s use. According to the URC4 director, 76% of building’s current maintenance expenditure is supplied by URC4, and 24% is supplied by the educational organization. Figure 6.1.4.1 displays the territory of URC4 and existing functions.
Figure 6.1.4.1. The floor plan of URC4.

There are three office sectors present in URC4 territory. One significant feature of these office sectors is the double function of their office cores. In the three office sectors available, the office cores are composed of convex spaces U106, U120 (first floor), U216 (second floor), and U323 (third floor). These three office cores, while being the main carriers for all cellular individual offices, also serve as primary circulation. This situation is a
result of the changes in the original design. When a fourth floor for the use of the educational organization was added, these office cores, originally intended for exclusive use of URC4, were also made part of primary circulation, since they are not currently confined to URC4 territory. However, because these convex spaces remain between laboratories and cellular individual offices used by URC4, they also function as office cores. Therefore, the offices and laboratories are separated by primary circulation spaces that also function configurationally as office cores.

Accordingly, there is no shared equipment present in the three URC4 office cores. There are ten cellular individual offices directly connected to the first floor office core (109, 111, 115, 117, 119, 121, 123, 125, 127, 129); ten cellular individual offices directly connected to the second floor office core (207, 209, 211, 213, 215, 217, 219, 221, 223, 225); and three cellular individual offices directly connected to the third floor office core (327, 329, 331).

The laboratory sectors on the first, second, and third floors are composed of a number of laboratories and laboratory support spaces composed of single convex spaces. On the first floor, convex spaces 110, 112, 118, 126, 128 and 134 constitute single convex space laboratories. Except for room numbers 128 and 134, which are interconnected, all laboratories are directly connected to the primary circulation. Seven laboratory support spaces are directly connected to laboratories, with one connected to 110 (110A), three connected to 118 (118A, 118B, 118C), one connected to 126 (126B), and two connected to 134 (130 and 132). Laboratory support spaces 130 and 132 are in fact showers, since “staging” (134) is a special function laboratory. The samples brought from the sea, such as large fish or other samples are initially processed in room number 134, named “staging”, and then carried to other laboratories. Therefore, room numbers 130 and 132 are not regular bathrooms functioning as other bathrooms on each floor of the building, but actually function as support spaces for staging.

The second floor laboratory sector is composed of single convex spaces 208, 210, 212, 214, 220, 222, and 226, which are all directly connected to primary circulation. Among these laboratories, only room number 210 has a support space. The rest of the laboratories on second floor carry support equipment since their floor area is sufficient. Room number 226 is a special laboratory used for teaching, where appropriate equipment is available for getting new researchers familiar with URC4’s laboratory work.

The third floor laboratory sector is composed of two single convex space laboratories (combination of 326 and 328, in addition to 332), which also carry support equipment since their floor area is sufficient. Similar to the two other floors, both laboratories are directly connected to primary circulation.
There are four common spaces available in URC4 territory, two on each of first and second floors. On the first floor, a formal common space (teleconference room 105) is located, directly connected to primary circulation. This room is primarily designated for teleconferences. Since teleconferencing equipment is located in this room, it is not usually used for other formal or informal group meetings. Room number 114, however, is designated as an informal common space. Named the “lounge”, this room accommodates shared office equipment: fax, mailboxes, a coffee machine, a microwave oven, a refrigerator, and a telephone. During the walk-through, the director mentioned that weekly informal “coffee hours” are held in this space on Thursdays.

Similarly, there are two common spaces provided on the second floor, one for formal, and the other for informal activities. Room number 205, also named a “teleconference room”, is designated for formal group meetings. Although named after teleconferences, this room does not actually carry teleconferencing equipment. The meetings for data collection were held in this room. Room number 206, named “lobby”, is designated as an informal common space. The lobby is an effort to facilitate informal and coincidental consultations among researchers, in addition to relaxing. Although formed by a single convex space, the lobby overlooks the first floor lobby, and has a high level of visibility. It is furnished by couches and seats, and the artwork of local citizens is displayed on walls. In terms of the care given to its furnishings, its place in the overall spatial configuration, and its high level of visibility, this second floor lobby was unique among those URCs visited. However, during the walk-through, the director mentioned that this space, “although having a large potential for informal information exchange, was not used up to its total potential”. Its usual use is for rare informal gatherings, such as parties where food is served. One decision made by URC4 researchers was having weekly meeting on the first floor lobby, rather than the second floor lobby. Compared to URC1’s family room, URC4’s second floor lobby exhibits a lot of investment in visual quality, whereas URC1’s family room exhibits a lot of investment for achieving a social center.

URC4 director also mentioned three general points that were considered to a large extent during the design process. First, the director, and URC4 researchers were concerned about the building’s welcoming image. Therefore, extra care was given to first and second floor lobbies. The void that provides high visibility between these two spaces, and views to the ocean were products of this concern. These spaces are also currently decorated by local artwork to keep them “visually appealing and welcoming”. Second, the laboratories and offices were designed in modules with relation to the structural axes, so that two offices would correspond to each laboratory. The rationale behind this decision was to minimize the metric distance between researchers’ offices and laboratories corresponding to their current work. Third, in order to reflect the flattened hierarchy in the organizational context of URC4, the designers were specifically requested to provide offices with equal floor areas, oriented towards the same direction. Therefore, as in URC1, whether graduate student or faculty
member; each researcher occupies an office “equal to his or her colleague” in URC4. Again, as in the case of URC1, the majority of the ideas that constructed the architectural program and spatial organization of URC4 were introduced by the director. As a result, the role of designers was limited to implementing these ideas.

6.1.4.3. Spatial Configuration

The justified permeability graph exhibits the segregated structure of URC4 spatial configuration. First, because the building is shared, a number of primary circulation spaces configurationally separate office sectors and laboratory sectors. Second, the primary circulation spaces separate office and laboratory sectors not only horizontally, but also vertically. In this respect, as in URC3, the metric distance among sectors is increased vertically and horizontally.

The office – laboratory relationships, while configurationally closer than URC3, are still weaker than URC1 and URC2, since primary circulation spaces separate them. This separation also increases the depth of spaces relatively from each other significantly. As in URC3, the number of steps from a first floor office to a third floor laboratory may reach up to 15. With these configurational properties, URC4 territory resembles URC3 territory to a large extent. The spatial configuration of URC4 territory is represented with the justified permeability graph in Figure 6.1.4.2, where the starting point is outside the entrance of the building, on landside.
Figure 6.1.4.2. The spatial configuration of URC4 territory: justified permeability graph with the starting point outside the entrance of the building.

6.1.4.4. Correspondence of URC4 with a Spatial Category

In the justified permeability graph of URC4 territory, all five basic functions introduced in Chapter 4 can be observed: office cores, offices, laboratories and laboratory support spaces. When the interrelationships of convex spaces constituting these functions are considered, the scheme becomes clear for categorizing URC4.
First, URC4 territory is separated into six sectors: three office sectors with an office core and offices \((OC + O)\), and three laboratory sectors each with laboratories and laboratory support spaces \((L + S)\). Second, these six sectors are indirectly connected to each other through several primary circulation spaces. Starting with the primary circulation, which is directly connected to the office sector \((PR \leftrightarrow [OC + O])\), offices are directly connected to the office core \((OC \leftrightarrow O)\), laboratory sectors are directly connected to the primary circulation \((PR \leftrightarrow [L + S])\), and laboratory support spaces are directly connected to laboratory convex spaces \((L \leftrightarrow S)\). These spatial interrelationships can be represented as:

\[ [OC + O] \leftrightarrow PR \leftrightarrow [L + S], \]

which in fact is an extended form of the configuration described for Category 2 URCs in Chapter 4:

\[ [OFFICE SECTOR] \leftrightarrow [PRIMARY CIRCULATION] \leftrightarrow [LABORATORY SECTOR]. \]

This series of convex space interrelationships form a spatial configuration that corresponds to a category 2 URC. As a result, URC4 was categorized as a **Category 2 University Research Center** according to its spatial configuration.

### 6.1.5. URC5

#### 6.1.5.1. Organizational Context

URC5 is a single-site URC located in Building 1. URC5 research focuses on statistical management and interpretation of genomic data. The purpose of URC5 is “to serve as a focal point for the development of computational and statistical tools for genomic data”. URC5 research is significant in this area due to the state of the art tools and software developed for genomic data analysis and interpretation, and their applicability in areas of agriculture, forestry, computational biology, and veterinary medicine.

There are a total of twenty-one researchers occupying offices in URC5 territory, with eight resident faculty, one non-resident faculty, two research scientists, four post-doctoral fellows, and six graduate students. URC5 has a flattened hierarchy in which graduate students are responsible for reporting to resident faculty. One of the significant features of URC5, the weekly morning coffee break in which ideas about research are exchanged, reflects the informal and friendly social atmosphere in URC5. Its parent university system, as well as private sector firms, fund URC5. These funds are used to support URC5 as a whole, rather than individual research projects.
The structured interviews with URC5 director revealed the presence of a high level of organizational focus in URC5. The director rated the organizational focus of URC5 as 5 on a 7-point Likert scale. The level of interdependence among researchers was rated 5, and the extent to which the research carried on by individuals / teams depended upon other individuals / teams was rated 4 on a 7-point Likert scale. There were a total of five research projects carried on in URC5 at the time of data collection. According to the director, URC5 research was highly aligned to a strategic plan, which he rated as 6 on a 7-point Likert scale.

6.1.5.2. Territory and Architectural Program

URC5 territory, located on the first floor of Building 1, is an intact territory with office cores, cellular individual offices, open individual offices, a shared space for computer workstations, a kitchen, and a common space named the “conference room”. URC5 territory accommodates offices, but not laboratories. Due to the nature of the research undertaken in URC5, the work patterns of the researchers do not require laboratories. URC5 researchers utilize offices for computer-based applications of genome data management and interpretation, rather than laboratory work.

Two office cores function as main circulation carriers within URC5 territory. Almost equal in floor plan area, these office cores accommodate open individual offices. The east office core is composed of four convex spaces (S01, S02, S03, S04). Six cellular individual offices (1501, 1503, 1504, 1505, 1506, 1507), fourteen open individual offices (C1 – C14), a reception area (URC5-R), and a formal common space (1513, the conference room) are directly connected to the east office core. The west office core is composed of five convex spaces (S06, S07, S08, S09, S10). Ten cellular individual offices (1515, 1517, 1519, 1521, 1520, 1522, 1523, 1527, 1529, 1531), twelve open individual offices (C15 – C28), a kitchen (URC5–K) and a formal common space (1513, the conference room) are directly connected to the west office core. The two office cores are connected directly by convex space S05, which forms a corridor in-between. Convex space S05 also carries a shared space designated for accommodating computer workstations (1514). An indirect connection between the two office cores is also available through the conference room, which has direct connections to both. Figure 6.1.5.1 exhibits the URC5 territory floor plan and accommodated functions.
The direct connection of the URC5 territory to the primary circulation is available with a door through the east office core. Although another door connects the west office core to the primary circulation, this door is not used. Notices request visitors and researchers to use the east office core door. The main reason for this is the presence of the reception immediately next to the east office core door. Therefore URC5 territory has a single direct connection to primary circulation.

During the walk-through, the URC5 director mentioned that he and other URC5 researchers requested from the designer to position a common meeting space in a central location, so that interactions and information flow among researchers could be facilitated. Consequently, the designer’s response was to separate the territory into two, locating the conference room in between two office cores. This decision has also formed a narrow corridor (convex space S05) connecting the two office cores in case the doors of conference room are closed. One of the initial claims of the URC5 director about this corridor was that it was narrow, dark, and “nobody passed through there”. This formed an interesting case for the study in order to understand certain fixed-feature space characteristics and their relations to human behavior.

The only common space provided in URC5 territory, the conference room, is designated for formal group meetings. It is furnished with a large meeting table and bookshelves that carry research-related periodicals. Although the initial idea of having a central common space also expressed a desire for facilitating informal
encounters, the solution of a cellular convex space with doors provided a formal atmosphere in the conference room. URC5 director mentioned that informal encounters were rare in the conference room; it usually remained empty, and functioned as a circulation carrier between the two office cores since the doors were always kept open. Consequently, the most frequent use of the conference room is for weekly group meetings in which information about ongoing research is exchanged, or circulation between the two office cores.

As in previously discussed URCs, the spatial organization and architectural program of URC5 territory was mainly formed by the ideas of the director and researchers. The designers’ role was to implement these ideas.

6.1.5.3. Spatial Configuration

The spatial configuration of URC5 exhibits a justified permeability graph composed of two tree-like structures that correspond to each of the two office cores (Figure 6.1.5.2). While office core convex spaces form several rings in each office core, the cellular and open individual offices appear at the deepest steps.

On the justified permeability graph, it can be observed that the west office core, in general, is much deeper than the east office core. As previously discussed, this is because the west office core connection to the primary circulation is not used. Consequently, the cellular and open offices connected to the east office core are at least one space shallower than those connected to the west office core.

Another significant feature of URC5 spatial configuration is the limited connection between the two office cores. The justified permeability graph provides a clear representation of this situation. The only main circulation convex space connecting the two office cores is S05. A second route between the two office cores is available through the conference room. Therefore, unless one passes through convex space S05 while navigating from one office core to the other, the only means of connection passes through the conference room.

This limited connection between the two office cores is more difficult to observe on the floor plans. This situation makes an interesting case, since, although URC5 territory is intact, the whole system works as two tree-like structures connected by only two convex spaces.
6.1.5.4. Correspondence of URC5 with a Spatial Category

In the justified permeability graph of URC5 territory, only three basic functions introduced in Chapter 4 can be observed: two office cores and offices, with a direct connection to the primary circulation via one of the office cores. When the interrelationships of convex spaces constituting these functions are considered, the scheme becomes clear for categorizing URC5. First, URC5 territory is composed of two office cores (OC) and cellular and open individual offices (O). Second, a number of cellular and open offices are directly connected to each of the office cores (OC \( \leftrightarrow \) O). Third, these office cores are directly connected to each other, which can be represented as:

\[ O \leftrightarrow OC1 \leftrightarrow OC2 \leftrightarrow O. \]

Fourth, one of these office cores is directly connected to the primary circulation, which remains outside URC5 territory. These spatial interrelationships can be represented as:

Figure 6.1.5.2. The spatial configuration of URC5 territory: justified permeability graph with the starting point as primary circulation.
Therefore, this series of convex space interrelationships form a spatial configuration that corresponds to a category 3 URC. As a result, URC5 was categorized as a **Category 3 University Research Center** according to its spatial configuration.

### 6.1.6. URC6

#### 6.1.6.1. Organizational Context

URC6 is a single-site URC located in Building 3. URC6 research focuses on adaptive optics, which is a method for removing the blurring of images caused by changing distortions within optical systems due to turbulence in the Earth's atmosphere. The objective of URC6 is “to advance and disseminate the technology of adaptive optics in service to science, health care, industry, and education”. URC6 research is significant in its research area due to the advanced tools and software developed, as well as cutting edge research conducted related to adaptive optics by the center.

There are a total of sixteen researchers occupying Building 3, designated exclusively for use of URC6. Of sixteen researchers, seven are faculty members, three are research scientists, three are postdoctoral fellows, and three are graduate students. URC6 is funded by the National Science Foundation. This funding is used for supporting the whole center rather than supporting individual research projects. At the time of data collection, there were three major research projects carried on in URC6.

The structured interview with URC6 director revealed a highly coherent organizational context. According to the director, the organizational focus of URC6 could be rated 6 on a 7-point Likert scale. The director rated the level of interdependence among researchers, and the extent to which the research carried on by individuals / teams depended upon other individuals / teams as 5 on a 7-point Likert scale. URC6’s alignment to a strategic plan was high, and rated as 7 on a 7-point Likert scale by the director.

#### 6.1.6.2. Territory and Architectural Program

URC6 territory is an **intact** territory located in Building 3, with office cores, cellular individual and shared offices, a kitchen and common spaces. Because of the nature of research undertaken in URC6, its territory accommodates offices, but not laboratories. The director of URC6 described the work pattern in the center as one composed of computer-based data analysis in the building.
Building 3 is a two-story building used only by URC6. This forms an interesting case, since URC6 is the only URC in this study that had its own building. Prior to a description of the territory and architectural program, it is important to make several notes about the design process of this building. The designers were commissioned by URC6 with the request of a plan layout that would facilitate interactions among researchers. During the walk-through, the director and researchers mentioned that the designers had a high level of consciousness about the potential effects of spatial organization on researchers' interactions. Therefore, working closely with the director, the designers attempted to come up with a spatial organization that would be able to facilitate face-to-face interactions among researchers. Figure 6.1.6.1 exhibits the URC6 territory floor plans and accommodated functions.
Figure 6.1.6.1. The floor plans of URC6.
Two office cores function as the main circulation carriers within URC6 territory, each on one story of Building 3. Since the building is located on a slope, the entrance level to the building is the second floor. The second floor office core is composed of five convex spaces (LOB, C201, C202, C203, C204). Seven cellular individual offices (203, 205, 207, 209, 211, 213, 215), one cellular shared office (C201), and one conference room (217) are directly connected to the second floor office core. Four corridors that are part of the second floor office core form a ring, which surrounds a number of common spaces: a copy room (CR), a kitchen (K), and a “journal room” (JR). The first floor office core is directly connected to the second floor office core via the stairs. When one takes the stairs down to the first floor, an “interaction space” (IS) with a double-height ceiling is reached. The first floor office core is composed of two convex spaces (C101, C102). Four cellular individual offices (101, 103, 105, 107), four cellular shared offices (102, 109, 111, 113) and the “interaction space” (IS) are directly connected to the first floor office core.

The spatial organization of the two floors and the number and locations of formal and informal commons exhibit the consciousness of both the designers and URC6 researchers about the potential effects of space on face-to-face interactions among researchers. There are a total of four common spaces in URC6 territory.

The “journal lounge” (JL) is an informal common space intended for relaxed activities, such as reading, coffee breaks, and informal meetings. Two decisions were made in order to further facilitate coincidental interactions in this space. First, a kitchen is directly connected to the journal lounge, in order to utilize coffee and food as a “magnet” for researchers. Second, this space was not enclosed on three sides, so that it would be easily accessible and visible. The journal lounge is furnished by comfortable chairs, a table, and bookshelves for both magazines/newspapers and research-related periodicals. Natural illumination is also provided for the journal lounge via the clerestories located over the conference room. Similar to the “family room” of URC1, the journal lounge is an effort to facilitate interactions, but with additional spatial features such as high visibility and a central location.

The “conference room” (217) is mainly intended for formal group meetings. It accommodates a large table and chairs for fourteen people. There is also videoconferencing equipment available in the conference room. As an additional effort for facilitating interactions, a large sliding glass door was located on the entrance wall of the conference room. This door increases visibility to the journal lounge, and is kept open when formal meetings are not taking place. The meeting for data collection was held in the conference room, and after the formal presentation of the study, an informal chat / information exchange environment was easily created by opening the sliding doors to the journal lounge.
The “copy room” (CR) is the only example of a space allocated specifically for copying and printing. The room accommodates a copier and network printers, with storage space for copying and printing equipment.

The “interaction space” (IS) on the first floor is an interesting example for this study, both with the design decision and its nomenclature that literally points out “facilitating interactions”. Several efforts were made to make this space visually appealing, informal and relaxing in order to facilitate interactions. First, visibility and spaciousness was increased by a double-height ceiling. This space also forms a welcoming scene for visitors upon entrance. Second, large two-story high windows were provided on the façade for increased natural illumination. Third, a projection screen, projection equipment and whiteboards for information exchange were located on the walls of the interaction space. Therefore, the interaction space was intended to accommodate those encounters that were also intended to take place in the journal lounge.

The interaction space was the focus of discussions with researchers during the visit to URC6. Almost all researchers and the director mentioned that the interaction space was left virtually empty for most of a typical day, while the journal room seemed to be a focal point of encounters. An attempt to encourage researchers to use this space was made by arranging prescheduled presentations about research in this space. This attempt was unsuccessful, however, since the windows provided “too much” natural light, making projection impossible. URC6 researchers were therefore very interested in the result of data collection about the interaction space, and how much it was actually used.

The territory and architectural program of URC6 is a unique example among URCs that participated in the study, with deliberate efforts to facilitate interactions both on the side of the “client” (researchers and the director) and the designers.

6.1.6.3. Spatial Configuration

The spatial configuration of URC6 territory exhibits a tree-like structure when both floors are examined together on the justified permeability graph. Starting with the entrance lobby, each convex space gets deeper until cellular offices as the deepest spaces on each floor are reached. The two floors are connected via a stairway and an elevator, which also connect the two office cores.

When the floors are examined individually, however, a ringy structure is apparent on both floors. The office core convex spaces on both floors form rings, to which cellular convex spaces are directly connected. The central location of the journal lounge becomes clearer on the justified permeability graph. One interesting feature of the URC6 justified permeability graph is its configurational resemblance to that of URC5. While the connection between the two floors of URC6 is weak due to the presence of two floors, URC5 territory displays a similarly
weak connection between its two office cores despite the fact that both are on the same floor. The justified permeability graph of URC6 territory is displayed on Figure 6.1.6.2, with the space outside the entrance lobby as the starting point.

![Figure 6.1.6.2. The spatial configuration of URC6 territory: justified permeability graph with the space outside the entrance lobby as the starting point.](image)

### 6.1.6.4. Correspondence of URC6 with a Spatial Category

In the justified permeability graph of URC6 territory, only three basic functions introduced in Chapter 4 can be observed: two office cores and offices, with a direct connection to the primary circulation through one of the office cores. When the interrelationships of convex spaces that constitute these functions are considered, the scheme becomes clear for categorizing URC6. First, URC6 territory is composed of two office cores (OC) on two floors, and cellular and open individual offices (O). Second, a number of cellular and open offices are directly connected to each of the office cores (OCÆ→O). Third, these office cores are directly connected to each other, which can be represented as:
Fourth, one of these office cores is directly connected to the primary circulation, which remains outside URC6 territory. These spatial interrelationships can be represented as:

\[
\begin{align*}
O & \leftrightarrow OC1 \leftrightarrow OC2 \leftrightarrow O \\
\end{align*}
\]

This series of convex space interrelationships form a spatial configuration that corresponds to a category 3 URC. As a result, URC6 was categorized as a **Category 3 University Research Center** according to its spatial configuration.

### 6.1.7. Summary

Based on this analysis, six URCs that participated in the study corresponded with one of the three previously defined URC categories. Accordingly, URC1 and URC2 corresponded with Category 1 URCs, URC3 and URC4 corresponded with Category 2 URCs, and URC5 and URC6 corresponded with Category 3 URCs.

The following section will report the findings from each of the individual case studies.
6.2. CUMULATIVE DATA ANALYSES ACROSS CASES IN FIXED-FEATURE SPACE

Prior to an analysis of URCs as individual case studies, a cumulative analysis of data gathered from all URCs was conducted. The main objective of cumulative data analysis was to identify overall tendencies in the relationships between technical consultations and fixed-feature space, which would be informative during data analyses in individual cases. Cumulative data analysis was conducted in three phases.

In the first phase, the quantities and types of technical consultations reported in all URCs were examined and tabulated. The objective of this phase was to understand to what extent the participants from all URCs preferred different types of technical consultations in their work.

In the second phase, aggregated data tables were prepared for each type of technical consultation and each fixed-feature space property (syntactical properties and walking distances) by uniting data points from all URCs. Then, bivariate relationships of aggregated technical consultations to syntactical properties of space and walking distances were analyzed.

In the third phase, bivariate relationships of technical consultations to syntactical properties of space and walking distances were analyzed in each individual URC. Then, correlation coefficients of these bivariate relationships from all URCs were tabulated across URCs. This phase of cumulative data analysis concluded by comparing the correlation coefficients of bivariate relationships from each individual URC, and identifying patterns of relationships that repeated across cases.

6.2.1. Cumulative Findings About the Quantities and Types of Technical Consultations Reported in all URCs

At the time of data collection, a total of 104 researchers were working with the six URCs that participated in the study. Among these, 85 researchers responded to the activity logs and the follow-up surveys, yielding an 82% cumulative response rate. Researchers across six URCs reported a total of 1763 research related technical consultations by responding to activity logs.

Among the 1763 research related technical consultations reported, 57% were unscheduled office visits, 23% were coincidental consultations, 3% were prescheduled group meetings, 2% were prescheduled office visits and 2% were unscheduled group meetings. Of the remaining technical consultations, 8% were technical consultations through e-mails, and 4% were technical consultations through telephone calls. Thus, while 88% of the reported research related technical consultations were face-to-face technical consultations, only 12% of the total occurred through e-media (Chart 6.2.1).
From the analyzed data, it was found that 80% of all the reported research related technical consultations occurred in the form of unprogrammed encounters (unscheduled office visits and coincidental consultations), 7% occurred in the form of programmed encounters (prescheduled group meetings, prescheduled office visits and unscheduled group meetings), and 12% were technical consultations through e-media.

From these results, it was evident that face-to-face technical consultations were the main medium of research related technical consultations. Moreover, among all face-to-face technical consultations, unprogrammed encounters formed the main medium of research related technical consultations.

6.2.2. Aggregated Bivariate Relationships of Technical Consultations to Fixed-feature Space (Syntactical Properties of Space and Walking Distances) in all URCs

In order to identify bivariate relationships, aggregated data tables were prepared for each type of technical consultation and each fixed-feature space property (syntactical properties and walking distances) by uniting data points from all URCs.
6.2.2.1. Coincidental Consultations

In each URC, numbers of reported coincidental consultations per researcher were calculated by dividing the reported numbers of coincidental consultations by the total number of respondents. A data table was then prepared by uniting syntactical properties of each single convex space and numbers of reported coincidental consultations per researcher from all URCs. The relationships between coincidental consultations and syntactical properties of space were analyzed (Table 6.2.2.1).

Table 6.2.2.1. Aggregated bivariate relationships of coincidental consultations (per researcher) and syntactical properties in fixed-feature space in all URCs (n=114).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>coincidental consultations per researcher</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.44$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.38$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>$r^2=0.28$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.29$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.29$, $p&lt;0.0001$ (negative correlation)</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>$r^2=0.20$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2=0.10$, $p=0.0035$ (negative correlation)</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.32$, $p&lt;0.0001$</td>
</tr>
</tbody>
</table>

The results of this analysis indicated that syntactical properties of space were significantly related to quantities of reported coincidental consultations when all responses were aggregated. In all URCs that participated in the study, more coincidental consultations were reported in convex spaces with high global integration (RRAn), high connectivity (CONN), high control value (CV), high local integration (RRA3), high intelligibility (I) and high visibility (MeanISO) measures. Thus, positive statistically significant relationships were found between these syntactical properties of space and quantities of reported coincidental consultations when all responses were aggregated. On the other hand, point depth from the most globally integrated space (DEPTH RRAnMAX) and mean depth (MD) were negatively but significantly related to quantities of reported coincidental consultations. Thus, more coincidental consultations were reported in convex spaces with lower point depth from most globally integrated convex spaces and lower mean depth measures. However, this aggregated analysis merely depended on numerical values based on configurational analysis. In this respect, no explanations of these relationships either about individual URCs or about individual convex spaces were provided with this analysis.

As a result, this analysis, while showing relationships between syntactical properties of space and quantities of reported coincidental consultations, also indicated that individual analysis of each URC is necessary in order to fully understand and explain these relationships.
### 6.2.2.2. Unscheduled Office Visits

Following coincidental consultations, aggregated data analyses were conducted in order to identify the relationships between quantities of reported unscheduled office visits and syntactical properties of space in all URCs. An aggregated data table was prepared by uniting syntactical properties of each single convex space and quantities of reported unscheduled office visits per researcher from all URCs. The relationships of unscheduled office visits to syntactical properties of space were analyzed (Table 6.2.2.2).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS PER RESEARCHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.42, p&lt;0.0001$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.18, p&lt;0.0001$</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>$r^2=0.12, p=0.0001$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.16, p&lt;0.0001$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.27, p&lt;0.0001$ (negative correlation)</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2=0.34, p=0.01$ (negative correlation)</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.28, p&lt;0.0001$</td>
</tr>
</tbody>
</table>

This analysis yielded weaker relationships between unscheduled office visits and syntactical properties of space compared to coincidental consultations. However, the relationships were similar in terms of the direction of correlations. Higher numbers of unscheduled office visits per researcher were reported in those offices with high global integration (RRAn), higher connectivity (CONN), higher control value (CV), higher local integration (RRA3), higher visibility (MeanISO), lower point depth from the most globally integrated space (DEPTH RRAnMAX) and lower mean depth (MD) measures. Intelligibility of convex spaces did not exhibit any significant relationship to unscheduled office visits.

Similar to the findings about coincidental consultations, these results were also based only on the numerical values from configurational analysis, and therefore, did not include any explanations about individual cases or individual convex spaces. However, this analysis indicated that certain levels of statistically significant correlations did exist between numbers of unscheduled office visits per researcher and syntactical properties of space across all URCs.

### 6.2.2.3. Programmed Technical Consultations

The identical aggregated data analysis procedure was applied to unscheduled group meetings, prescheduled group meetings and prescheduled office visits. Findings indicated that there were no statistically significant
relationships between syntactical properties of space and quantities of programmed technical consultations. Therefore, further analyses of how these types of face-to-face technical consultation related to space are discussed in each individual case study.

6.2.2.4. Technical Consultations Through E-media

The identical procedure of aggregated data analysis was conducted in order to understand how the quantities of reported consultations through e-media related to syntactical properties of space. Initially, the sum of reported e-mails and telephone calls were calculated for each convex space in all URCs, to achieve the reported numbers of consultations through e-media. Numbers of consultations through e-media per researcher were then calculated for each convex space in each URC.

An aggregated data table was formed and the relationships of consultations through e-media to syntactical properties of space were analyzed. The findings of this analysis were informative in indicating how syntactical properties of space were related to quantities and origins of technical consultations through e-media. Although the strength of the relationships were low, the found relationships were statistically significant. Overall, it was identified that most of the technical consultations originated in those spaces with low global integration (RRAn), higher point depth (DEPTH RRAnMAX) and low visibility (MeanISO) spaces. Therefore, this analysis indicated that those researchers in segregated and less visible offices had a higher tendency to use e-media for their technical consultations compared to their colleagues in more integrated and visible offices.

6.2.2.5. Aggregated Bivariate Relationships of Technical Consultations to Walking Distances in all URCs

The walking distance traveled for each single reported technical consultation was calculated from its origin to destination in all URCs. Technical consultations were then categorized into 10 feet walking distance intervals, and the number of technical consultations in each interval was calculated. Finally, bivariate relationships between the number of technical consultations in each interval and the maximum walking distance of these intervals were examined.

An analysis of the effects of walking distances on technical consultations in fixed-feature space across cases yielded the following results. No significant relationships were found between walking distances and programmed encounters. On the other hand, it was found that unprogrammed encounters (both coincidental consultations and unscheduled office visits) were negatively correlated to walking distances (Table 6.2.2.3).
### Table 6.2.2.3. Aggregated bivariate relationships of unprogrammed encounters (coincidental consultations and unscheduled office visits) and walking distance in fixed-feature space in all URCs.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.50$, $p&lt;0.0001$</td>
<td>$r^2=0.37$, $p&lt;0.0001$</td>
<td>$r^2=0.41$, $p&lt;0.0001$</td>
</tr>
</tbody>
</table>

The analysis indicates that the majority of unprogrammed encounters occurred within a fifty feet walking distance range when all URCs were considered. Within walking distances of more than fifty feet, the numbers of reported unprogrammed encounters drastically decreased. Thus, it was identified that when researchers left their offices, there was a higher probability of engaging in an unprogrammed encounter within a fifty feet walking distance of their offices. This finding indicated that the researchers’ tendency was to remain within a short walking distance when they left their offices. This result also showed that those URCs that provided shorter walking distances within their territories had a higher probability of facilitating unprogrammed encounters. Therefore, aggregated data analysis showed that overall, walking distances were negatively correlated to unprogrammed encounters.

### 6.2.2.6. Summary

Overall, analyses of aggregated data tables indicated that syntactical properties of space were significantly related to quantities of coincidental consultations, unscheduled office visits and technical consultations through e-media. However, no relationships were found between syntactical properties of space and unscheduled group meetings, prescheduled group meetings and prescheduled office visits. While higher numbers of coincidental consultations and unscheduled office visits were reported in globally integrated and highly visible spaces, it was also identified that technical consultations through e-media mainly originated from relatively segregated and less visible convex spaces. Aggregated data tables’ analyses also indicated that walking distances were negatively related to unprogrammed encounters (coincidental consultations and unscheduled office visits). These findings indicated a higher probability of engaging unprogrammed encounters for researchers within shorter walking distances.

The results of these analyses showed that more unprogrammed encounters were reported in centrally located, configurationally accessible and highly visible convex spaces in all six URCs. In addition, those researchers occupying configurationally segregated and less visible convex spaces had a higher tendency to use e-media for their technical consultations.

Analyses of aggregated data tables yielded preliminary findings based on numerical values of configurational analysis and walking distances. However, it was also noted that in order to build detailed explanations about the
effects of space on face-to-face technical consultations, further analyses at the individual case level is necessary. Therefore, detailed explanations of these relationships will be discussed in individual case study reports.

6.2.3. Patterns of Bivariate Relationships between Technical Consultations and Syntactical Properties of Space / Walking Distances in all URCs

The relationships between each syntactical property and each technical consultation type were examined individually in each URC. In addition, relationships between walking distances and each technical consultation type were also examined individually in each URC. Findings from each URC were then combined to see which relationships were repeating across cases. The results indicated that fixed-feature space was related to unprogrammed encounters (coincidental consultations and unscheduled office visits) in all six URCs.

6.2.3.1. Coincidental Consultations

Positive statistically significant correlations were found between global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), and visibility (MeanISO) of convex spaces and reported coincidental consultations in all six URCs. Negative statistically significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) of convex spaces and reported coincidental consultations in all six URCs. In addition, it was found that reported coincidental consultations negatively correlated with walking distances in all six URCs. Positive statistically significant correlations between intelligibility of convex spaces (I) and reported coincidental consultations were found in URC1, URC2, URC3 and URC4 only.

The significance of these relationships indicated that the majority of coincidental consultations occurred in configurationally accessible and highly visible convex spaces in all six URCs. In addition, the majority of reported coincidental consultations occurred within short walking distances. Table 6.2.3.1 shows the strength and statistical significance of the relationships found in all six URCs.
Table 6.2.3.1. Patterns of relationships between fixed-feature space (syntactical properties and walking distances) and coincidental consultations across all six URCs. Numbers in each cell indicate the strength of the relationship (correlation coefficient $r$), and number of stars indicates the statistical significance of the relationship. (-) indicates a negative correlation.

<table>
<thead>
<tr>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>URC1</th>
<th>URC2</th>
<th>URC3</th>
<th>URC4</th>
<th>URC5</th>
<th>URC6</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRA$n$)</td>
<td>0.48****</td>
<td>0.54****</td>
<td>0.52****</td>
<td>0.4****</td>
<td>0.44***</td>
<td>0.57****</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>0.6****</td>
<td>0.67****</td>
<td>0.36****</td>
<td>0.65****</td>
<td>0.33**</td>
<td>0.31**</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>0.49****</td>
<td>0.67****</td>
<td>0.28***</td>
<td>0.65****</td>
<td>0.2*</td>
<td>0.25*</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>0.5****</td>
<td>0.65****</td>
<td>0.39****</td>
<td>0.66****</td>
<td>0.31**</td>
<td>0.29**</td>
</tr>
<tr>
<td>POINT DEPTH FROM MAXIMUM GLOBALLY INTEGRATED SPACE (DEPTH RRA$n$MAX)</td>
<td>0.41****(-)</td>
<td>0.21**(-)</td>
<td>0.22***(-)</td>
<td>0.16**(-)</td>
<td>0.37**(-)</td>
<td>0.48***(-)</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>0.52****</td>
<td>0.59****</td>
<td>0.14**</td>
<td>0.56****</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>0.15*(-)</td>
<td>0.33**(-)</td>
<td>0.35****(-)</td>
<td>0.12*(-)</td>
<td>0.28*(-)</td>
<td>0.36***(-)</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>0.54****</td>
<td>0.56****</td>
<td>0.47****</td>
<td>0.27**</td>
<td>0.56**</td>
<td>0.61****</td>
</tr>
<tr>
<td>DISTANCE (DIST)</td>
<td>0.36**(-)</td>
<td>0.90****(-)</td>
<td>0.35****(-)</td>
<td>0.23**(-)</td>
<td>0.74****(-)</td>
<td>0.20*(-)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEGEND</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p &lt; 0.1</td>
<td>*</td>
</tr>
<tr>
<td>p &lt; 0.05</td>
<td>**</td>
</tr>
<tr>
<td>p &lt; 0.01</td>
<td>***</td>
</tr>
<tr>
<td>p &lt; 0.001</td>
<td>****</td>
</tr>
</tbody>
</table>

While supporting the findings of aggregated data analyses, these results, also indicated statistically stronger relationships within individual URCs. Therefore, by analyzing each URC individually, it was possible to clearly identify these relationships.

6.2.3.2. Unscheduled Office Visits

Positive significant correlations were found between global integration (RRA$n$), local integration (RRA3), and visibility (MeanISO) of convex spaces and reported unscheduled office visits in all six URCs. Negative statistically significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRA$n$MAX) and mean depth (MD) of convex spaces and reported unscheduled office visits in all six URCs. It was also identified that reported unscheduled office visits negatively correlated with walking distances in all six URCs.

These results indicated that those researchers occupying centrally located, configurationally more accessible and highly visible offices received more unscheduled office visits in all six URCs. In addition, when the walking
distances between the origin and destination of each unscheduled office visit were measured across URCs, it became clear that the majority of unscheduled office visits were occurring within short walking distances. Table 6.2.3.2 shows the strength and statistical significance of the relationships found in all six URCs.

Table 6.2.3.2. Patterns of relationships between fixed-feature space (syntactical properties and walking distances) and unscheduled office visits across all six URCs. Numbers in each cell indicate the strength of the relationship (correlation coefficient r²), and number of stars indicates the statistical significance of the relationship. (-) indicates a negative correlation.

<table>
<thead>
<tr>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>URC1</th>
<th>URC2</th>
<th>URC3</th>
<th>URC4</th>
<th>URC5</th>
<th>URC6</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>0.49****</td>
<td>0.52***</td>
<td>0.54****</td>
<td>0.28***</td>
<td>0.53****</td>
<td>0.42**</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>0.65****</td>
<td>0.21**</td>
<td></td>
<td></td>
<td>0.27*</td>
<td></td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>0.55***</td>
<td>0.16**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>0.22**</td>
<td>0.6***</td>
<td>0.27***</td>
<td>0.3***</td>
<td>0.27**</td>
<td>0.46***</td>
</tr>
<tr>
<td>POINT DEPTH FROM MAXIMUM GLOBALLY INTEGRATED SPACE (DEPTH RRAnMAX)</td>
<td>0.43****(-)</td>
<td>0.28*(-)</td>
<td>0.14**(-)</td>
<td>0.12*(-)</td>
<td>0.56****(-)</td>
<td>0.29**(-)</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>0.57***</td>
<td></td>
<td>0.1*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>0.54***(-)</td>
<td>0.38****(-)</td>
<td>0.23**(-)</td>
<td>0.22**(-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>0.31*</td>
<td>0.71*****</td>
<td>0.46*****</td>
<td>0.27***</td>
<td>0.34**</td>
<td>0.28*</td>
</tr>
<tr>
<td>DISTANCE (DIST)</td>
<td>0.68****(-)</td>
<td>0.55***(-)</td>
<td>0.23**(-)</td>
<td>0.23**(-)</td>
<td>0.54**(-)</td>
<td>0.39**(-)</td>
</tr>
</tbody>
</table>

LEGEND

- p < 0.1 **
- p < 0.05 ***
- p < 0.01 ****
- p < 0.001 ****

6.2.3.3. Programmed Technical Consultations

Although statistically significant relationships were found between some syntactical properties of space and programmed technical consultations occasionally, these relationships did not exhibit any patterns across cases. In addition, no relationships were found with walking distances. Therefore, it was not possible to identify any relationships between fixed-feature space and unscheduled group meetings, prescheduled group meetings and prescheduled office visits.
6.2.3.4. Technical Consultations Through E-media

Statistically significant correlations were found between syntactical properties of space and technical consultations through e-media in URC1 and URC3. The directions of the found correlations were parallel to the findings of aggregated data analyses: it was found that when a statistically significant relationship occurred, technical consultations through e-media negatively correlated to global integration (RRAn) and local integration (RRA3), but positively correlated to mean depth (MD) of convex spaces in URC1 and URC3. In this respect, the finding that e-mails and telephone calls originated in relatively segregated and less visible spaces was supported with these results. Therefore, although it was not possible to exhibit strong statistical correlations and repeating patterns across all six cases, it was still possible to see the previously reached results from aggregated data analyses (Table 6.2.3.3).

Table 6.2.3.3. Patterns of relationships between fixed-feature space (syntactical properties and walking distances) and technical consultations through e-media across all six URCs. Numbers in each cell indicate the strength of the relationship (correlation coefficient $r^2$), and number of stars indicates the statistical significance of the relationship. (-) indicates a negative correlation.

<table>
<thead>
<tr>
<th>TECHNICAL CONSULTATIONS THROUGH E-MEDIA</th>
<th>URC1</th>
<th>URC2</th>
<th>URC3</th>
<th>URC4</th>
<th>URC5</th>
<th>URC6</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>0.32**(-)</td>
<td></td>
<td>0.19**(-)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.10*(-)</td>
<td></td>
</tr>
<tr>
<td>POINT DEPTH FROM MAXIMUM GLOBALLY INTEGRATED SPACE (DEPTH RRAnMAX)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.26**</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>0.18*</td>
<td>0.55*</td>
<td>0.08*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>0.14**(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DISTANCE (DIST)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LEGEND: $p < 0.1$ *  
$p < 0.05$ **  
$p < 0.01$ ***  
$p < 0.001$ ****
6.2.4. Summary of Findings: Cumulative Data Analyses Across Cases at Fixed-Feature Space

Cumulative data analyses across cases yielded the following six findings.

1. Face-to-face technical consultations were the main source of research related technical consultations in all six URCs.

2. Among face-to-face technical consultations, unprogrammed encounters formed the main source of research related technical consultations. Therefore, unscheduled office visits and coincidental consultations were the most important types of technical consultations in all URCs.

3. Aggregated data analyses across all URCs indicated that statistically significant correlations existed between unprogrammed encounters (unscheduled office visits and coincidental consultations) and syntactical properties of space. It was identified that more unscheduled office visits and coincidental consultations were reported in configurationally accessible, centrally located and highly visible convex spaces in all URCs.

4. Findings revealed that unprogrammed encounters across all URCs negatively correlated with walking distances. Therefore, it was identified that a high number of unscheduled office visits and coincidental consultations occurred within a fifty feet walking distance, and the number of reported unscheduled office visits and coincidental consultations dropped drastically as walking distances increased.

5. Data analyses within individual cases revealed that the relationships of unprogrammed encounters to fixed-feature space (syntactical properties of space and walking distances) formed repeating patterns across all URCs. Therefore, repeating patterns across all six URCs supported the findings of aggregated data analyses. In addition, these repeating patterns exhibited much higher levels of statistical strength than aggregated data analyses. Overall, it was found that unscheduled office visits and coincidental consultations strongly related to syntactical properties of space and walking distances in all six URCs. Higher numbers of unprogrammed encounters were reported in configurationally accessible and highly visible convex spaces within shorter walking distances.

6. Both aggregated data analyses and patterns of relationships across cases indicated that there was a certain level of relationship between technical consultations through e-media and syntactical properties of space. Overall, the findings indicated that e-mails and telephone calls originated in relatively segregated and less visible office spaces. Although statistically the found correlations were not as
strong as previously discussed findings, a certain trend was identified, which was parallel in both aggregated data analyses and patterns of relationships across cases.

As a result, cumulative data analyses indicated that fixed-feature space was mostly related to unprogrammed encounters, which were also the main media of technical consultations. High global integration and visibility were good predictors of unprogrammed encounters in all six URCs. However, semi-fixed feature and non-fixed feature space were not parts of analyses at this level. Therefore, while this initial analysis was informative and guiding for further explanation building, it was noted that further data analyses within each individual case was necessary in order to understand the effects of fixed-feature, semi-fixed feature and non-fixed feature space on patterns of space use for technical consultation. Individual case study reports will be presented according to spatial categories in the following section.

6.3. INDIVIDUAL CASE STUDY REPORTS ACCORDING TO SPATIAL CATEGORIES

This section consists of the conclusions drawn from each URC case study. Each case study report includes a descriptive analysis of the URC under consideration, followed by data analyses findings.

6.3.1. URC1 (CATEGORY 1)

In URC1, 12 of a total of 16 researchers responded to the activity logs and follow-up surveys, yielding a 75% response rate. The responses of URC1 researchers to the activity logs and the follow-up surveys were analyzed according to the data analysis procedure described in Chapter 5. Initially, based on the data collected through the activity logs, research related technical consultations that took place among URC1 researchers were tabulated across technical consultation types defined in the study. URC1 researchers reported a total of 306 technical consultations recorded during the five weekdays in which activity logs were completed.

Among these, 92% were face-to-face technical consultations, and 8% were technical consultations through e-media (e-mails and telephone calls). Of the total number of 306 reported technical consultations, 59% were unscheduled office visits, 20% were coincidental consultations, 6% were unscheduled group meetings, 4% were prescheduled group meetings, and 3% were prescheduled office visits. In addition, 4% of the reported technical consultations were realized through e-mails and 4% were realized through telephone calls. No videoconferences or faxes were reported during this period of time. The tabulation of technical consultations that took place among URC1 researchers is shown in Chart 6.3.1.1.
Chart 6.3.1.1. Tabulation of research related technical consultations reported by URC1 researchers, recorded during the five weekdays in which activity logs were completed.

This tabulation indicated that more than 90% of technical consultations took place through face-to-face discussions, rather than using e-media. Therefore, the main medium for technical consultations in URC1 was face-to-face technical consultations that took place in space, rather than in front of computers or telephones. This finding was parallel to the results of aggregate level data analyses. Consequently, how the amounts and locations of these technical consultations related to fixed-feature, semi-fixed feature and non-fixed feature space was of great importance in answering the research questions of the study.

In order to see these relationships, a behavior map of technical consultations was prepared, indicating the locations of each reported technical consultation on URC1 territory (Figure 6.3.1.1). This behavior map made it possible to visually locate which types of technical consultations took place in convex spaces of different properties.
6.3.1.1. Fixed-feature Space: Configurational Analysis of URC1 Territory

URC1 was previously categorized as a “Category 1 URC”, with its intact territory including both offices and laboratory convex spaces, where the laboratory was directly connected to the office core.

A configurational analysis of URC1 territory was conducted using space syntax methods, in order to analyze the relationships between technical consultations and spatial configuration of URC1 territory. Global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRAn), mean depth (MD), intelligibility (I) and visibility (mean isovist area / MeanISO) were calculated for each single convex space within the territory of URC1. Color-coded plans of URC1 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.1.2).
Figure 6.3.1.2 shows the global integration (RRAn) values of convex spaces within URC1 territory, where a high global integration axis was observed on convex spaces B02, B04, BL01 and BL08. These convex spaces formed the global integration core of the system, which are represented by dark yellow and red tones in Figure 6.3.1.2. Those office spaces that were directly connected to the global integration core were relatively more integrated than those that were not. Other office core convex spaces B01 and B05 were relatively less integrated. The family room (FR), kitchen (URC1-K) and convex space 2501 (see Figure 6.19) exhibited very low RRAn values, indicating that they were relatively segregated from the rest of the system. Laboratory convex spaces that were relatively shallow from the global integration core (BL02, BL03, BL04 and BL09) were more globally integrated than other laboratory convex spaces. Finally, the laboratory support spaces exhibited the most segregated picture from the rest of the system, with lowest RRAn values.

The visibility of convex spaces (mean isovist areas) within URC1 territory were calculated and displayed on color-coded plans. During the calculation process, those furnishings that remained below eyesight were excluded in calculations, since they did not form obstacles to visibility. Figure 6.3.1.3 shows the visibility (mean isovist areas / MeanISO) of convex spaces within URC1 territory.

On Figure 6.3.1.3, the highest mean isovist areas (highest visibility) were observed in laboratory convex spaces. The reason for high visibility in laboratory convex spaces was that visual obstacles were at a minimum in these convex spaces. Since most of the furnishings (i.e. counters) were below eyesight, they did not form obstacles for visibility. Laboratory support spaces, however, exhibited low mean isovist values since they were defined by full-height walls. Within the office core, convex spaces B02 and B04 had relatively higher mean isovist values compared to other office core convex spaces and offices. Those offices directly connected to B02 and B04 were therefore more visible than other offices such as 2518, 2519 and 2520.
Therefore, based on the configurational analysis of URC1 territory, B02 and B04 were the most globally integrated and most visible spaces within office core convex spaces. Within laboratory convex spaces, BL01, BL02, BL03, BL04, BL08 and BL09 were more globally integrated and visible. When the entire system was considered, it convex spaces B02, B04, BL01 and BL08 formed the global integration core of URC1 territory, along with high visibility.

6.3.1.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC1: Syntactical Properties of Space and Walking Distances

The effects of fixed-feature space on technical consultations were searched through data analysis. First, the relationships between syntactical properties of convex spaces and numbers of reported technical consultations were sought. In doing so, bivariate analysis of syntactical properties of convex spaces and numbers of reported technical consultations was conducted, and Pearson’s r correlations were calculated between each pair of variables. Second, the relationships between walking distances within URC1 territory and numbers of reported technical consultations were sought.

Unscheduled Office Visits in URC1. Syntactical properties of URC1 convex spaces were compared to the numbers of unscheduled office visits reported for each convex space. Therefore, the effects of syntactical properties of each space on the numbers of reported unscheduled office visits for each space were analyzed. Figure 6.3.1.4 shows the mapping of unscheduled office visits in URC1 territory.
(CV), visibility (MeanISO), mean depth (MD) and intelligibility (I) did not exhibit any significant relationships to numbers of reported unscheduled office visits. Figure 6.3.1.5 shows the bivariate relationships between unscheduled office visits and each syntactical property.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>r²=0.36, p=0.0021</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td></td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td></td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>r²=0.18, p=0.0415</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>r²=0.30, p=0.0052</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td></td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>r²=0.01, p=0.8</td>
</tr>
</tbody>
</table>

**Figure 6.3.1.5.** Bivariate analysis of the relationships between unscheduled office visits and syntactical properties of convex spaces.

On the scatterplots in Figure 6.3.1.5, it was observed that a very high number of unscheduled office visits were reported in a single space (office number 2524, represented on the scatterplots with a blue square). Since unscheduled office visits occur as visits to individual researchers in their offices, the important point was whether this high number of unscheduled office visits reported in office number 2524 was due to the individual role of that researcher, or the syntactical properties of his/her office. This question was also important in order to interpret the relationships between unscheduled office visits and syntactical properties of convex spaces in the entire system.

In order to understand whether the reason for this observation was the individual role of this researcher or syntactical properties of his/her office, social network analysis of URC1 technical consultation network was conducted based on the data collected through the activity logs. Social centrality values of URC1 researchers were calculated based on the number of directional relations of each researcher. This analysis revealed the
relative social centrality of each researcher. A higher social centrality value for a researcher indicated that, that particular researcher had directional relations with a higher number of researchers compared to his/her colleagues in URC1. The social centrality values of URC1 researchers are tabulated in Chart 6.3.1.2, where each researcher is represented by the space code of his/her office.

<table>
<thead>
<tr>
<th>URC 1 RESEARCHERS: SOCIAL CENTRALITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2530</td>
</tr>
<tr>
<td>R2528</td>
</tr>
<tr>
<td>R2526</td>
</tr>
<tr>
<td>R2524</td>
</tr>
<tr>
<td>R2520</td>
</tr>
<tr>
<td>R2519</td>
</tr>
<tr>
<td>R2518</td>
</tr>
<tr>
<td>R2517</td>
</tr>
<tr>
<td>R2516</td>
</tr>
<tr>
<td>R2515</td>
</tr>
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<td>R2514</td>
</tr>
<tr>
<td>R2513</td>
</tr>
<tr>
<td>R2506</td>
</tr>
<tr>
<td>R2501</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.38</td>
</tr>
<tr>
<td>0.54</td>
</tr>
<tr>
<td>0.46</td>
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<tr>
<td>0.08</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.38</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.15</td>
</tr>
<tr>
<td>0.62</td>
</tr>
<tr>
<td>0.000 0.200 0.400 0.600 0.800 1.000 1.200 1.400 1.600</td>
</tr>
</tbody>
</table>

Chart 6.3.1.2. Social centrality of URC1 researchers based on the number of directional relations of each researcher. R2524 was a key communicator, with the highest social centrality value calculated through social network analysis.

The tabulation shown in Chart 6.3.1.2 indicated that researcher R2524 was a key communicator, with the highest social centrality value. When the distribution of URC1 researchers’ social centrality values was analyzed, R2524 existed as an outlier among other URC1 researchers. This analysis revealed that the researcher occupying office number 2524 had technical consultations with a higher number of researchers compared to his/her colleagues in URC1. Such a high social centrality indicates that the high number of unscheduled office visits paid to this particular researcher’s office was due to his/her individual role rather than the syntactical properties of his/her office. This finding showed that office number R2524 was a clear outlier in the scatterplots shown in Figure 6.3.1.5.
In order to focus on the effects of spatial configuration on unscheduled office visits and maintain the internal validity of the study, the previously conducted bivariate analyses were repeated for unscheduled office visits by removing the key communicator as shown in Figure 6.3.1.6.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.49$, $p=0.0002$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td></td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td></td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.22$, $p=0.02$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.43$, $p=0.0007$</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td></td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td></td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.32$, $p=0.074$</td>
</tr>
</tbody>
</table>

*Figure 6.3.1.6. Bivariate analysis of the relationships between unscheduled office visits and syntactical properties of convex spaces when the key communicator is removed from the data set.*

When the key communicator was removed from the data set, it was observed that the previously observed relationships between syntactical properties and unscheduled office visits were stronger. Global integration (RRAn), local integration (RRA3), point depth from the most globally integrated space (DepthRRAn) exhibited statistically more significant relationships to the reported numbers of unscheduled office visits. Moreover, while visibility (MeanISO) showed no relationship to the reported numbers of unscheduled office visits before the key communicator was removed; this relationship was statistically significant after the removal of the key communicator from the data set.

Another finding at this point was about another space that exhibited high numbers of unscheduled office visits: office number 2516. On the behavior map of unscheduled office visits, it was clear that the researcher in office number 2516 had received a high number of unscheduled office visits. After the social network analysis, it was noted that the researcher occupying this space was not a key communicator, but rather an average
communicator. However, this office was directly connected to the integration core of the system. Therefore, although the researcher occupying this space was an average communicator, a high number of unscheduled office visits took place in this office due to its direct connection to the integration core of the system. This researcher had received a much higher number of unscheduled office visits compared to other researchers in relatively segregated offices. This result further supported the finding about the effects of spatial configuration on unscheduled office visits. Therefore, by removing the key communicator from the data set, it was possible to see the actual relationship between syntactical properties of space and unscheduled office visits.

As a result, global integration (RRAn), local integration (RRA3), point depth from the most globally integrated space (DepthRRAn) and mean isovist area (MeanISO) were effective on the numbers and locations of unscheduled office visits. These results indicated that those researchers occupying centrally located, configurationally accessible and highly visible office convex spaces received more unscheduled office visits compared to their colleagues. Consequently, it was identified that configurational integration and high visibility in office convex spaces facilitated unscheduled office visits.

**Coincidental Consultations in URC1.** Following unscheduled office visits, the syntactical properties of URC1 convex spaces were compared to the numbers of coincidental consultations reported for each convex space. The effects of syntactical properties of each space on the numbers of reported coincidental consultations for each space were sought. Figure 6.3.1.7 shows the behavior map of coincidental consultations in URC1 territory.

![Figure 6.3.1.7. Coincidental consultations and their locations in URC1 territory.](image)

Based on bivariate analyses of syntactical properties of URC1 convex spaces and the numbers of coincidental consultations reported, all measured syntactical properties exhibited statistically significant relationships to numbers of reported coincidental consultations. Within URC1 territory, higher numbers of coincidental consultations were reported in those convex spaces with higher global integration (RRAn), higher connectivity...
(CONN), higher control value (CV), higher local integration (RRA3), lower point depth from the most globally integrated space (DepthRRAnMAX), and higher intelligibility (I). Mean depth (MD), however, did not exist as a strong predictor of coincidental consultations within URC1 territory (Figure 6.3.1.8). These results indicated that the global integration core of URC1 territory actually facilitated coincidental consultations.

On the scatterplots in Figure 6.3.1.8, it was observed that one convex space (the data point highlighted with a red ellipse) exhibited a relatively high number of coincidental consultations compared to others. Although this convex space was relatively segregated from, and less connective to the rest of the system, the number of coincidental consultations reported in this space was relatively higher. Data analysis revealed that this was the “family room”, previously introduced as one of the unique features of URC1 territory. The scatterplots also

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.48$, $p=0.0002$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.60$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>$r^2=0.49$, $p=0.0002$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.50$, $p=0.0001$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.41$, $p=0.0007$</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>$r^2=0.52$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2=0.15$, $p=0.07$</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.54$, $p=0.0004$</td>
</tr>
</tbody>
</table>

**Figure 6.3.1.8.** Bivariate analysis of the relationships between coincidental consultations and syntactical properties of convex spaces in URC1. The data point highlighted with a red ellipse indicates the family room.
indicated that if the family room would be removed from the data set, the relationships between syntactical properties and coincidental consultations could have been much stronger.

This result indicated that the availability of an informal common space itself increased the possibility of coincidental consultations. Despite its segregated location, the informal common function attributed to the family room attracted URC1 researchers to this space. In this respect, the family room formed a “spatial outlier” by forming a social center due to the informal function attributed to it. Whether and how semi-fixed and non-fixed feature elements were effective on the number of coincidental consultations happening in this space were questions that were left to data analysis at the semi-fixed and non-fixed feature level data analysis at this point.

Due to the high levels of difference in visibility levels between the office core and laboratory convex spaces, the relationships of coincidental consultations to visibility values were analyzed separately in the office core and laboratory convex spaces (Figure 6.3.1.9).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>OFFICE CORE</td>
</tr>
<tr>
<td></td>
<td>LABORATORY CONVEX SPACES</td>
</tr>
<tr>
<td>r²=0.54, p=0.0004</td>
<td>r²=0.39, p=0.0041</td>
</tr>
</tbody>
</table>

**Figure 6.3.1.9.** Bivariate analysis of the relationships between coincidental consultations and visibility (MeanISO) of convex spaces in URC1. The data point highlighted with a red ellipse indicates B01, which is relatively segregated from the rest of the system, despite its high visibility. The three data points highlighted with a blue ellipse indicate those laboratory spaces that are relatively segregated from the rest of the system, despite their high visibility.

The analysis indicated that within the office core, higher numbers of coincidental consultations took place in highly visible convex spaces. Office core convex spaces with high visibility also exhibited higher global integration and lower mean depth values. One exception to this situation was office core convex space B01 (highlighted with a red ellipse in Figure 6.3.1.9). Although the visibility of B01 was higher compared to many other office core convex spaces, syntactically it was not as well integrated. Consequently, the number of
reported coincidental consultations was low in B01. Clearly, the overlapping of the integration core with highly visible spaces facilitated coincidental consultations.

Within the laboratory convex spaces, visibility – coincidental consultations relationship was weaker, since researchers spent less of their time in the laboratory. In addition, although the visibility of many laboratory convex spaces were high due to the absence of visual obstacles, their other syntactical properties did not facilitate coincidental consultations. Many of the laboratory convex spaces were relatively segregated from the rest of the system despite their high visibility. Those laboratory convex spaces that were both integrated with the rest of the system, and highly visible exhibited highest numbers of coincidental consultations (i.e. BL01, BL02, BL04, BL08 and BL09). In the second scatterplot of Figure 6.3.1.9, this situation was clearly observable, where those data points highlighted with a blue ellipse indicate those laboratory spaces that are relatively segregated from the rest of the system (BL03, BL06 and BL07), despite their high visibility. This finding indicated that visibility itself was not a direct facilitator of coincidental consultations, but those convex spaces with high visibility and high global integration facilitated coincidental consultations.

Overall, it was identified that syntactical properties of space affected the numbers and locations of coincidental consultations significantly within URC1 territory. While there was significant evidence that those syntactical properties except visibility had facilitating effects on coincidental consultations, when high visibility values overlapped with relatively more integrated convex spaces, larger numbers of coincidental consultations were identified. Findings about the family room indicated that the provision of an informal common space facilitated coincidental consultations.

The findings indicated that those convex spaces with high local (RRAn) and global integration (RRA3), high connectivity (CONN), high control value (CV), high intelligibility (I) and low point depth from the maximum globally integrated convex space (DepthRRAn) facilitated coincidental consultations in URC1. Therefore, it was found that centrally located, configurationally accessible and highly visible convex spaces facilitated coincidental consultations among URC1 researchers. Consequently, the findings indicated that for URC1 researchers, there was a higher probability of engaging in coincidental consultations in globally and locally more integrated, and highly visible convex spaces,

**Unscheduled Group Meetings in URC1.** On the behavior map of unscheduled group meetings in URC1 (Figure 6.3.1.10), it was identified that all unscheduled group meetings except one occurred in two convex spaces: the family room (FR) and office number 2513. The only unscheduled group meeting that occurred outside these two spaces took place in office number 2524, a situation parallel to the previous finding that the researcher occupying this space was a key communicator.
Therefore, it was not possible to seek statistical correlations between syntactical properties of space and unscheduled group meetings, since there would have been only three data points on a scatterplot. However, since the majority of unscheduled group meetings occurred in two spaces, the findings stressed the importance of providing an informal common space in URC territories.

The family room was used for such meetings, parallel to the original intentions when it was designated. Office number 2513, however, was used as a “hangout location” by graduate students within URC1. Therefore, if an unscheduled group meeting was to be held by all researchers, it took place in the family room, while if only graduate students were exchanging information, the meeting took place in office number 2513. One interesting observation was that, although there were six graduate student offices in URC1, office number 2513, which was the most integrated graduate student office with the rest of the system, was selected as the location for unscheduled group meetings by graduate students.

As a result, the location of unscheduled group meetings depended on other factors than only syntactical properties of space. The informal common space “family room” evidently facilitated unscheduled group meetings. However, the graduate students’ location selection for their unscheduled group meetings was an insightful observation as to how syntactical properties of space can be influential on the location of such meetings.

**Prescheduled Group Meetings in URC1.** Throughout the five weekdays in which the activity logs were completed, prescheduled group meetings were reported in three convex spaces: the family room, the conference room (2504) and office number 2513 (Figure 6.3.1.11).
Since there were only three data points, statistical analysis of the relationships between prescheduled group meetings and syntactical properties of space was not conducted. However, as in the unscheduled group meetings, the locations of these meetings were informative. The role of office number 2513 for graduate students was further supported by the finding that this space was the only office space in which a prescheduled group meeting was held. Only two unscheduled group meetings were reported in the formal conference room 2504, which can be explained by the dominant role of the family room as a common space for URC1 researchers.

The family room sustained its role as a gathering space in the analysis of prescheduled group meetings. Nine of a total of eleven prescheduled group meetings were reported for the family room. When the findings about coincidental consultations, unscheduled group meetings and prescheduled group meetings are considered, it becomes clear that the original intentions of URC1 director were achieved in the family room. Evidently, the family room functioned as a social focal point, where researchers met each other, relaxed and discussed issues related to their daily research activities. This was supported by the finding that, despite the presence of a formal conference room (2504), most of the prescheduled group meetings were held in the family room. As a result, for prescheduled group meetings, the location selection was influenced by the role of the family room, rather than syntactical properties of space in URC1.

**Prescheduled Office Visits in URC1.** Prescheduled office visits were reported in five convex spaces in URC1 territory: 2504, 2514, 2524, 2528 and 2530 (Figure 6.3.1.12).
No statistically significant relationships were found between the numbers of reported prescheduled office visits and syntactical properties of their locations. Based on this analysis, it was evident that prescheduled office visits were formal, and directed to specific individuals for previously decided discussions. The finding that the highest number of prescheduled office visits has taken place in the key communicator’s office (2524) supports this result. Therefore, prescheduled office visits were not related to syntactical properties of space.

Technical Consultations through E-media (telephone calls and e-mails) in URC1. A relatively low number of technical consultations through e-media (telephone calls and e-mails) were reported in URC1 (Figure 6.3.1.13), indicating that face-to-face consultations formed the main source of technical consultations.
that originated in each space. Bivariate analysis indicated that global integration (RRAn), local integration (RRA3) and visibility were negatively related to the numbers of e-media consultations that originated in convex spaces (Table 6.3.1.1).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>TECHNICAL CONSULTATIONS THROUGH E-MEDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.32$, $p=0.02$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.29$, $p=0.03$</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.14$, $p=0.08$</td>
</tr>
</tbody>
</table>

Although the relationships found were not statistically as strong as previously discussed technical consultation types, lower levels of statistical significance were still observed with these variables. These relationships indicated that the majority of e-mails and telephone calls originated from less globally and locally integrated, less visible spaces. Moreover, it was found that the majority of e-mails and telephone calls originated from the two offices (2528, 2530) that were not directly connected to the office core, but were directly connected to laboratory convex spaces. As a result, it was identified that researchers that occupied configurationally less accessible and low visibility office convex spaces had a higher tendency to use e-media for their technical consultations.

The Relationship of Walking Distances to the Numbers of Unprogrammed Encounters in URC1. Statistical analyses of the relationships between numbers of technical consultations and syntactical properties of space indicated that the strongest relationships of space existed with unscheduled office visits and coincidental consultations. Walking distances between all pairs of convex spaces were initially categorized into 10 feet intervals, each interval having a maximum walking distance. By measuring the distance between the origin and destination of each unprogrammed encounter, the number of unprogrammed encounters falling into each 10 feet interval was identified. The numbers of unprogrammed encounters reported for each walking distance interval were then compared to the maximum walking distance of each interval (Table 6.3.1.2).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.36$, $p=0.04$</td>
<td>$r^2=0.68$, $p=0.0017$</td>
<td>$r^2=0.71$, $p=0.0012$</td>
</tr>
</tbody>
</table>

This analysis indicated that as the walking distance between the origin and destination of unprogrammed encounters increased, the number of unprogrammed encounters decreased. Evidently, there was a higher
chance of being involved in unprogrammed encounters within closer walking distances for researchers in URC1. When the same bivariate analysis was repeated for unscheduled office visits only, a negative correlation of \( r^2=0.68 \) and \( p=0.0017 \) was found between the number of reported unscheduled office visits and the distance between the origin and destination of each unscheduled office visit. The same bivariate analysis was also repeated for coincidental consultations. This analysis indicated that a negative correlation of \( r^2=0.36 \) and \( p=0.04 \) existed between the number of reported coincidental consultations and the distance between the origin and destination of each coincidental consultation.

Based on these analyses, it was evident that there was a higher chance of engaging in unprogrammed encounters for URC1 researchers within shorter distances from the origin of their movement within URC1 territory. This relationship was stronger when unscheduled office visits were analyzed, indicating that when a URC1 researcher leaves his/her office, there is a higher chance of paying an unscheduled office visit to a colleague within a shorter walking distance. This finding indicated that when URC1 researchers left their offices, they engaged in coincidental consultations within shorter walking distances from their offices. As a result, it was noted that walking distances affected unprogrammed encounters in URC1, where shorter distances facilitated unprogrammed encounters.

6.3.1.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC1: Summary of Findings

At the fixed-feature space level, the results of data analysis indicated that spatial configuration and distance affected unprogrammed encounters in URC1. Positive statistically significant correlations were found between numbers of unscheduled office visits and global integration (RRAn), local integration (RRA3) and visibility (MeanISO) of convex spaces. The analysis also yielded a negative statistically significant correlation between numbers of unscheduled office visits and convex spaces’ point depth from the maximum globally integrated space (DepthRRAn). Positive statistically significant correlations were found between numbers of coincidental consultations and global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), and intelligibility (I) of convex spaces. The analysis also yielded a negative statistically significant correlation between numbers of coincidental consultations and convex spaces’ point depth from the maximum globally integrated space (DepthRRAn). Within the office core and laboratory convex spaces of URC1, positive statistically significant correlations were found between numbers of coincidental consultations and visibility (MeanISO) of convex spaces.

Therefore, findings in the case of URC1 indicated that configurationally integrated, highly visible convex spaces facilitated unprogrammed encounters (coincidental consultations and unscheduled office visits) in URC1. For
unscheduled office visits, this situation was double checked by identifying the key communicator, and it was found that when the key communicator was removed from the data set, unscheduled office visits related even stronger to syntactical properties of space. Thus, it was confirmed that higher configurational integration and high visibility facilitated unscheduled office visits, and these effects were not due to individual roled of researchers.

Among all unprogrammed encounters, it was found that walking distances had an effect on unscheduled office visits and coincidental consultations. Data analysis indicated that the numbers of unscheduled office visits and coincidental consultations decreased significantly as the walking distances between the origins and destinations increased.

It was found that the availability of an informal common space, “the family room”, facilitated unscheduled group meetings. It was also found that an office space with direct connection to the integration core of URC1 was usually chosen by the graduate students for unscheduled group meetings. For prescheduled group meetings, it was found that the family room was mostly chosen as a location. Therefore, the presence of such an informal common space apparently facilitated group meetings, especially in a territory where a more formal conference room was also available. When the locations and numbers of prescheduled office visits were analyzed, it was found that they were related to the individual researcher to be contacted, rather than spatial properties of the individual’s office.

Consultations through e-media (e-mails and telephone calls) were chosen much less than face-to-face technical consultations as media for information exchange. The clear indication was that face-to-face technical consultations were the first choice as opposed to consultations through e-media. When the locations of e-media consultation locations were analyzed, it was observed that e-media consultations mainly originated from less visible and syntactically relatively segregated offices. Despite the fact that these results were statistically weaker than previously discussed findings, they still exhibited statistical significance, and were informative about how fixed-feature space affects choice of information exchange media. To summarize, data analyses indicated that fixed-feature space mainly affected the unprogrammed encounters in URC1.

6.3.1.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC1: Environmental Qualities and Reasons for Space Use

Following data analyses about the relationships between fixed-feature space and technical consultations, the relationships between semi-fixed and non-fixed feature space and technical consultations were analyzed. The environmental qualities and reasons for use of those spaces where researchers most frequently met others and
where researchers most frequently visited when they left their offices were analyzed. Based on the researchers’ responses to the follow-up surveys, cited environmental qualities and reasons for use were associated with the convex spaces indicated by researchers (Figure 6.3.1.14). In some cases, it was observed that URC1 researchers also indicated fixed-feature space level comments and evaluations in the follow-up surveys.

**Figure 6.3.1.14.** The relationships between semi-fixed and non-fixed feature space and technical consultations in URC1, based on the follow-up surveys. Red colored texts indicate environmental qualities, and blue colored texts indicate reasons for space use as indicated by URC1 researchers.

The results of content analysis indicated that among office core convex spaces, B04 was cited highly for meeting other researchers. The high number of citations of B04 for meeting other researchers supported the findings from the activity logs. B04, also being the global integration core of URC1 territory, was referred to as a hot spot of coincidental consultations in URC1. Environmental qualities at non-fixed feature level were indicated for B04 by URC1 researchers. The researchers perceived the fact that “they always ran into someone” in B04 as a positive environmental quality. However, they were not satisfied with the narrowness of B04, since “it was not conducive to chatting due to narrowness”. These results indicated that office core convex space B04 was
facilitating coincidental consultations not only because it formed the global integration core of URC1, but also because researchers thought that they had a high chance of coincidentally meeting their colleagues.

URC1 researchers cited the informal common space “family room” as a space where they most frequently met other researchers. The positive and negative environmental qualities indicated for the family room were complementary to findings at the fixed-feature space level. At the semi-fixed feature space level, the majority of URC1 researchers felt that the informal, comfortable and clean environment of the family room was a positive environmental quality. The furnishings of the family room were cited frequently as a reason for this. At the fixed-feature space level, the family room’s closeness to the coffee machine was perceived as a positive environmental quality. URC1 researchers also indicated that if the family room was in a more central location, they could have been “a more cohesive group”. This citation actually pointed at a desire of a more configurationally integrated location for the family room. The most frequently indicated reasons for going to the family room were “to see other researchers”, “to get coffee” and “to get water”. Considering the findings about the family room from the activity logs, the following conclusions were drawn.

The very presence of a space explicitly allocated for informal gatherings and relaxation was a facilitator of coincidental consultations among URC1 researchers. At the fixed-feature space level, the family room’s closeness to conveniences such as coffee, water, and food (by the kitchen) created a “magnet effect” for URC1 researchers. At the semi-fixed feature space level, the perception of an informal, comfortable and relaxed environment was a facilitator for URC1 researchers’ visits to the family room. Finally, at the non-fixed feature level, the perception that there was a high chance of coincidentally meeting colleagues in the family room had a positive effect on the number of coincidental consultations in this space. Moreover, the shared “lobby” in Building 1, although offering the same material conveniences as the family room (coffee, food) was not used to a large extent since the researchers thought it was “not that homey”. Therefore, the presence of an informal common space within the territory of URC1, supported by material conveniences and an informal and relaxed atmosphere formed another hot spot of coincidental consultations, although the space was syntactically relatively segregated from the rest of the system.

Another positive environmental quality frequently pointed out by URC1 researchers was access to daylight. Almost all spaces with direct access to daylight were cited for this environmental quality. However, this environmental quality did not have any effect on researcher’s reasons for going to these spaces, nor the frequency of meeting others. Moreover, in the case of laboratory convex spaces, some URC1 researchers indicated that this turned out to be a technical inconvenience due to the negative effects of daylight on the solutions they were working on.
Most cited reasons for space use were about business tools, such as visits to space number 2501 “to check supplies” or visits to laboratory convex space BL04 “to do laboratory work” using specific equipment. “Daily discussions about research” was cited as a reason for going to office number 2513, which was a result also found in the analysis of activity logs. The kitchen was one of the most frequently visited spaces, due to the presence of food and drinks in this space.

To summarize, the results indicated that business tools, access to food, drink and the possibility of meeting other researchers were the most frequently cited reasons for space use in URC1. When environmental qualities of those spaces where URC1 researchers most frequently met others were considered, perceived environmental comfort, access to daylight, perception of an informal environment and the presence of other researchers were mostly cited as positive environmental qualities. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation” in Table 6.3.1.3.

Table 6.3.1.3. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC1. Examples of URC1 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Configurational integration within the territory for common spaces (i.e. “a central location for the family room”)</td>
<td></td>
</tr>
<tr>
<td>- Metric proximity to desired functions (i.e. “food, water”)</td>
<td></td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Perceived environmental comfort / furnishing (i.e. “couches”)</td>
<td></td>
</tr>
<tr>
<td>- Access to daylight (i.e. “large windows”)</td>
<td>Material conveniences (i.e. “access to food / drink”)</td>
</tr>
<tr>
<td><strong>Non-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Perception of an informal environment (i.e. “relaxed”)</td>
<td>Concentrated work (i.e. “lab work / reading”)</td>
</tr>
<tr>
<td>- Meeting others / breaks</td>
<td></td>
</tr>
</tbody>
</table>

6.3.1.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC1

A summary of findings of the relationships between fixed-feature space and technical consultations in URC1 is shown in Table 6.3.1.4.
Table 6.3.1.4. Summary of findings: relationships between fixed-feature space and technical consultations in URC1. (*) indicates negative correlations.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>SYNTACTICAL PROPERTIES OF SPACE</th>
<th>WALKING DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRAn</td>
<td>CONN</td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td>$r^2=0.49$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0002$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.22$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.02$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.43$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0007$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.32$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.074$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.68$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0017$</td>
<td></td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td>$r^2=0.49$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0002$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.60$</td>
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</tr>
<tr>
<td></td>
<td>$p&lt;0.0001$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.49$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0002$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.50$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0001$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.41$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0007$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.52$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0001$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.15$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.071$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.54$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.0004$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$r^2=0.36$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.04$</td>
<td></td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td>$r^2=0.32$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.02$</td>
<td></td>
</tr>
<tr>
<td>PRESCRIBED GROUP MEETINGS</td>
<td>$r^2=0.29$ (*)</td>
<td></td>
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<tr>
<td></td>
<td>$p=0.03$</td>
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<tr>
<td>PRESCRIBED OFFICE VISITS</td>
<td>$r^2=0.14$ (*)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$p=0.08$</td>
<td></td>
</tr>
</tbody>
</table>

In the case study of URC1, it was initially found that face-to-face technical consultations were preferred significantly more than consultations through e-media. Therefore, face-to-face technical consultations formed the main medium for information exchange in URC1.

Findings of the study in URC1 indicated that at the fixed-feature space level, spatial configuration and walking distances significantly affected the number and locations of unprogrammed encounters (unscheduled office visits and coincidental consultations). The results showed that higher global integration, higher local integration, higher visibility and lower point depth from the maximum globally integrated space increased chances of unscheduled office visits. Higher levels of global integration, local integration, connectivity, control value, visibility, intelligibility and lower levels of point depth from the maximum globally integrated space increased chances of coincidental consultations. Consequently, it was identified that centrally located, configurationally accessible and highly visible convex spaces facilitated unprogrammed encounters (unscheduled office visits and coincidental consultations) in URC1.

The results indicated that shorter walking distances increased the chances of higher numbers of unscheduled office visits among URC 1 researchers. The greatest effect on the number and locations of coincidental consultations was formed by the syntactical properties of space, while shorter walking distances also had a facilitating effect.
The allocation of an informal common space facilitated face-to-face technical consultations of various types. Coincidental consultations were facilitated in the family room despite its relatively segregated syntactical properties. The family room also formed a “magnet effect” for unscheduled and prescheduled group meetings. Analysis of the follow-up surveys indicated that providing such an informal environment, supported by desired material conveniences and perceived as a “comfortable, relaxed, homey” environment had a great facilitating effect on coincidental consultations, unscheduled and prescheduled group meetings. The fact that the family room was within URC1 territory, and was not shared by other URCs in the building was also a positive feature facilitating the formation this interactive environment. It was also found that in URC1, prescheduled office visits were mainly related to the researchers targeted for discussions, rather than any spatial properties of their offices.

As a result, while at the fixed-feature space, syntactical properties of space and walking distances highly affected unprogrammed encounters, at the semi-fixed and non-fixed feature space, positively perceived environmental qualities, access to desired functions and the possibility of meeting others significantly affected patterns of space use for face-to-face technical consultation. The availability of an informal common space within URC1 territory was another facilitator of face-to-face technical consultations.

6.3.2. URC2 (CATEGORY 1)

At the time of data collection, of the 12 researchers working with URC2, Nine URC2 researchers responded to the activity logs and follow-up surveys, yielding a response rate of 75%. The responses of URC2 researchers to the activity logs and the follow-up surveys were analyzed according to the data analysis procedure described in Chapter 5. The reported research related technical consultations in URC2 were initially tabulated across technical consultation types defined in the study. During the five weekdays in which activity logs were completed, a total of 226 research related technical consultations were reported in URC2.

95% of the reported technical consultations were face-to-face, while 5% were technical consultations through e-media. Among the reported technical consultations, 65% were unscheduled office visits, 23% were coincidental consultations, 1% were unscheduled group meetings, 2% were prescheduled group meetings, and 3% were prescheduled office visits. 3% of the reported technical consultations had occurred through telephone calls, and 2% through e-mails. The tabulation of technical consultations that took place among URC2 researchers is shown in Chart 6.3.2.1.
This tabulation of technical consultations indicated that face-to-face technical consultations were the main media for technical consultations in URC2. This result also supported the previous findings in aggregate level data analyses and in the individual case study report of URC1. The locations of reported research related technical consultations were then mapped on the floor plan of URC2, which made it possible to identify the types of technical consultations occurring in convex spaces of different properties (Figure 6.3.2.1).
6.3.2.1. Fixed-feature Space: Configurational Analysis of URC2 Territory

URC2 was previously identified as a “Category 1 URC”, with its intact territory, which included both offices and laboratory convex spaces, where the laboratory was directly connected to the office core.

A configurational analysis of URC2 territory was conducted using space syntax methods in order to understand the relationships between technical consultations and spatial configuration of URC2 territory. Global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRAn), mean depth (MD), intelligibility (I) and visibility (mean isovist area / MeanISO) were calculated for each single convex space within URC2 territory. Color-coded plans of URC2 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.2.2).
It was identified that the global integration core of the system was formed on the axis containing convex spaces G02, GL08, GL11 and GL12 (see Figure 6.3.2.1). In Figure 6.3.2.2, the global integration core of the system was identified by dark yellow and red colors across this axis. In general, it was identified that those convex spaces with direct connections to the global integration core were more integrated than others. In the office core, shared workspaces G04 and G06 were relatively more integrated, while among the laboratory convex spaces, GL03 was relatively more integrated. GL 04 was the most segregated convex space among laboratory convex spaces. Laboratory support spaces exhibited a segregated picture from the rest of the system. In addition, the conference room (2103) and the only individual office space (2105) were relatively segregated from the system. The visibility of URC2 convex spaces were also calculated and displayed on color-coded floor plans. During the calculation process, those furnishings that remained below eyesight were excluded in calculations, since they did not form obstacles to visibility. Figure 6.3.2.3 shows the visibility (mean isovist areas / MeanISO) of convex spaces within URC2 territory.
In URC2, laboratory convex spaces had much higher visibility values than office core convex spaces and offices. The reason for high visibility in laboratory convex spaces was that the visual obstacles (i.e. counters) were below eyesight, and the shelves on top of the counters did not have backboards. Within the office core, convex spaces G02, G02, G03, G04, G05 and G06 had relatively high visibility values compared to convex spaces 2103, 2105 and 2104, since these convex spaces were defined by full-height walls.

Configurational analysis of URC2 territory indicated that the global integration core of the system passed through both the office core and laboratory convex spaces (G02, GL08, GL11 and GL12). Highest levels of visibility were identified within laboratory convex spaces due to the minimum amount of visual obstacles, while their global integration values were relatively smaller (i.e. GL04).

6.3.2.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC2: Syntactical Properties of Space and Walking Distances

According to the data analysis protocol, effects of fixed-feature space on unscheduled office visits were analyzed. First, the relationships between syntactical properties of space and different types of technical consultations were examined. Pearson’s r correlations were examined between each syntactical property and numbers of reported technical consultations in URC2 convex spaces. Second, the relationships between walking distances and technical consultations were analyzed.
Unscheduled Office Visits in URC2. A behavior map of unscheduled office visits was used to compare the syntactical properties of URC2 convex spaces to the numbers of unscheduled office visits reported for each convex space (Figure 6.3.2.4). The effects of syntactical properties of convex spaces on the reported numbers of unscheduled office visits were examined.

The behavior map of unscheduled office visits indicated that by regularly working in the laboratory, most URC2 researchers were using laboratory convex spaces as their “home bases” instead of cellular offices. Consequently, many unscheduled office visits were reported in laboratory convex spaces. The behavior map indicated that the majority of unscheduled office visits had occurred on globally more integrated and more visible convex spaces among both office core and laboratory convex spaces. In addition, the shared office space 2104 was also reported as the location of eight unscheduled office visits. In order to understand how syntactical properties of URC2 convex spaces were related to the numbers of unscheduled office visits reported for each convex space, bivariate analyses were conducted. Table 6.3.2.1 shows bivariate analyses of the relationships between unscheduled office visits and each syntactical property.
Table 6.3.2.1. Bivariate analyses of the relationships between unscheduled office visits and syntactical properties of convex spaces in URC2.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.52$, $p=0.005$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.65$, $p=0.0009$</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>$r^2=0.55$, $p=0.004$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.60$, $p=0.001$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.33$, $p=0.02$</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>$r^2=0.57$, $p=0.002$</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2=0.54$, $p=0.004$</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.71$, $p=0.0001$</td>
</tr>
</tbody>
</table>

Bivariate analyses indicated that numbers of unscheduled office visits in convex spaces were positively and significantly correlated to global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces. Negative significant correlations were found between numbers of unscheduled office visits in convex spaces and point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces.

These correlations indicated that unscheduled office visits occurred in more integrated and more visible convex spaces, and researchers occupying relatively segregated and less visible convex spaces had lower chances of receiving unscheduled office visits. An example set for this finding was the relatively segregated and less visible laboratory convex space GL04, which received only two unscheduled office visits, whereas the more integrated and visible laboratory convex spaces GL03 and GL05 received many more unscheduled office visits compared to GL04 (see Figure 6.3.2.4).

In order to understand if these correlations were affected by individual roles of any researchers in URC2, social network analysis of the URC2 technical consultation network was conducted. Unlike URC1, no key communicators were identifiable in URC2 technical consultation network. The social network analysis indicated that there were no outliers within the distribution of social centrality of URC2 researchers. Chart 6.3.2.2 shows the social centrality of URC2 researchers, where each URC2 researcher is indicated by the convex space he/she occupies as a “home base”.
Chart 6.3.2.2. Social Centrality of URC2 researchers based on the number of directional relations of each researcher. No key communicators were identifiable in URC2, where it was not possible to note any outliers in terms of social centrality.

Since no key communicators were identified in URC2 technical consultation network, the relationships found between unscheduled office visits and syntactical properties of space were not affected by individual researcher roles. Therefore, the relationships were related to the effects of syntactical properties of space, which also removed any concern about the validity of findings at this stage in the analysis.

As a result, these findings indicated that higher levels of global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values, and lower levels of point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) increased the possibility of unscheduled office visits in URC2 convex spaces. Therefore, it was identified that URC2 researchers that occupied more centrally located, more configurationally accessible and highly visible convex spaces had received more unscheduled office visits compared to their colleagues.

Coincidental Consultations in URC2. A behavior map of coincidental consultations reported in URC2 was prepared by plotting each coincidental consultation on the floor plan of URC2. The syntactical properties of
URC2 convex spaces were then compared to the numbers of coincidental consultations reported for each convex space.

![Image](image)

**Figure 6.3.2.5.** Coincidental consultations and their locations in URC2 territory.

The behavior map indicated that coincidental consultations occurred in globally integrated and highly visible convex spaces (Figure 6.3.2.5). In order to understand how syntactical properties of URC2 convex spaces were related to the numbers of coincidental consultations reported for each convex space, bivariate analyses were conducted. Table 6.3.2.2 shows bivariate analyses of the relationships between coincidental consultations and each syntactical property.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>r²=0.54, p=0.0002</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>r²=0.67, p&lt;0.0001</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>r²=0.67, p&lt;0.0001</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>r²=0.65, p&lt;0.0001</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>r²=0.21, p=0.04</td>
</tr>
<tr>
<td>INTELLIGIBILITY (l)</td>
<td>r²=0.59, p&lt;0.0001</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>r²=0.20, p=0.05</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>r²=0.56, p=0.0004</td>
</tr>
</tbody>
</table>
Bivariate analyses indicated that statistically significant positive correlations were present between global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces and numbers of reported coincidental consultations. Negative statistically significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces and numbers of reported coincidental consultations.

Since there were no informal common spaces provided within URC2 territory, none of the URC2 convex spaces exhibited unusually high numbers of coincidental consultations. This result supported the finding from URC1 case study report, where it was identified that URC1 family room as an informal common space had attracted unusually high numbers of coincidental consultations despite its relatively segregated location.

Overall, bivariate analyses between coincidental consultations and syntactical properties of URC2 convex spaces indicated that there was a higher possibility of engaging in coincidental consultations for URC2 researchers within highly integrated and visible convex spaces. These results were parallel to previously conducted aggregated data analyses.

**Unscheduled Group Meetings in URC2.** URC2 researchers reported only three unscheduled group meetings in two laboratory convex spaces, in the form of discussions alongside counters (Figure 6.3.2.6). Therefore, it was not possible to identify any relationships between syntactical properties of space and unscheduled group meetings. However, this result was informative, since it indicated that in a URC that did not have any informal common spaces, unscheduled group meetings rarely occurred. The lack of an informal common space in URC2 territory had hindered possible unscheduled group meetings.
Prescheduled Group Meetings in URC2. Within the five-weekday period in which activity logs were completed, URC2 researchers reported only five prescheduled group meetings. Due to the low number of data points, no statistical analysis was conducted. However, it was identified that four of the reported prescheduled group meetings occurred in the shared office 2104, and one occurred in laboratory support space 2112 (Figure 6.3.2.7).
Similar to unscheduled group meetings in URC2, the low number of prescheduled group meetings was interpreted as an indication of the lack of an informal common space. Since the conference room 2103 also was not used for the reported prescheduled group meetings, it was evident that the shared office 2104 rarely functioned as an informal common space.

**Prescheduled Office Visits in URC2.** All six prescheduled office visits reported in URC2 occurred in the shared office 2104 (Figure 6.3.2.8). Evidently, since most URC2 researchers occupied laboratory convex spaces as their “home bases” instead of individual offices, in the case of a need for an individually appointed meeting, shared office 2104 was used.

![Figure 6.3.2.8. Prescheduled office visits and their locations in URC2 territory.](image)

The findings about unscheduled and prescheduled group meetings, and prescheduled office visits indicated that shared office 2104 was being used as a multi-function convex space based on arising needs for different types of technical consultations. Therefore, the functioning of shared office 2104 for multiple purposes confirmed that the lack of an informal multi-function common space was met by occasionally using this space for different purposes than its original function.

**Technical Consultations through E-media (telephone calls and e-mails) in URC1.** Technical consultations through e-media constituted a small percentage (5%) of the total number of reported technical consultations in URC2. Therefore, it was not possible to conduct statistical analysis due to the low number of data points. However, the behavior map of technical consultations through e-media indicated that the majority of e-mails and telephone calls originated in the reception desk and shared office space 2104 (Figure 6.3.2.9). Since computers
were not available in most of the laboratory convex spaces due to the nature of the work done on counters, majority of these consultations originated from those convex spaces where they were available.

![Diagram of URC 2](image)

**Figure 6.3.2.9.** Origins of e-mails and telephone calls in URC2 territory.

No relationships were found between syntactical properties of space and origins of e-mails and telephone calls in URC2 territory. On the other hand, the low number of e-media consultations indicated that the wide bandwidth of face-to-face technical consultations was the first preference among URC2 researchers, within a small territory where face-to-face technical consultations would form a much more efficient medium for information exchange than e-mails or telephone calls.

**The Relationships of Walking Distances to Unprogrammed Encounters in URC2.** In terms of metric distance, URC2 territory was the smallest among the six URCs that participated in the study. Consequently, walking distances within URC2 territory were very short compared to other URCs studied. This situation provided the possibility of engaging in technical consultations by walking minimal distances in URC2 territory. Accordingly, when the relationships between walking distances and unprogrammed encounters were analyzed within URC2 territory, significant correlations were found (Table 6.3.2.3). On the other hand, due to the low numbers of programmed encounters and technical consultations through e-media, no relationships were found between these types of consultations and walking distances.
Table 6.3.2.3. Bivariate analyses of the relationships between unprogrammed encounters and walking distances in URC2.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.90$, p&lt;0.0001</td>
<td>$r^2=0.55$, p=0.0087</td>
<td>$r^2=0.64$, p=0.0032</td>
</tr>
</tbody>
</table>

These analyses indicated that as walking distances increased, numbers of unprogrammed encounters decreased significantly in URC2 territory. The high R-square values found in bivariate analyses were interpreted as the effect of very short overall walking distances within URC2 territory. In many of the reported unprogrammed encounters, it was identified that the origin and destination were two neighboring convex spaces. Therefore, in many cases, URC2 researchers needed no more than a number of steps to reach their colleagues for technical consultation. In general, the negative correlations between walking distances and unprogrammed encounters paralleled the findings from aggregated data analyses.

6.3.2.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC2: Summary of Findings

Data analyses at the fixed-feature level indicated that syntactical properties of space and walking distances affected unprogrammed encounters in URC2.

Bivariate analyses indicated that reported numbers of unscheduled office visits and coincidental consultations were positively and significantly correlated to global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces. Negative statistically significant correlations were found between numbers of unscheduled office visits and coincidental consultations and point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces. These results indicated that centrally located, configurationally accessible and highly visible convex spaces facilitated unprogrammed encounters (unscheduled office visits and coincidental consultations).

It was identified that numbers of unprogrammed encounters negatively correlated walking distances. As the walking distances between origins and destinations increased, numbers of unscheduled office visits and coincidental consultations decreased.

The low numbers of unscheduled and prescheduled group meetings reported by URC2 researchers were attributed to the lack of an informal common space. It was identified that a shared office space (2104) was used both for unscheduled and prescheduled group meetings. Moreover, all reported prescheduled office visits occurred in the shared office space 2104, since URC2 researchers occupied laboratory convex spaces as their
“home bases” rather than cellular offices. Therefore, it was noted that shared office space 2104 was used for multiple purposes due to a lack of a multi-function informal common space in URC2 territory. Furthermore, these findings supported the result from URC1 individual case study report that, informal common spaces had facilitating effects on technical consultations.

Technical consultations through e-media were rarely preferred by URC2 researchers for information exchange. This finding was parallel to previously discussed aggregated data analyses, and indicated that the high bandwidth of face-to-face technical consultations formed the first priority for URC2 researchers. Overall, it was identified that both syntactical properties and walking distances in fixed-feature space affected unscheduled office visits and coincidental consultations in URC2.

6.3.2.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC2: Environmental Qualities and Reasons for Space Use

Following analyses of the relationships between fixed-feature space and patterns of space use for technical consultations, the relationships between semi-fixed/non-fixed feature space and patterns of space use for technical consultations were analyzed. Those spaces where URC2 researchers most frequently met other researchers, and most frequently visited when they left their offices were identified based on the follow-up surveys. The cited environmental qualities and reasons for use of these spaces were then tabulated, and associated with convex spaces on URC2 floor plan (Figure 6.3.2.10).
Content analysis of the environmental qualities and reasons for space use cited by URC2 researchers indicated that they most frequently met their colleagues in laboratory convex spaces. Among these, laboratory convex spaces GL03 and GL05 were cited the most, which supported the findings at fixed-feature space level. In addition, GL06 and laboratory convex spaces on the global integration core of the system (GL08, GL11 and GL12) were also frequently cited. The most frequently indicated positive environmental qualities about these laboratory convex spaces were high visibility, proximity to colleagues, and the amount of working space provided.

A number of researchers were satisfied with the visibility within the laboratory, since no backboards were present behind shelves, and it was possible to see other areas of the laboratory while they were working. However, while some researchers thought that visibility of these convex spaces were high, others thought it was not high enough, by mentioning that it was hard to see what was going on the other areas of the laboratory. Since this issue was addresses most frequently (either positively or negatively), it was identified that visibility was an
important issue in laboratory convex spaces. Almost all citations indicated that URC2 researchers were satisfied with the proximity to their colleagues within URC2 territory. Close-by counters in laboratory convex spaces made it possible for URC2 researchers to easily contact their colleagues during work. Therefore, at the level of semi-fixed feature space, furniture-related issues of visibility and metric proximity among laboratory counters were indicated as important environmental qualities.

At the non-fixed feature space level, the amount of workspace provided to URC2 researchers was cited frequently (i.e. “enough space for working comfortably…”). While most researchers were satisfied with their amount of workspace, the high number of citations about this issue indicated that URC2 researchers wanted to keep a certain level of personal space while they were working. Another relevant non-fixed feature space level issue was space ownership. Many researchers indicated that they were satisfied with those convex spaces that they felt were “their zone”.

Office core convex spaces were mostly perceived as “serene, homey” settings by URC2 researchers. Perceived environmental comfort and issues of decoration were other frequently cited environmental qualities. Some researchers felt that their work environment “felt like a hospital” due to the colors used. Therefore, perceived environmental comfort and perception of an informal environment were the semi-fixed and non-fixed feature environmental qualities indicated in office core convex spaces.

The reasons for space use in URC2 were mostly related to access to material conveniences (i.e. access to food/drink), concentrated work and meeting their colleagues. As in URC1, URC2 researchers also visited those spaces where they thought they could meet colleagues. An interesting finding at this point was the citation of URC1’s family room for meeting other colleagues. Evidently, the family room attracted researchers even from outside of URC1 territory. However, no consultations were reported in the family room by URC2 researchers on the activity logs. Other frequently visited spaces were those URC2 convex spaces where specific laboratory equipment was placed. These spaces were cited as spaces visited for tasks such as preparing solutions and materials.

Overall, content analyses indicated that at semi-fixed feature space level, frequently cited environmental qualities of those spaces where URC2 researchers most frequently met their colleagues were perceived environmental comfort, visibility and metric proximity to colleagues. At non-fixed feature space level, perception of an informal environment, available amount of personal workspace, space ownership and decoration were frequently cited environmental qualities. At the level of semi-fixed feature space, most frequently cited reason for space use was access to material conveniences, such as getting water. At the level of non-fixed feature space, most frequently cited reasons for space use were concentrated work and the presence of other researchers in a
space. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation in Table 6.3.2.4.

Table 6.3.2.4. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC2. Examples of URC2 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Fixed-feature space</th>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Semi-fixed feature space</th>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perceived environmental comfort / furnishing (i.e. “very comfortable”)</td>
<td>Material conveniences (i.e. “to get soda / water”)</td>
</tr>
<tr>
<td></td>
<td>Visibility (i.e. “no backboards on shelves makes it easy to see/find people”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metric proximity to colleagues (i.e. “counters are next to one another so you can work and ask questions at the same time”)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Non-fixed feature space</th>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Perception of an informal environment (i.e. “serene”)</td>
<td>Concentrated work (i.e. “preparing solutions / materials”)</td>
</tr>
<tr>
<td></td>
<td>Available amount of personal workspace (i.e. “enough space for working comfortably”)</td>
<td>Meeting colleagues (i.e. “to interact with colleagues”)</td>
</tr>
<tr>
<td></td>
<td>Space ownership (i.e. “my zone”)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decoration (i.e. “colors remind me of a hospital”</td>
<td></td>
</tr>
</tbody>
</table>

6.3.2.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC2

A summary of findings of the relationships between fixed-feature space and technical consultations in URC2 is shown in Table 6.3.2.5.
Findings from URC2 as an individual case study were parallel to the findings from URC1 and aggregated data analyses. It was found that syntactical properties of space and walking distances affected unprogrammed encounters. Higher global and local integration, lower point and mean depth, and higher visibility facilitated unprogrammed encounters within URC2 territory. Therefore, centrally located, configurationally accessible and highly visible convex spaces generated a high possibility of coincidental consultations and unscheduled office visits. Similarly, shorter walking distances facilitated higher numbers of unprogrammed encounters.

Findings in URC2 confirmed that informal common spaces were important for facilitating face-to-face technical consultations in URC territories. It was identified that the lack of an informal common space in URC2 territory was met by using a shared office space for multiple purposes. In addition, a very small percentage of group meetings were reported in URC2, which was attributed to the lack of an informal common space.

At the level of semi-fixed and non-fixed feature space, environmental qualities such as metric proximity to colleagues, visibility, perceived environmental comfort facilitated face-to-face technical consultations. Findings also indicated that awareness of the presence of colleagues and access to material conveniences such as food and water attracted researchers for use of spaces with such features, which increased the possibility for unprogrammed encounters.
6.3.3. URC3 (CATEGORY 2)

The response rate to activity logs and follow-up surveys in URC3 was 75%, where 16 of a total of 20 researchers participated in the study. Data provided by URC3 researchers was analyzed according to the data analysis procedure. Initially, reported research related technical consultations were tabulated across technical consultation types. A total of 507 research related technical consultations were reported by URC3 researchers.

83% of the reported research related technical consultations were face-to-face technical consultations, and 17% were technical consultations through e-media. 49% of all the reported technical consultations were unscheduled office visits, 30% were coincidental consultations, 2% were prescheduled group meetings, 1% were unscheduled group meetings, and 1% were prescheduled office visits. Of the 17% technical consultations through e-media, 11% were e-mails and 6% were telephone calls (Chart 6.3.3.1).

![URC 3: REPORTED TECHNICAL CONSULTATIONS](chart.png)

**Chart 6.3.3.1.** Tabulation of research related technical consultations reported by URC3 researchers, recorded during the five weekdays in which activity logs were completed.

Tabulation of reported technical consultations indicated that face-to-face technical consultations were the main media for information exchange used by URC3 researchers. While this finding was similar to previous findings in URC1 and URC2, an increase in the percentage of technical consultations through e-media was also apparent in
URC3. A behavior map of all reported technical consultations was then prepared on the floor plans of URC3 territory, in order to identify the types of technical consultations that occurred in convex spaces of different properties (Figure 6.3.3.1).

Figure 6.3.3.1. Behavior map of research related technical consultations reported by URC3 researchers.
6.3.3.1. Fixed-feature Space: Configurational Analysis of URC3 Territory

URC3 was identified as a “Category 2 URC” in Section 6.1. URC3 had a non-intact territory, where an office sector on the first floor, and two laboratories on second and third floors were separated by primary circulation. Thus, the office core of URC3 territory was on the first floor of the building, while two laboratory sectors were on the second and third floors.

Configurational analysis of URC3 territory was conducted using space syntax methods in order to understand the relationships between technical consultations and spatial configuration of URC3 territory. Global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRAn), mean depth (MD), intelligibility (I) and visibility (mean isovist area / MeanISO) were calculated for each single convex space within URC3 territory. Color-coded plans of URC3 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.3.2).
Figure 6.3.3.2. Global integration (RRAn) of convex spaces within URC3 territory.
On the color-coded plans, it was identified that configurational properties of URC3 territory were different from the two previously discussed URCs. The *global integration core of the entire URC3 system* was on the second floor corridor S22. The main reason for this shift was that, URC3 territory was divided into three sectors on three floors, and when the system was connected through the two stairways on both sides of the building, corridor S22 remained as the most central location. Therefore, the global integration values of primary circulation spaces connecting the three sectors on three floors were relatively higher than many of the convex spaces *within* URC3 territory.

Since the *global integration core of the entire system* was on the second floor corridor S22, the laboratory convex spaces on the second floor (which were shallow from S22) also had higher global integration values. It was identified that laboratory convex spaces FL01 and FL06 formed the *global integration core within the second-floor laboratory sector*. Similarly, office core convex space FL01 formed the *global integration core within the first-floor office sector*. The *global integration core within the third-floor laboratory sector* was formed by laboratory convex space FL11.

Therefore, configurational analysis indicated that the separation of URC3 territory into three sectors caused the *global integration core of the entire system* to shift to primary circulation space S22. When each sector on each of the floors was examined separately, the *global integration cores within each of the three sectors* were identified.

Visibility of convex spaces within URC3 territory was calculated and displayed on color-coded plans (Figure 6.3.3.3). During the calculation process, those furnishings that remained below eyesight were excluded in calculations, since they did not form obstacles to visibility.
Figure 6.3.3.3. Mean isovist areas (MeanISO) of convex spaces within URC3 territory.
Figure 6.3.3.3 indicates that primary circulation spaces had relatively high visibility values. The reason for this situation was the relatively large floor areas of these spaces. When URC3 sectors on each floor were examined, it was identified that central spaces had relatively high visibility values. Within the office core convex spaces on the first floor, central convex space F01 indicated a higher level of visibility than cellular office spaces in the office sector. Similar to the previously discussed two URCs, laboratory convex spaces on both the second and third floors exhibited high visibility levels since the furnishings (i.e. counters) in these spaces did not obstruct visibility.

6.3.3.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC3: Syntactical Properties of Space and Walking Distances

The identical data analysis protocol that was applied to previously discussed URC1 and URC2 was also applied to URC3 in order to understand the relationships between fixed-feature space and technical consultation patterns. In doing so, the relationships between syntactical properties of space and technical consultations were examined. Following this analysis, the relationships between walking distances and technical consultations were examined.

Unscheduled Office Visits in URC3. A behavior map of unscheduled office visits was used to compare the syntactical properties of URC3 convex spaces to the numbers of unscheduled office visits reported for each convex space (Figure 6.3.3.4).
Figure 6.3.3.4. Unscheduled office visits and their locations in URC3 territory.
The behavior map of unscheduled office visits in URC3 indicated that the majority of unscheduled office visits occurred in the office sector on the first floor. Similar to the situation in URC2, a number of URC3 researchers were using laboratory convex spaces on the second floor as their “home bases” instead of cellular offices. Therefore, the amount of reported unscheduled office visits on the second floor laboratory convex spaces followed the office sector on the first floor. The third floor laboratory sector, on the other hand, had received only two unscheduled office visits, indicating the segregation of this sector of URC3 territory from the rest of the system. On the behavior map, it was also identified that two office spaces (2103 and 2105) had received very high numbers of unscheduled office visits. In order to understand how the reported numbers of unscheduled office visits related to syntactical properties of space, bivariate analyses were conducted between numbers of unscheduled office visits and syntactical properties of space (Figure 6.3.3.5).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>-</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>-</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>-</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>-</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>-</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>-</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure 6.3.3.5. Bivariate analyses of the relationships between unscheduled office visits and syntactical properties of convex spaces in URC3.
This initial series of bivariate analyses indicated that none of the syntactical properties yielded significant correlations with numbers of reported unscheduled office visits. However, on the scatterplots in Figure 6.3.3.5, it was also identified that two office convex spaces (office numbers 2103 and 2105, represented on the scatterplots with blue squares) existed as outliers among others with very high numbers of reported unscheduled office visits. Since unscheduled office visits occur as visits to individual researchers in their offices, the important question was whether this high number of unscheduled office visits reported in office numbers 2103 and 2105 were due to the individual roles of these researchers, or the syntactical properties of their offices. In order to answer this question, social network analysis of URC3 technical consultation network was conducted based on the data collected through the activity logs. Social centrality values of URC3 researchers were calculated based on the number of directional relations of each researcher. The social centrality values of URC3 researchers are tabulated in Chart 6.3.3.2, where each researcher is represented by the space code of his/her office.

![chart]

**Chart 6.3.3.2.** Social centrality of URC3 researchers based on the number of directional relations of each researcher. R1203 and R1205 were key communicators, with the highest social centrality values calculated through social network analysis.

Social network analysis indicated that researchers occupying offices 1203 and 1205 had the highest social centrality values among their colleagues. When the distribution of social centrality values of URC3 researchers...
was analyzed, these two researchers existed as outliers. Therefore, the high numbers of unscheduled office visits reported in the offices of these two researchers were due to their individual roles rather than syntactical properties of their offices. In fact, these two researchers were the director and associate director of URC3, and their individual roles were clearly confirmed by the results of the social network analysis of URC3 technical consultation network. In order to focus on the effects of spatial configuration on unscheduled office visits and maintain the internal validity of the study, the previously conducted bivariate analyses were repeated for unscheduled office visits by removing the key communicators from the data tables as shown in Figure 6.3.3.6.

![Bivariate analyses of the relationships between unscheduled office visits and syntactical properties of convex spaces in URC3, after the key communicators were removed from the data set.](image)

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.54$, $p&lt;0.0001$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.21$, $p=0.01$</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>$r^2=0.16$, $p=0.03$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.27$, $p=0.0032$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2=0.14$, $p=0.03$</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2=0.38$, $p=0.0004$</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2=0.46$, $p&lt;0.0001$</td>
</tr>
</tbody>
</table>

Figure 6.3.3.6. Bivariate analyses of the relationships between unscheduled office visits and syntactical properties of convex spaces in URC3, after the key communicators were removed from the data set.

When the key communicators were removed from the data set, it was identified that syntactical properties of space actually correlated with the numbers of reported unscheduled office visits. While none of the syntactical properties exhibited correlations with unscheduled office visits when key communicators were included in the
data set, statistically significant correlations were found after the key communicators were removed from the data set. Bivariate analyses indicated that numbers of reported unscheduled visits in URC3 positively correlated with global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), visibility (MeanISO), and negatively correlated with point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD).

The researcher occupying the third floor office 3900A exemplified an important indication of the effects of syntactical properties of space. Social network analyses had indicated that this researcher had one of the highest social centrality values among his/her colleagues. However, the number of unscheduled office visits that occurred in office 3900A was only two. Evidently, despite his/her high social centrality, a low number of researchers were paying unscheduled office visits to his/her office due his/her segregated location. Therefore, this example further confirmed the findings about the effects of syntactical properties of space.

As a result, these findings indicated that higher levels of global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), and visibility (MeanISO) values, and lower levels of point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) increased the possibility of unscheduled office visits in URC3 convex spaces. Therefore, it was identified that URC3 researchers that occupied more integrated and more visible offices had a higher possibility of receiving unscheduled office visits compared to their colleagues.

**Coincidental Consultations in URC3.** Reported coincidental consultations in URC3 were mapped on URC3 territory floor plans (Figure 6.3.3.7). The behavior map indicated that the majority of coincidental consultations had occurred in the first floor office sector and second floor laboratory sector in URC3 territory. No coincidental consultations were reported on the third floor laboratory sector. However, a small number of coincidental consultations had occurred in the primary circulation spaces S11, S22 and L01, in addition to the shared common space L02.

Among the office core convex spaces, the majority of coincidental consultations were reported in the office sector global integration core F01. Similarly, within the second floor laboratory sector, coincidental consultations were mostly reported in high global integration convex spaces, such as FL01, FL06 and FL09.
Figure 6.3.3.7. Coincidental consultations and their locations in URC3 territory.
In order to understand how syntactical properties of URC3 convex spaces were related to the numbers of coincidental consultations reported for each convex space, bivariate analyses were conducted. Table 6.3.3.1 shows bivariate analyses of the relationships between coincidental consultations and each syntactical property.

**Table 6.3.3.1.** Bivariate analyses of the relationships between coincidental consultations and syntactical properties of convex spaces in URC3.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>( r^2=0.52, p&lt;0.00001 )</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>( r^2=0.36, p=0.0003 )</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>( r^2=0.28, p=0.001 )</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>( r^2=0.39, p=0.0001 )</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>( r^2=0.22, p=0.0072 )</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>( r^2=0.15, p=0.02 )</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>( r^2=0.35, p=0.0005 )</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>( r^2=0.47, p=0.0001 )</td>
</tr>
</tbody>
</table>

Bivariate analyses indicated that significant positive correlations were present between global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces and numbers of reported coincidental consultations. Negative significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces and numbers of reported coincidental consultations.

The global integration core of the entire system remained on primary circulation spaces. However, it was identified that more coincidental consultations had occurred within the office sector and laboratory convex spaces in URC3. Therefore, although the global integration core of the entire system was on S22, more coincidental consultations were reported within URC3 territory. These results indicated that in URC3, coincidental consultations occurred in those convex spaces with high global integration values within URC3 territory. It was evident that researchers mostly remained within URC3 territory, and rarely moved from one territorial sector to another by passing through primary circulation spaces. This situation was observable on the floor plans in Figure 6.3.3.7, where the maximum globally integrated space S22 had less coincidental consultations than those spaces within the office core and second floor laboratory sector. Evidently, if URC3 territory was intact, even stronger correlations between coincidental consultations and syntactical properties of space could be found.

In conclusion, bivariate analyses indicated that highly integrated and highly visible convex spaces facilitated coincidental consultations in URC3. However, the majority of coincidental consultations had occurred within URC3 territories rather than more globally integrated primary circulation spaces. This situation indicated that in URCs with non-intact territories, there was a higher possibility of engaging in coincidental consultations within
the territory rather than primary circulation spaces. This was also an indication of the negative effects of a non-intact territory as opposed to an intact territory for URCs.

**Unscheduled and Prescheduled Group Meetings in URC3.** Among all reported technical consultations, 2% were prescheduled group meetings, and 1% were unscheduled group meetings in URC3. Thus, it was not possible to conduct statistical analyses due to the low number of data points. However, when these group technical consultations were mapped on URC3 territory floor plans, it was identified that the majority of prescheduled group meetings took place in the conference space 3002 (Figure 6.3.3.8). This space was shared by other URCs and R&D units in Building 1, and was not exclusively designated for use of URC3. The majority of unscheduled group meetings, however, took place in conference room 2106 which remained within URC3 territory. Finally, two prescheduled and one unscheduled group meetings were held in office space 2105, one of the key communicators’ offices.

These findings indicated two conclusions. First, due to the lack of an informal common space, group meetings were not occurring frequently in URC3. For instance, compared to URC1, which had an informal common space, the percentage of unscheduled and prescheduled group meetings were much lower in URC3. Second, URC3 researchers tended to hold more prescheduled group meetings than unscheduled group meetings. Due to the lack of an informal common space in URC3 territory, casual, unscheduled group meetings had to be held less than prescheduled and formal meetings. Prescheduled meetings, on the other hand, had to be held in a non-territorial conference room (3002). These findings indicated that, since URC3 researchers did not have an informal common space, most group meetings had to be held formally and in a non-territorial space shared with other organizations. Therefore prescheduled and unscheduled group meetings were rarely preferred when compared to other media of technical consultations.
Figure 6.3.3.8. Unscheduled and prescheduled group meetings in URC3 and their locations.

Prescheduled Office Visits in URC3. Only 1% of the reported technical consultations in URC3 were prescheduled office visits. Analyzed data indicated that all of these prescheduled office visits occurred in office numbers 1203 and 1205, except one that occurred in office number 1201 (Figure 6.3.3.9). This finding was not
unexpected, since the key communicators in URC3 occupied office numbers 1203 and 1205. Therefore, it was identified that prescheduled office visits were related to individual roles of researchers rather than syntactical properties of space in URC3.

![Figure 6.3.3.9. Prescheduled office visits and their locations in URC3 territory.](image)

**Technical Consultations Through E-media (telephone calls and e-mails) in URC3.** Data analysis indicated that the percentages of technical consultations through e-mails and telephone calls were considerably higher than in URC1 and URC2. Consequently, the percentage of face-to-face technical consultations was also lower. These findings indicated that the separation of URC3 territory into three sectors affected the amount of face-to-face technical consultations taking place among URC3 researchers. It was evident that URC3 researchers had to rely on e-mails and telephone calls more than their colleagues in URC1 and URC2 due to this separation into three floors. In order to understand how syntactical properties of space related to the origins and numbers of reported - mails and telephone calls, bivariate analyses were conducted (Table 6.3.3.2).

**Table 6.3.3.2.** Bivariate analysis of the relationships between consultations through e-media and syntactical properties of convex spaces in URC3.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>TECHNICAL CONSULTATIONS THROUGH E-MEDIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2=0.19$, $p=0.01$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2=0.11$, $p=0.06$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2=0.10$, $p=0.08$</td>
</tr>
<tr>
<td>POINT DEPTH FROM THE MOST GLOBALLY INTEGRATED SPACE (DEPTH RRAnMAX)</td>
<td>$r^2=0.26$, $p=0.0028$</td>
</tr>
</tbody>
</table>
Bivariate analyses indicated that the majority of consultations through e-media had originated from globally and locally less integrated, but deeper spaces from the maximum globally integrated space. Although the strength of these found correlations were not as strong as findings about face-to-face technical consultations, this bivariate analysis still indicated that those researchers in relatively segregated convex spaces tended to rely more on e-media consultations. Therefore, these results showed that the separation of URC3 territory into three floors increased the reliance on technical consultations through e-media, compared to the two previously discussed URCs, which had intact territories.

The Relationships of Walking Distances to Unprogrammed Encounters in URC3 Territory. The separation of URC3 territory into three sectors on three floors caused long walking distances between sectors. When moving from one sector to another, URC3 researchers not only had to walk through primary circulation, but also had to change level through stairways. This situation was clearly identified when the relationships between walking distances and unprogrammed encounters (coincidental consultations and unscheduled office visits) were analyzed (Table 6.3.3.3).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.35$, $p=0.0002$</td>
<td>$r^2=0.23$, $p=0.0038$</td>
<td>$r^2=0.27$, $p=0.0013$</td>
</tr>
</tbody>
</table>

The analysis indicated that as walking distances increased between locations, numbers of unprogrammed encounters decreased. These results therefore exhibited the inhibiting effect of increased walking distances on unprogrammed encounters (coincidental consultations and unscheduled office visits) in URC3 territory. However, it was also noted that these negative correlations between walking distances and unprogrammed encounters were not as strong as the findings about walking distances from URC1 and URC2. It was identified that once the walking distance between two convex spaces exceeded 50 feet, the numbers of unprogrammed encounters drastically decreased, which also decreased the slope of these correlations. In order to further understand this phenomenon, reported unprogrammed encounters (coincidental consultations and unscheduled office visits) in URC3 were tabulated according to their origins and destinations (Chart 6.3.3.3).
This tabulation confirmed the findings of the bivariate analysis. When the origins and destinations of each unprogrammed encounter was traced in URC3, it was identified that 82% of the entire set of unprogrammed encounters had their origins and destinations on the same floor. Specifically, 54% of unprogrammed encounters had originated and ended on the first floor office sector, and 28% of unprogrammed encounters had originated and ended on the second floor laboratory sector. In only 18% of the unprogrammed encounters, researchers had changed level through stairways.

The tabulation therefore explained the drastic drops in numbers of unprogrammed encounters within a distance of more than 50 feet. Evidently, URC3 researchers did not prefer to go up and down the stairs frequently, and mostly remained on the same floor. Therefore, researchers on each floor were mostly consulting to each other, and unprogrammed encounters between floors were rarely occurring. These findings clearly indicated that the segregation of URC3 territory into three sectors on three floors, and walking distances among these sectors negatively affected the possibility of coincidental consultations and unscheduled office visits across floors in URC3.
6.3.3.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC3: Summary of Findings

Data analyses at the fixed-feature level indicated that syntactical properties of space and walking distances affected unprogrammed encounters in URC3. It was identified that the separation of URC3 territory into three sectors on three floors significantly affected unprogrammed encounters. Two major results of this separation were identified in fixed-feature space. First, global integration core of the entire system had shifted towards primary circulation spaces (outside of URC3 territory), since primary circulation spaces connected the three separate sectors. Second, walking distances among the three sectors had increased significantly due to the level differences and relative locations of the three sectors on the floor plans of each floor. The effects of these phenomena on technical consultations were clearly identified during data analyses.

First, due to this separation, URC3 researchers relied on technical consultations through e-media more than their colleagues in URC1 and URC2. The percentage of reported technical consultations through e-media were much higher than those of URC1 and URC2.

Second, bivariate analyses indicated that numbers of unscheduled office visits and coincidental consultations were positively and significantly correlated to global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces. Negative statistically significant correlations were found between numbers of unscheduled office visits and coincidental consultations and point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces. Due to the separation of URC3 territory, maximum globally integrated convex spaces (primary circulation corridors S11 and S22) received lower amounts of unprogrammed encounters. On the other hand, centrally located, configurationally accessible and highly visible convex spaces within URC3 territory (within office or laboratory sectors) facilitated unprogrammed encounters (unscheduled office visits and coincidental consultations).

Third, it was identified that 82% of all unprogrammed encounters had originated and ended on the same floor. The percentage of inter-floor unprogrammed encounters was limited to 18. These percentages indicated that the number of inter-floor technical consultations were very low due to increased walking distances as a result of the separation.

Therefore, it was found that the separation of URC3 territory into three sectors clearly had inhibiting effects on face-to-face technical consultations among URC3 researchers both through changes in spatial configuration and
increased walking distances. Overall, it was identified that syntactical properties of space and walking distances in fixed-feature space clearly affected technical consultations among researchers in URC3.

6.3.3.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC3: Environmental Qualities and Reasons for Space Use

Following analyses of the relationships between fixed-feature space and patterns of space use for technical consultations, the relationships between semi-fixed/non-fixed feature space and patterns of space use for technical consultations were analyzed. Those spaces where URC3 researchers most frequently met other researchers, and most frequently visited when they left their offices were identified based on the follow-up surveys. The environmental qualities and reasons for use of these spaces cited by URC3 researchers were then tabulated, and associated with convex spaces on floor plans of URC3 territory (Figure 6.3.3.10).
Figure 6.3.3.10. The relationships between semi-fixed and non-fixed feature space and technical consultations in URC3, based on the follow-up surveys. Red colored texts indicate environmental qualities, and blue colored texts indicate reasons for space use as indicated by URC3 researchers.

Content analysis of environmental qualities and reasons for space use cited by URC3 researchers indicated that they most frequently met their colleagues in two convex spaces: the integration core within the office sector (F01, F02, F03…) and the integration core within the laboratory sector (FL01 and FL06).

URC3 researchers indicated that within the integration core of the office core, interactions were easy, and they were satisfied by the flexibility of these convex spaces. They also indicated that most encounters occur in these
spaces. However, they were dissatisfied by the separation of the office core from the laboratories, and also thought that the cubicles in these convex spaces blocked eyesight. The researchers that occupied cellular offices indicated that they were satisfied with this space definition, and mentioned that this feature helped them in concentrated work. The only negative citation about a cellular office was for office space 1201, mentioning that too many people “dropped in” too frequently. This comment supported previous findings, since this office was directly connected to the integration core of the office sector, and had a high possibility of receiving unprogrammed encounters. As with previously discussed URCs, offices that had access to daylight and outside view were also cited as spaces with positive environmental qualities. Therefore, for the office sector, configurational integration of the office core convex spaces, visibility, the separation of the office sector from the laboratories, and access to daylight were the most cited four environmental qualities.

Some researchers indicated that they frequently met their colleagues in front of the main entrance to the building. They also indicated that they visited this area in order to smoke and chat with their colleagues. Thus, having immediate access to an open-air area was noted as a facilitative factor for unprogrammed encounters among URC3 researchers.

Within the second floor laboratory sector, the most frequently cited issue was the separation between these laboratory convex spaces and the office sector. Almost all of the researchers indicated the separation of the laboratory convex spaces from the office sector as a negative environmental quality. Lack of access to daylight in the laboratory convex spaces, and limited workspace were the other two frequently mentioned negative environmental qualities. Therefore, for the second floor laboratory sector, metric distance to the office sector, access to daylight and personal space in laboratory convex spaces were the most frequently cited three environmental qualities.

A number of researchers who occupied second floor workspaces indicated that they occasionally used the second floor lobby (L02) in order to eat lunch, to use the refrigerator and the microwave oven. Thus, access to material conveniences such as kitchen equipment was another factor that attracted URC3 researchers. This finding was informative, since there were no spaces allocated for such functions in the second floor laboratory sector of URC3 territory. The indication was that, due to the lack of such conveniences within URC3 territory, researchers had to use this non-territorial space. However, a very small number of coincidental consultations were reported in convex space L02. Therefore, lack of these conveniences negatively affected the possibility of coincidental consultations by causing researchers to occasionally use non-territorial convex spaces. The presence of these conveniences within URC3 territory, on the other hand, could have facilitated coincidental consultations by frequent use due to easy access, as exemplified by the case of URC1.
Overall, content analyses of the follow-up surveys indicated that at the fixed-feature space level, the separation of URC3 territory was a negative influence on technical consultations among researchers, while configurational integration of office core convex spaces had a positive influence. At the semi-fixed feature space level, frequently cited environmental qualities of those spaces where URC3 researchers most frequently met their colleagues were high visibility and access to daylight. At the non-fixed feature space level, lack of personal space in laboratory convex spaces was frequently cited as a negative environmental quality. At the level of semi-fixed feature space, most frequently cited reason for space use was access to material conveniences, such as using the microwave oven. At the level of non-fixed feature space, most frequently cited reason for space use was the presence of other researchers in a space, which was exemplified by the use of the open-air area in front of the main entrance of Building 1. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation in table 6.3.3.4.

Table 6.3.3.4. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC3. Examples of URC3 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Configurational integration (i.e. “open and central, most encounters here”)</td>
<td>Access to open air (i.e. to smoke)</td>
</tr>
<tr>
<td>- Metric proximity to colleagues (i.e. “disjunction between labs and offices”)</td>
<td>Access to daylight (i.e. “offices with windows”)</td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Access to daylight (i.e. “offices with windows”)</td>
<td>Material conveniences (i.e. “to use microwave”)</td>
</tr>
<tr>
<td>- Visibility (i.e. “cubicles block line of sight”)</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>- Available amount of personal workspace (i.e. “enough space for working comfortably”)</td>
<td>Concentrated work (i.e. “preparing solutions / materials”)</td>
</tr>
<tr>
<td>- Meeting colleagues (i.e. “to chat with people”)</td>
<td>Meeting colleagues (i.e. “to chat with people”)</td>
</tr>
<tr>
<td>- Awareness of other researchers’ presence</td>
<td></td>
</tr>
</tbody>
</table>

6.3.3.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC3

A summary of findings of the relationships between fixed-feature space and technical consultations in URC3 is shown in Table 6.3.3.5.
Table 6.3.3.5. Summary of findings: relationships between fixed-feature space and technical consultations in URC3. (*) indicates negative correlations.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>SYNTACTICAL PROPERTIES OF SPACE</th>
<th>WALKING DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRAn CONN CV RRA3 DEPTH RRA3MAX</td>
<td>I MD MeanISO DIST</td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td>( r^2 = 0.54 ) ( p &lt; 0.0001 )</td>
<td>( r^2 = 0.54 ) ( p &lt; 0.0001 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.21 ) ( p = 0.01 )</td>
<td>( r^2 = 0.27 ) ( p = 0.0032 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.16 ) ( p = 0.03 )</td>
<td>( r^2 = 0.14 ) (*) ( p = 0.03 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.38 ) ( p &lt; 0.0001 )</td>
<td>( r^2 = 0.46 ) ( p &lt; 0.0001 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.21 ) ( p = 0.0038 )</td>
<td>( r^2 = 0.23 ) (*) ( p = 0.0038 )</td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td>( r^2 = 0.52 ) ( p &lt; 0.0001 )</td>
<td>( r^2 = 0.36 ) ( p = 0.0003 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.28 ) ( p = 0.001 )</td>
<td>( r^2 = 0.39 ) ( p &lt; 0.0001 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.22 ) (*) ( p = 0.0072 )</td>
<td>( r^2 = 0.22 ) (*) ( p = 0.0072 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.15 ) ( p = 0.0005 )</td>
<td>( r^2 = 0.35 ) (*) ( p = 0.0005 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.47 ) ( p &lt; 0.0001 )</td>
<td>( r^2 = 0.47 ) ( p &lt; 0.0001 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.35 ) (*) ( p = 0.0002 )</td>
<td>( r^2 = 0.35 ) (*) ( p = 0.0002 )</td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td>( r^2 = 0.19 ) (*) ( p = 0.01 )</td>
<td>( r^2 = 0.11 ) (*) ( p = 0.06 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.10 ) (*) ( p = 0.08 )</td>
<td>( r^2 = 0.26 ) ( p = 0.0028 )</td>
</tr>
<tr>
<td>PRESCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESCHEDULED OFFICE VISITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSULTATIONS THROUGH E-MEDIA</td>
<td>( r^2 = 0.19 ) (*) ( p = 0.01 )</td>
<td>( r^2 = 0.11 ) (*) ( p = 0.06 )</td>
</tr>
<tr>
<td></td>
<td>( r^2 = 0.10 ) (*) ( p = 0.08 )</td>
<td>( r^2 = 0.26 ) ( p = 0.0028 )</td>
</tr>
</tbody>
</table>

Data analysis in the case of URC3 confirmed the effects of fixed-feature, semi-fixed feature and non-fixed feature space on technical consultations among researchers.

At the level of fixed-feature space, it was found that separation of the non-intact URC3 territory into three sectors caused the global integration core of the entire system to shift towards primary circulation spaces, which were non-territorial convex spaces. Consequently, the majority of unprogrammed encounters were reported on the global integration cores within the office sector and second-floor laboratory sector. It was also identified that the majority of unprogrammed encounters occurred among researchers on the same floor, and inter-floor trips for unprogrammed encounters occurred very rarely due to increased walking distances. Moreover, reliance on technical consultations through e-media was higher than Category 1 URCs, indicating that the separation of URC3 territory and subsequent increased walking distances hindered face-to-face technical consultations. These findings were illuminating in highlighting the different effects of Category 1 and Category 2 URCs on technical consultation patterns of researchers.

Data analyses indicated that syntactical properties of space and walking distances affected unprogrammed encounters. Higher global and local integration, lower point and mean depth, and higher visibility facilitated unprogrammed encounters within URC3 territory. Therefore, configurationally accessible and highly visible convex spaces within office and laboratory sectors of URC3 territory increased the possibility of unscheduled office visits and coincidental consultations.
Findings in URC3 confirmed that informal common spaces were important for facilitating face-to-face technical consultations in URC territories. It was identified that the lack of an informal common space in URC3 territory resulted in fewer group meetings. By completing follow-up surveys, URC3 researchers indicated that environmental qualities such as metric proximity to colleagues, visibility and configurational integration facilitated face-to-face technical consultations. Findings also indicated that awareness of the presence of colleagues and access to material conveniences such as kitchen equipment attracted researchers for use of spaces with such features. In conclusion, findings in the case of URC3 about the effects of space on technical consultations supported previous findings in Category 1 URCs.

6.3.4. URC4 (CATEGORY 2)

At the time of data collection, 15 of the 19 researchers working with URC4 responded to the activity logs and follow-up survey, yielding a response rate of 75%. Responses were analyzed according to the data analysis procedure described in Chapter 5. Initially, research related technical consultations reported by URC4 researchers were tabulated across technical consultation types. A total of 133 research related technical consultations were reported through the five weekdays in which activity logs were completed in URC4.

Of the total number of reported research related technical consultations, 84% were face-to-face technical consultations, and the remaining 16% were technical consultations through e-media. Among the reported technical consultations, 50% were unscheduled office visits, 29% were coincidental consultations, 4% were prescheduled office visits, and 2% were prescheduled group meetings. No unscheduled group meetings were reported in URC4. 14% of the reported technical consultations had occurred through e-mails, while 2% had occurred through telephone calls. The tabulation of technical consultations reported by URC4 researchers is shown in Chart 6.3.4.1.
Chart 6.3.4.1. Tabulation of research related technical consultations reported by URC4 researchers, during the five weekdays in which activity logs were completed.

The tabulation of technical consultations showed that in URC4, a Category 2 URC, face-to-face technical consultations formed the main media for technical consultations, which was a result that paralleled the findings in the previously discussed URCs. However, it was also noted that while in URC4, the percentage of technical consultations through e-media was larger than those of Category 1 URCs, it was quite close to the findings in URC3, which is another Category 2 URC.

A behavior map of all reported technical consultations was then prepared on the floor plans of URC4 territory; in order to identify the types of technical consultations that occurred in convex spaces of different properties (Figure 6.3.4.1).
6.3.4.1. Fixed-feature Space: Configurational Analysis of URC4 Territory

URC4 was identified as a “Category 2 URC” in Section 6.1. URC4 had a non-intact territory, where an office sector and varying numbers of laboratories were located on each of the first, second and third floors of Building 2. A configurational analysis of URC4 territory was conducted using space syntax methods in order to understand the relationships between technical consultations and spatial configuration of URC4 territory. Global
integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRAn), mean depth (MD), intelligibility (I) and visibility (mean isovist area / MeanISO) were calculated for each single convex space within URC4 territory. Color-coded plans of URC4 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.4.2).

Figure 6.3.4.2. Global integration (RRAn) of convex spaces within URC4 territory.
On the color-coded plans of URC4 territory, it was noted that the spatial configuration resembled that of URC3 territory. In both URC4 and URC3 territories, primary circulation spaces were separating the office sectors from laboratories. However, URC4 territory was different from URC3 in one aspect. The primary circulation spaces U120, U216 and U323 also functioned as office core convex spaces to which cellular office spaces were directly connected. On the other hand, it was also possible for members of the organization that shared Building 2 with URC4 to pass through these spaces. Therefore, the office core convex spaces of URC4 did receive public access from the sharing organization.

When URC4 territory was analyzed using space syntax methods, it was identified that the global integration core of the entire URC4 system was on the second floor axis that passes through convex spaces U216, U206 and U203. This indicated a shift of the global integration core of the entire system toward primary circulation spaces, which was very similar to the situation in URC3. The main reason for this shift was that, when the three floors were connected through the two stairways on both sides of the building, the axis that passes through convex spaces U216, U206 and U203 remained as the most central location. In addition, the global integration of first floor convex spaces U120, U106, U100 and U104 were very close to that of the second floor axis.

These findings indicated that the global integration core of the entire system not only passed through the double-functioning office core convex spaces, but also through non-territorial convex spaces such as the first floor lobby (U100), and second floor lobby (U206). Another noted issue was the separation of conference rooms 105 and 205 from URC4 territory by primary circulation convex spaces.

Therefore, configurational analysis indicated that the separation of URC4 territory into three floors caused the global integration core of the entire system to shift to the second floor axis that passes through convex spaces U216, U206 and U203. Compared to URC3 territory, sectors of URC4 territory were more segregated from each other.

The visibility of URC4 convex spaces were calculated and displayed on color-coded floor plans. Figure 6.3.4.3 shows the visibility (MeanISO) of convex spaces within URC4 territory. During the calculation process, those furnishings that remained below eyesight were excluded in calculations, since they did not form obstacles to visibility.
Figure 6.3.4.3. Mean isovist areas (MeanISO) of convex spaces within URC4 territory.

On Figure 6.3.4.3, it was identified that the highest visibility areas were the intersection of first floor axis U106-U120 and first floor lobby U100. In addition, those areas of office core convex spaces on which entrances to cellular offices and laboratories intersected on each floor had high visibility. Cellular offices, and the majority of laboratories had low visibility values.
Overall, configurational analyses indicated that both the global integration core and maximum visibility areas overlapped either primary circulation spaces or office core convex spaces that also had public access. In this respect, majority of convex spaces within URC4 territory remained relatively deep from the global integration core and maximum visibility areas. When findings from previously discussed case studies were considered, this situation existed as a potential disadvantage for face-to-face technical consultations in URC4.

6.3.4.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC4: Syntactical Properties of Space and Walking Distances

The identical data analysis protocol that was applied to previously discussed URCs was applied to URC4 in order to understand the relationships between fixed-feature space and technical consultation patterns. In doing so, the relationships between syntactical properties of space and technical consultations were examined by analyzing Pearson’s r correlations between each pair of variables. Following this analysis, the relationships between walking distances and technical consultations were analyzed.

**Unscheduled Office Visits in URC4.** A behavior map of unscheduled office visits was used to compare the syntactical properties of URC4 convex spaces to the numbers of unscheduled office visits reported for each convex space (Figure 6.3.4.4).
On the behavior map of unscheduled office visits, it was noted that the majority of unscheduled office visits were reported in the cellular office spaces that had direct connection to the two most globally integrated axes on the first and second floor. In addition, a number of unscheduled office visits were reported in those laboratories that had direct connection to the two most globally integrated axes on the first and second floor. It was also identified that the number of unscheduled office visits reported on the third floor was very low compared to the first two
floors. Bivariate analyses of the relationships between reported unscheduled office visits and syntactical properties of space was conducted (Table 6.3.4.1).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>( r^2=0.28, p=0.0031 )</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>( r^2=0.11, p=0.07 )</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>( r^2=0.30, p=0.0021 )</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>( r^2=0.12, p=0.07 )</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>( r^2=0.23, p=0.0086 )</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>( r^2=0.10, p=0.09 )</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>( r^2=0.27, p=0.0034 )</td>
</tr>
</tbody>
</table>

Bivariate analyses indicated that numbers of unscheduled office visits in convex spaces were positively and significantly correlated to global integration (RRAn), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces. Negative statistically significant correlations were found between numbers of unscheduled office visits in convex spaces and point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces. These correlations indicated that unscheduled office visits occurred in those convex spaces that had direct connections to the global integration core of the system, with consequent high global integration values. Researchers occupying relatively segregated and less visible convex spaces had lower chances of receiving unscheduled office visits.

Based on the results of bivariate analyses, it was noted that the correlations found were significant but not as strong as those found in Category 1 URCs. The reason for this situation was the shift of the global integration core of the entire system towards non-territorial spaces in Building 2. Therefore, although unscheduled office visits were still identified on high global integration convex spaces within URC4 territory, non-territorial convex spaces with even higher global integration values did not receive any unscheduled office visits, causing smaller correlation coefficients.

In order to understand if these correlations were affected by individual roles of any researchers in URC4, social network analysis of the URC4 technical consultation network was conducted. Unlike URC1 and URC3, no key communicators were identified in URC4 technical consultation network. Distribution analysis of social centrality values indicated that there were no outliers among URC4 researchers. Chart 6.3.4.2 shows the social centrality values calculated for URC4 researchers, where each researcher is indicated by the convex space he/she occupies as a “home base”. 
Chart 6.3.4.2. Social centrality of URC4 researchers based on the number of directional relations of each researcher. No key communicators were identifiable in URC4, where it was not possible to note any outliers in terms of social centrality.

As a result, it was identified that the relationships found between unscheduled office visits and syntactical properties of space were not affected by any individual researcher roles. Consequently, these results indicated that the correlations found were actually related to the effects of syntactical properties rather than individual roles of researchers, removing concerns about the validity of findings. Those researchers that occupied configurationally more accessible and highly visible convex spaces had received higher numbers of unscheduled office visits in URC4.

**Coincidental Consultations in URC4.** Following unscheduled office visits, the effects of syntactical properties of each convex space on the numbers of reported coincidental consultations were examined in URC4. Figure 6.3.4.5 shows the behavior map of coincidental consultations on the floor plans of URC4 territory.
Figure 6.3.4.5. Coincidental consultations and their locations in URC4 territory.

The behavior map of coincidental consultations reported in URC4 indicated that majority of coincidental consultations had occurred in highly globally integrated convex spaces such as the first and second floor corridors. Bivariate analyses of syntactical properties of space and coincidental consultations confirmed this relationship with statistically significant correlations (Figure 6.3.4.6).
BIVARIATE RELATIONSHIPS

<table>
<thead>
<tr>
<th>Property</th>
<th>r^2</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>0.40</td>
<td>0.0007</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>0.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>0.65</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>0.66</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>0.16</td>
<td>0.04</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>INTELLIGIBILITY (I)</td>
<td>0.56</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>0.27</td>
<td>0.0092</td>
</tr>
</tbody>
</table>

COINCIDENTAL CONSULTATIONS

The results of bivariate analyses indicated that the majority of coincidental consultations had occurred in high global integration convex spaces. However, it was also noted that these coincidental consultations had occurred within URC4 territory, or those convex spaces close to the territory. For example, although the first floor lobby, a primary circulation space, had a high global integration value, it had received far less coincidental consultations than office core convex spaces U106 and U120. These results confirmed that URC4 researchers tended to remain within or close to URC4 territory.

Another finding was that the majority of coincidental consultations had occurred in high visibility convex spaces. However, it was also noted that when a high visibility convex space was relatively segregated from the rest of the system, numbers of coincidental consultations dropped. A good example for such a situation is third floor corridor U323, which was highly visible, but configurationally segregated.
corridor U 323 (highlighted by a red ellipse on Figure 6.3.4.6). Although the mean isovist area of this space was among the highest in URC4 territory, it was configurationally segregated from the rest of the system. Consequently, no coincidental consultations were reported in this convex space.

On the behavior map, it was noted that five coincidental consultations were reported in the informal common space, the lounge (convex space 114). Despite its low global integration and visibility values, a considerable number of coincidental consultations were reported in this space. This finding once again confirmed the facilitative effect of informal common spaces on coincidental consultations in URC territories.

As a result, findings from the behavior map and bivariate analyses indicated that those spaces with high global integration and mean isovist areas, which also were within or close to URC4 territory, facilitated coincidental consultations. Moreover, it was found that more coincidental consultations occurred in convex spaces with both high global integration and high visibility areas, and that a combination of these two factors facilitated coincidental consultations significantly. As found in previously discussed URCs, configurationally accessible and highly visible convex spaces facilitated coincidental consultations in URC4.

**Unscheduled and Prescheduled Group Meetings in URC4.** URC4 researchers reported only two prescheduled group meetings. Both of the prescheduled group meetings were reported in the formal conference room 105. In addition, no unscheduled group meetings had occurred in the five-weekday period in which the activity logs were completed. Therefore, it was not possible to seek any relationships between both types of group meetings and syntactical properties of space. However, it was possible to see the effects of URC4’s non-intact territory on such technical consultations.

Configurational analysis of URC4 territory had indicated that common spaces were separated from URC4 territory by primary circulation spaces or double-functioning office core convex spaces, making them less convenient and readily available for the researchers: in order to reach any common space, one had to pass through primary circulation spaces. The formal conference rooms with direct connection to first and second floor lobbies were mainly used for prescheduled group meetings, by appointments. The informal common space (first floor lounge) 114, on the other hand, was mainly used for checking mails or using business equipment such as the fax machine due to its small size. Thus, the lack of an informal common space closely integrated with URC4 territory evidently discouraged unscheduled group meetings, which were much more casual than prescheduled group meetings. Therefore, the positive effects of an informal common space conveniently available within a URC territory on face-to-face technical consultations were confirmed by these findings.
Prescheduled Office Visits in URC4. Similar to unscheduled and prescheduled group meetings, the number of reported prescheduled office visits was very small in URC4. However, it was also noted that these prescheduled office visits did not show any relations to syntactical properties of space. Therefore, it was noted that prescheduled office visits were mainly related to the individual researcher occupying an office rather than syntactical properties of that convex space; a result that was also found in previously discussed URCs.

Technical Consultations Through E-media (telephone calls and e-mails) in URC4. Data analysis indicated that the percentages of technical consultations through e-mails and telephone calls were considerably higher in URC4 than in Category 1 URCs, URC1 and URC2. Consequently, the percentage of face-to-face technical consultations was lower. These findings indicated that the separation of URC4 territory into three floors affected the amount of face-to-face technical consultations taking place among URC4 researchers. As in URC3, it was evident that URC4 researchers had to rely on e-mails and telephone calls more than their colleagues in Category 1 URCs due to the separation of URC4 territory into three floors. However, no statistically significant relationships were found between syntactical properties of space and origins of e-mails and telephone calls in URC4.

Nevertheless, with these results, it was also noted that the percentages of technical consultations through e-media were considerably higher in Category 2 URCs than Category 1 URCs. Therefore, it was evident that separation of a URC territory into several sectors by primary circulation spaces had a negative effect on face-to-face technical consultations.

The Relationships of Walking Distances to Unprogrammed Encounters in URC4 Territory. The separation of URC4 territory into three floors caused very long walking distances between sectors. When moving from one sector to another, URC4 researchers not only had to walk through primary circulation spaces, but also had to change levels through stairways. This situation was clearly identified when the relationships between walking distances and unprogrammed encounters (coincidental consultations and unscheduled office visits) were analyzed. Table 6.3.4.2 exhibits the results of bivariate analyses between unprogrammed encounters (coincidental consultations and unscheduled office visits) and walking distances.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRNOMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$ r^2=0.23, p=0.006 $</td>
<td>$ r^2=0.23, p=0.006 $</td>
<td>$ r^2=0.26, p=0.0032 $</td>
</tr>
</tbody>
</table>
Bivariate analyses indicated that as walking distances increased between convex spaces, the number of unprogrammed encounters significantly decreased in URC4. Based on the scatterplots and small correlation coefficients, it was also possible to identify that in distances more than fifty feet, numbers of unprogrammed encounters drastically decreased. While this finding was confirming the findings in URC3, it also displayed the hindering effects of separation of URC territories across floors on unprogrammed encounters. As in the analyses conducted in URC3, reported unprogrammed encounters in URC4 were tabulated according to their origins and destinations in order to further understand this phenomenon (Chart 6.3.4.3).

<table>
<thead>
<tr>
<th>ORIGINS AND DESTINATIONS OF UNPROGRAmMED ENCOUNTERS</th>
<th>PERCENTAGE OF TOTAL NUMBER OF REPORTED UNPROGRAMMED CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3RD FLOOR --&gt; 2ND FLOOR</td>
<td>0</td>
</tr>
<tr>
<td>3RD FLOOR --&gt; 1ST FLOOR</td>
<td>8</td>
</tr>
<tr>
<td>2ND FLOOR --&gt; 3RD FLOOR</td>
<td>0</td>
</tr>
<tr>
<td>2ND FLOOR --&gt; 1ST FLOOR</td>
<td>9</td>
</tr>
<tr>
<td>1ST FLOOR --&gt; 3RD FLOOR</td>
<td>3</td>
</tr>
<tr>
<td>1ST FLOOR --&gt; 2ND FLOOR</td>
<td>17</td>
</tr>
<tr>
<td>3RD FLOOR --&gt; 3RD FLOOR</td>
<td>4</td>
</tr>
<tr>
<td>2ND FLOOR --&gt; 2ND FLOOR</td>
<td>23</td>
</tr>
<tr>
<td>1ST FLOOR --&gt; 1ST FLOOR</td>
<td>36</td>
</tr>
</tbody>
</table>

**Chart 6.3.4.3.** Tabulation of unprogrammed encounters according to their origins and destinations in URC4.

Similar to the results in the case of URC3, this tabulation confirmed the findings of bivariate analyses in URC4. Tracing the origins and destinations of each reported unprogrammed encounter, it was found that 63% of all unprogrammed encounters originated and ended on the same floor. 37% of unprogrammed encounters had originated and ended on different floors. Among these, 26% were inter-floor unprogrammed encounters between the first and second floors. Clearly, as the number of floors between the origins and end points of trips increased, the number of unprogrammed encounters decreased. Researchers’ tendency was to remain on the same floor when they were navigating URC4 territory.
Therefore, these results clearly indicated that increasing walking distances and separation of a URC territory into different floors had hindering effects on unprogrammed face-to-face technical consultations. In both of the Category 2 URCs analyzed (URC3 and URC4) identical effects of walking distances were found.

6.3.4.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC4: Summary of Findings

Data analyses in URC4 at fixed-feature space yielded very similar results to those found in URC3. Syntactical properties of space and walking distances affected unprogrammed encounters in URC4. It was identified that, as in URC3 territory, the separation of URC4 territory into three floors significantly affected unprogrammed encounters. Two major results of this separation were identified in fixed-feature space. First, global integration core of the entire system had shifted towards primary circulation spaces, since primary circulation spaces connected the three separate floors. Second, walking distances among the three floors had increased significantly due to this separation.

URC4 researchers relied more on technical consultations through e-media than their colleagues in Category 1 URCs. The percentage of reported technical consultations through e-media were higher than those of Category 1 URCs in both of the Category 2 URCs. Evidently, increasing walking distances and number of floors between origins and end points of trips discouraged researchers to make trips for face-to-face technical consultations, and rely more on technical consultations through e-media.

The separation of URC4 territory also affected unprogrammed encounters among researchers. As in URC3, it was identified in URC4 that the majority of unprogrammed encounters had originated and ended on the same floor. The number of inter-floor technical consultations was very low compared to intra-floor technical consultations due to increased walking distances as a result of the separation.

Similar to the results reached in the previously discussed URCs, bivariate analyses indicated that numbers of unscheduled office visits and coincidental consultations were positively and significantly correlated to global integration (RRAn), control value (CV), local integration (RRA3), intelligibility (I) and visibility (MeanISO) values of convex spaces. Negative statistically significant correlations were found between numbers of unscheduled office visits and coincidental consultations and point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces. The correlation coefficients found for these relationships in URC4 were smaller than previously discussed URCs due to the shift of the global integration core towards primary circulation spaces. Nevertheless, results indicated that configurationally accessible and highly visible convex spaces facilitated unprogrammed encounters.
Overall, it was identified that syntactical properties of space and walking distances in fixed-feature space clearly affected technical consultations among researchers in URC4, and these effects were very similar to those detected in the case of URC3.

6.3.4.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC4: Environmental Qualities and Reasons for Space Use

Following analyses of the relationships between fixed-feature space and patterns of space use for technical consultations, the relationships between semi-fixed/non-fixed feature space and patterns of space use for technical consultations were analyzed. Those spaces where URC4 researchers most frequently met other researchers, and most frequently visited when they left their offices were identified based on the follow-up surveys. The environmental qualities and reasons for use of these spaces cited by URC4 researchers were then tabulated, and associated with convex spaces on floor plans of URC4 territory (Figure 6.3.4.7).
Content analysis of follow-up surveys in URC4 indicated that researchers most frequently met their colleagues on the first floor. Corridors U106, U107 and U120, entrance lobby (U100), the loading dock (140), and the lounge (114) were among the most frequently cited convex spaces for meeting other researchers on the first floor. On
the second floor, corridor U216 and lobby U206, and on the third floor, corridor U323 were the most frequently cited convex spaces for meeting other researchers. These corridors were also those convex spaces that had higher global integration values.

The positive environmental quality most frequently cited for the corridors on all three floors was the high amounts of traffic on these corridors. As in the previously discussed URCs, awareness of presence of other researchers in a convex space was evidently an attractive factor for researchers. On the other hand, in all three floors, a frequently cited negative environmental quality for the corridors was their “sterile, bland” visual quality. In addition, the majority of URC4 researchers indicated that these corridors “separated offices from laboratories with through traffic”. These two negative environmental qualities cited by URC4 researchers about the corridors were illuminating.

First, it was evident that URC4 researchers felt that the double functioning of these corridors both as office cores and primary circulation spaces was distracting. While these corridors connected their offices to laboratories, it was also possible for outsiders to pass through these spaces. Thus, URC4 territory was further separated by “through traffic”. This finding from the follow-up surveys further confirmed previously found low levels of coincidental consultations on these corridors. Clearly, URC4 researchers did not “possess” these corridors, and they were not “wondering around” the URC territory, which decreased the possibility of coincidental consultations. This finding was further supported by the observed visual quality of these corridors. Also as frequently cited by URC4 researchers, these corridors did not reflect a sense of belonging to an organization during the walk-through.

As a result, both the activity logs and follow-up surveys showed that the corridors on the first, second and third floors not only separated offices from laboratory spaces by functioning as primary circulation spaces, but also with their sterile visual quality that indicated a lack of possession. These findings indicated that at the fixed-feature space level, those convex spaces within the URC territory were more attractive to researchers for casual presence. At the non-fixed feature space level, visual qualities of convex spaces, and feeling of possession were attractive to researchers.

Informal common spaces on the first and second floor yielded additional findings about the importance of informal commons. The first floor lounge (convex space 114) was a noteworthy example. This space was mainly designated for mailboxes, a kitchenette and business equipment such as the fax machine. In addition, in terms of its location and size, it was evident that it was not intended to function as a “family room”, as in URC1. This lounge was one of the most globally segregated convex spaces in URC4 system. Consequently, a small number of coincidental consultations and no unprogrammed group meetings were reported in this space in the activity
logs. Supporting this, many URC4 researchers indicated that the location of this lounge was a negative environmental quality. In addition, researchers frequently cited its small size and lack of access to daylight. Still, URC4 researchers indicated the small number of coincidental consultations occurring in this space as a positive environmental quality. Other positive environmental qualities cited for this space were easy access to food and drinks, and its kitchenette. When compared to the family room of URC1, the conclusion was that, if a more globally integrated and visible convex space had been designated for this function, it could have facilitated many face-to-face technical consultations including unprogrammed group meetings.

Another example of informal common spaces in URC4 was the second floor lounge (U206). This space was specifically designated for casual encounters, with its views toward the ocean and gallery space between the first and second floors. In addition, it was located on the global integration of the entire system. However, no coincidental consultations were reported in this space in the activity logs. Moreover, only three researchers indicated that they frequently met their colleagues in this space.

One of the observations about this space was that, although it had a pleasant view, and was located on the integration core, no semi-fixed feature elements supported this space. Conveniences such as access to food/drinks, business equipment, etc. did not exist in this space. In addition, this space was not within URC4 territory, and was open to everybody's access in the building. In effect, positive qualities such as including material conveniences, and being within the URC territory did not exist in the second floor lounge U206.

Evidently, the presence of material conveniences in an informal common space that is within the URC territory created a feeling of possession in researchers. URC4’s second floor lobby U206, on the other hand, lacked both of these features. Therefore, the findings in the case of URC4 confirmed the important role of informal common spaces in facilitating face-to-face technical consultations in URCs.

Other positive environmental qualities indicated by URC4 researchers were access to daylight and pleasant views in cellular offices, and the convenience of the staging room (134) for fieldwork. Similar to the findings in the case of URC3, access to an open-air area was also indicated as a positive quality by the researchers. The loading dock (140) was cited frequently for meeting colleagues, as well as for breaks. Whenever possible, researchers used the open-air loading dock for "getting fresh air". These citations supported the six coincidental consultations reported in the activity logs on the loading dock.

Overall, content analyses of the follow-up surveys indicated that at the fixed-feature space level, the separation of URC4 territory was a negative influence on technical consultations among researchers. In addition, the influence that informal common spaces can have on face-to-face technical consultations was confirmed. The
informal common spaces of URC4 either were not within the territory, or lacked material conveniences. Consequently, face-to-face technical consultations rarely occurred in these convex spaces. At the semi-fixed feature space level, frequently cited environmental qualities of those spaces where URC4 researchers most frequently met their colleagues were pleasant views and access to daylight. At the non-fixed feature space level, visual quality and a sense of possession was frequently cited issue. At the level of fixed-feature space, most frequently cited reason for space use was access to open air, as exemplified by the use of loading dock. At the level of semi-fixed feature space, most frequently cited reason for space use was access to material conveniences, such as using the kitchenette or checking the mailbox. At the level of non-fixed feature space, most frequently cited reason for space use was awareness of the presence of other researchers in a space, which was exemplified by the first floor corridor and the first floor lounge. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation in table 6.3.4.3.

Table 6.3.4.3. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC4. Examples of URC4 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td>■ Integration of offices and laboratories, metric proximity (i.e. &quot;separation of offices from labs with through traffic&quot;)</td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td>■ Access to daylight (i.e. &quot;great windows&quot;) ■ Pleasant views (i.e. &quot;nice view, great view&quot;)</td>
</tr>
<tr>
<td><strong>Non-fixed feature space</strong></td>
<td>■ Visual quality (i.e. &quot;too sterile and bland hallways&quot;)</td>
</tr>
</tbody>
</table>

6.3.4.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC4

A summary of findings of the relationships between fixed-feature space and technical consultations in URC4 is shown in Table 6.3.4.4.
Table 6.3.4.4. Summary of findings: relationships between fixed-feature space and technical consultations in URC4. (*) indicates negative correlations.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>SYNTACTICAL PROPERTIES OF SPACE</th>
<th>WALKING DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRAn</td>
<td>CONN</td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td>r²=0.28</td>
<td>p=0.0031</td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td>r²=0.40</td>
<td>p=0.0007</td>
</tr>
<tr>
<td>UNSCHEDULED GROUP MEETINGS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESCRIBED GROUP MEETING</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PRESCRIBED OFFICE VISITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONSULTATIONS THROUGH E-MEDIA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Data analysis in the case of URC4 confirmed the effects of fixed-feature, semi-fixed feature and non-fixed feature space on technical consultations among researchers. Moreover, the following findings in the case of URC4 were almost identical to those findings reached in the case of URC3. Consequently, the differences between Category 1 and Category 2 URCs, as well as the similarities between the two Category 2 URCs URC3 and URC4 were further confirmed. It was observed that certain patterns of findings were appearing in the URCs discussed up to this point.

At the level of fixed-feature space, it was found that separation of the non-intact URC4 territory into three floors caused the global integration core of the entire system to shift towards primary circulation spaces, which were non-territorial convex spaces. Consequently, a small number of face-to-face technical consultations were reported in these spaces. It was also identified that the majority of unprogrammed encounters occurred among researchers on the same floor, and inter-floor trips for unprogrammed encounters occurred very rarely due to increased walking distances. Moreover, reliance on technical consultations through e-media was higher than Category 1 URCs, indicating that the separation of URC4 territory and subsequent increased walking distances hindered face-to-face technical consultations. These findings were illuminating in highlighting the different effects of Category 1 and Category 2 URCs on technical consultation patterns of researchers.

Data analyses indicated that syntactical properties of space and walking distances affected unprogrammed encounters. Higher global and local integration, lower point and mean depth, and higher visibility facilitated
unprogrammed encounters within URC4 territory. Therefore, configurationally accessible and highly visible convex spaces facilitated unprogrammed encounters.

Findings in URC4 confirmed that informal common spaces were important for facilitating face-to-face technical consultations in URC territories. Those environmental qualities that were previously found to be positively influencing face-to-face technical consultations were lacking in URC4 informal common spaces. Consequently, face-to-face technical consultations rarely occurred in these convex spaces.

By completing follow-up surveys, URC4 researchers indicated that environmental qualities such as metric proximity to colleagues and configurational integration facilitated face-to-face technical consultations. Findings also indicated that awareness of the presence of colleagues and access to material conveniences such as the kitchenette attracted researchers for use of spaces with such features. In conclusion, findings in the case of URC4 about the effects of space on technical consultations supported previous findings in Category 1 and Category 2 URCs.

6.3.5. URC5 (CATEGORY 3)

At the time of data collection, 21 researchers were working with URC5. 17 researchers responded to the activity logs and follow-up surveys, yielding an 81% response rate. The data provided in URC5 was analyzed according to the data analysis procedure described in Chapter 5. Reported research related technical consultations were tabulated across technical consultation types. A total of 320 technical consultations were reported by URC5 researchers during the five-weekday period in which the activity logs were completed.

Among the reported research related technical consultations, 91% were face-to-face technical consultations, and 9% had occurred through e-media. 68% of all the reported technical consultations were unscheduled office visits, 12% were coincidental consultations, 5% were prescheduled group meetings, 3% were unscheduled group meetings, and 3% were prescheduled office visits. Of the 10% technical consultations through e-media, 9% were e-mails and 1% was telephone calls (Chart 6.3.5.1).
Chart 6.3.5.1. Tabulation of research related technical consultations reported by URC5 researchers, recorded during the five weekdays in which the activity logs were completed.

As in the previously discussed four URCs, face-to-face technical consultations were the main media for information exchange used by URC5 researchers. Compared to Category 1 and Category 2 URCs, URC5’s percentage of face-to-face technical consultations was closer to those of Category 1 URCs. A behavior map of these reported technical consultations were prepared on the floor plan of URC5. This behavior map helped identify the types of technical consultations that occurred in convex spaces of different properties (Figure 6.3.5.1).
6.3.5.1. Fixed-feature Space: Configurational Analysis of URC5 Territory

URC5 was previously identified as a “Category 3 URC”, with its intact territory. URC5 territory was composed of two interconnected office cores, to which cellular and open office spaces were connected. In this respect, URC5 as a Category 3 URC was different from Category 1 and 2 URCs, since its territory did not include any laboratory convex spaces.

A configurational analysis of URC5 territory was conducted using space syntax methods in order to understand the relationships between technical consultations and spatial configuration of URC4 territory. Global integration (RRA), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRA), mean depth (MD), intelligibility (I) and visibility (mean isovist area / MeanISO) were calculated for each single convex space within URC5 territory. Color-coded plans of URC5 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.5.2).
Figure 6.3.5.2. Global integration (RRAn) of convex spaces within URC5 territory.

Space syntax analysis of URC5 territory indicated that the global integration of the system overlapped office core convex spaces S01, S03, S06, S07 and S09. At the same time, this global integration core passed through the conference room (1513). This initial finding indicated that convex space S05, which was designated as a corridor to connect the two office cores was actually much less integrated than many office core convex spaces, and even the conference room. The visibility of URC5 convex spaces was also calculated by using space syntax methods. As in previously discussed URCs, during the calculation process, those furnishings that remained below eyesight were excluded in calculations, since they did not form obstacles to visibility. Figure 6.3.5.3 shows the visibility (mean isovist areas / MeanISO) of convex spaces within URC5 territory.
Visibility analysis in URC5 indicated that the highest visibility areas within URC5 territory quite precisely overlapped the global integration of the system. In this respect, based on the findings from previously discussed cases, these convex spaces existed as high-potential areas that could facilitate face-to-face technical consultations, particularly coincidental consultations. However, it was also noted that the global integration and maximum visibility core of the system was passing right through a formal conference room. Therefore, it was evident that in the case of meetings in the conference room, the chances of coincidental consultations would drop compared to times without any meetings.

As a result, configurational analysis of URC5 territory indicated that most centrally located, most configurationally accessible convex spaces (the global integration core) and most visible areas in URC5 overlapped. This finding indicated that based on previous findings, these convex spaces had a high potential for facilitating coincidental consultations. It was also noted that this high-potential series of spaces included a formal conference room, which, in the case of formal meetings, would reduce chances of coincidental consultations. Finally, it was noted that the connecting space between two office cores, S05, was not among these highly central and visible convex spaces.

6.3.5.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC5: Syntactical Properties of Space and Walking Distances

According to the data analysis protocol, effects of fixed-feature space on unscheduled office visits were analyzed. First, the relationships between syntactical properties of space and different types of technical
consultations were examined. Pearson’s r correlations were examined between each syntactical property and numbers of reported technical consultations in URC5 convex spaces. Second, the relationships between walking distances and technical consultations were analyzed.

Unscheduled Office Visit in URC5. A behavior map of unscheduled office visits was used to compare the syntactical properties of URC5 convex spaces to the numbers of unscheduled office visits reported for each convex space (Figure 6.3.5.4).

![Behavior map of URC5 unscheduled office visits](image)

**Figure 6.3.5.4.** Unscheduled office visits and their locations in URC5 territory.

Behavior map of URC5 unscheduled office visits showed that the majority of these technical consultations were reported in cellular office convex spaces rather than open offices. In addition, the majority of unscheduled office visits had occurred in office core 1, as opposed to office core 2. The highest number of unscheduled office visits was reported in office number 1501. In order to understand how the reported numbers of unscheduled office visits related to syntactical properties of space, bivariate analyses were conducted between numbers of unscheduled office visits and syntactical properties of space (Figure 6.3.5.5).
Bivariate analyses indicated that there was a certain level of relationship between syntactical properties of space and unscheduled office visits. However, on the scatterplots in Figure 6.3.5.5, it was also identified that one of the spaces had a very high number of reported unscheduled office visits. This space (indicated with a blue square on the scatterplots) was office space 1501, which was also spotted with a high number unscheduled office visits on the behavior map.

In order to understand whether the reason for this observation was the individual role of this researcher or syntactical properties of his/her office, social network analysis of URC5 technical consultation network was conducted based on the data collected through the activity logs. Social centrality values of URC5 researchers were calculated based on the number of directional relations of each researcher. A higher social centrality value for a researcher indicated that, that particular researcher had directional relations with a higher number of researchers compared to his/her colleagues in URC5. The social centrality values of URC5 researchers are tabulated in Chart 6.3.5.2, where each researcher is represented by the space code of his/her office.
Social network analysis indicated that the researcher occupying office space 1501 had the highest social centrality value among URC5 researchers. An analysis of the distribution of URC5 researchers’ social centrality values indicated that this researcher was an outlier. Thus, the researcher occupying office number 1501 was a key communicator. Based on these results, it was identified that the high numbers of unscheduled office visits reported in office space 1501 was not because of the syntactical properties of this space, but was due to the individual role of that particular researcher in URC5. In fact, this was URC5’s director, and this further supported the findings of social network analysis. Therefore, in order to focus on the effects of spatial configuration on unscheduled office visits and maintain the validity of the study, the previously conducted bivariate analyses were repeated for unscheduled office visits by removing the key communicator from the data set as shown in Figure 6.3.5.6.
When the key communicator was removed from the data set, it was found that the relationships between syntactical properties of space and unscheduled office visits were in fact stronger than the relationships found the previous analysis. Positive significant correlations were found between unscheduled office visits and global integration (RRAn), local integration (RRA3) and visibility of convex spaces (MeanISO). Negative significant correlations were found between unscheduled office visits and point depth from the most globally integrated space (Depth RRAnMAX) and mean depth (MD).

These findings indicated that those researchers occupying more centrally located, configurationally accessible and more visible offices (i.e. spaces with high global integration, low mean depth, high mean isovist values) had a higher probability of receiving unscheduled office visits. The researcher occupying office space 1507 set a good example for this situation. This researcher had an average social centrality among URC5 researchers, but had a highly visible office with a close connection to the global integration of the system. Despite his/her average social centrality, this researcher had a relatively high number of unscheduled office visits than those of his/her colleagues who also had average social centrality, but less accessible and less visible offices. These findings once again paralleled and confirmed the effects of syntactical properties of space on unscheduled office visits that were found in Category 1 and Category 2 URCs.
Coincidental Consultations in URC5. When reported coincidental consultations were mapped on the floor plan of URC5 territory, it was noted that the majority of coincidental consultations were reported on the integration core of URC5 system (Figure 6.3.5.7).

A brief visual analysis of the behavior map indicated that about 90% of reported coincidental consultations had occurred on highly visible, configurationally accessible office core convex spaces (on the integration core of the system). In order to further understand these relationships, bivariate analyses between coincidental consultations and syntactical properties of space were conducted (Table 6.3.5.1).

Table 6.3.5.1. Bivariate analyses of the relationships between coincidental consultations and syntactical properties of convex spaces in URC5.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>r²=0.45, p=0.0066</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>r²=0.33, p=0.02</td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>r²=0.20, p=0.09</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>r²=0.31, p=0.03</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>r²=0.37, p=0.01</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>r²=0.28, p=0.04</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>r²=0.56, p=0.0014</td>
</tr>
</tbody>
</table>

Bivariate analyses yielded positive significant correlations between global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), and visibility (MeanISO) values of convex spaces and
numbers of reported coincidental consultations. Negative significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces and numbers of reported coincidental consultations. Thus, the global integration core of the system facilitated coincidental consultations.

These findings, while confirming the results of the visual analysis on the behavior map, also indicated that highly central, configurationally accessible and highly visible convex spaces facilitated coincidental consultations among researchers in URC5. In this respect, these findings also supported previous findings about coincidental consultations in Category 1 and Category 2 URCs.

**Unscheduled and Prescheduled Group Meetings in URC5.** A behavior map of unscheduled and prescheduled group meetings in URC5 indicated that the majority of (more than 90%) of both types of technical consultations had occurred in the formal conference room 1513 (Figure 6.3.5.8). One prescheduled group meeting was reported in the key communicator’s office (1501), which paralleled the previous findings about this space. One unscheduled group meeting was reported in office space 1506.

![Figure 6.3.5.8. Prescheduled and unscheduled group meetings and their locations in URC5 territory.](image)

Since more than 90% of all group meetings were held in the same space, no statistical analyses were conducted. However, this finding indicated that the conference room was being used as it was originally intended. The number of prescheduled group meetings (5%) held in this space indicated its formal atmosphere.
The number of unscheduled group meetings (3% of all technical consultations) held in this space also indicated that this space had a semi-formal atmosphere. On the other hand, since no coincidental consultations were reported in this space, it was also evident that this space did not function entirely as an informal common space (i.e. similar to URC1’s family room). Thus, findings about this space once again indicated the importance of providing an informal common space in URC territories. Among the URCs discussed up to this point, more group meetings were held in URCs with formal common spaces; however, when informal common spaces were present in URC territories, they facilitated not only prescheduled and unscheduled group meetings, but also coincidental consultations.

Prescheduled Office Visits in URC5. The amount of reported prescheduled office visits in URC5 was limited to 3% of the total amount of technical consultations. Mapping the locations of these prescheduled office visits (Figure 6.3.5.9) indicated that these technical consultations were related to the individual roles of researchers rather than syntactical properties of space. For example, the majority of prescheduled office visits were reported in the key communicator’s office. Therefore, no relationships were found between syntactical properties of space and prescheduled office visits in URC5. This result was parallel to the findings in Category 1 and Category 2 URCs.

![Figure 6.3.5.9. Prescheduled office visits and their locations in URC5 territory.](image)

Technical Consultations Through E-media (telephone calls and e-mails) in URC5. Data analysis indicated that the percentages of technical consultations through e-mails and telephone calls in URC5 were higher than in
Category 1 URCs, but lower than in Category 2 URCs. However, no significant relationships were found between syntactical properties of space and origins of e-mails and telephone calls in URC5. Nevertheless, these findings confirmed that in intact-territory URCs such as URC5, reliance of researchers on e-media for technical consultations were less than those researchers in non-intact territory (Category 2) URCs.

The Relationships of Walking Distances to Unprogrammed Encounters in URC5 Territory. Statistical analyses of the relationships between numbers of technical consultations and walking distances indicated that as the walking distance between the origin and destination of trips increased, the number of unprogrammed encounters decreased. There was a higher chance of being involved in unprogrammed encounters within closer walking distances for researchers in URC5 (Table 6.3.5.2).

Table 6.3.5.2. Bivariate analyses of the relationships between unprogrammed encounters and walking distances in URC5.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.74$, $p=0.002$</td>
<td>$r^2=0.54$, $p=0.0044$</td>
<td>$r^2=0.81$, $p=0.0015$</td>
</tr>
</tbody>
</table>

During the initial configurational analysis, it was identified that the global integration core of the system passed through the conference room 1513, and the connecting corridor S05 between office core 1 and office core 2 was relatively segregated. In addition, between the two office cores, the path through S05 was longer than the path through the conference room 1513. Finally, it was also identified in configurational analysis that when the doors of the conference room were closed, it was creating a visual obstruction between the two office cores. In order to see if the conference room was actually creating a separation between the two office cores, and to see the effects of walking distances clearly, the origins and destinations of unprogrammed encounters were traced and tabulated (Chart 6.3.5.3).
Chart 6.3.5.3. Tabulation of unprogrammed encounters according to their origins and destinations in URC5. Dark gray indicates the inter-office core trips made by the key communicator.

This analysis displayed the separation between the two office cores. It was identified that 77% of all unprogrammed encounters had originated and ended in the same office core. The amount of trips for unprogrammed encounters from one office core to the other was limited to 23%. Moreover, 11% of the inter-office core trips were made by the key communicator. Evidently, the two office cores were perceptually separated from each other, and the conference room 1513 was contributing to this separation by increasing walking distances due to its blocking location.

When the visibility levels through a trip from office core 2 to office core 1 was measured, it was identified that the connecting corridor S05 between the two office cores had the minimum visibility values (Figure 6.3.5.10). In this respect, the conference room was also creating a visual obstacle between the two office cores, and visually contributing to the separation between these two office cores.
Figure 6.3.5.10. The visual block created by the conference room 1513. On a walking route from office core 2 to office core 1, the lowest visibility values were identified on the connecting corridor S05. These results indicated that the conference room was a contributing factor to the hindering effects of increased walking distances on unprogrammed encounters both by its location and visual obstruction. A formal common space designated for facilitating technical consultations was therefore hindering unprogrammed encounters in URC5. This finding confirmed that fixed-feature space could facilitate or hinder face-to-face technical consultations in URCs. Overall, findings about walking distances and their effects on unprogrammed encounters were supported in URC5.
6.3.5.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC5: Summary of Findings

Data analyses at the fixed-feature space level indicated that syntactical properties of space and walking distances significantly affected unprogrammed encounters in URC5.

First, similar to the findings in Category 1 and Category 2 URCs, it was identified that there was a higher probability of receiving unscheduled office visits in those offices that were centrally located, configurationally accessible, and highly visible. The same effect was confirmed for office core convex spaces when coincidental consultations were considered. More than 90% of the coincidental consultations reported in URC5 had occurred in centrally located, configurationally accessible, and highly visible office core convex spaces. These results indicated that as in previously discussed URCs, higher global integration, lower mean depth and higher visibility facilitated unprogrammed encounters in URC5 territory.

Second, it was identified that as walking distances increased, the numbers of unprogrammed encounters decreased in URC5 territory. As found in previously discussed URCs, within shorter walking distances, there was a higher probability of engaging in unprogrammed encounters for URC5 researchers. In URC5, the effects of the conference room set a good example for this situation. With its location, the conference room was not only causing increased walking distances between the two office cores, but also creating a visual obstacle between them. Consequently, it was found that the number of trips for unprogrammed encounters between the two office cores was less than a quarter of the total number of unprogrammed encounters. To summarize, it was evident that syntactical properties of space and walking distances could affect the numbers of unprogrammed encounters in URC5.

Third, as in Category 1 and Category 2 URCs, face-to-face technical consultations constituted the majority (91%) of all technical consultations in URC5, indicating that face-to-face technical consultations formed the main media for information exchange. In addition, the percentages of technical consultations through e-media in URC5 was less than non-intact territory Category 2 URCs, but more than intact-territory Category 1 URCs, highlighting the different effects of these separate spatial categories on technical consultations.

6.3.5.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC5: Environmental Qualities and Reasons for Space Use

Following analyses of the relationships between fixed-feature space and patterns of space use for technical consultations, the relationships between semi-fixed/non-fixed feature space and patterns of space use for technical consultations were analyzed. Those spaces where URC5 researchers most frequently met other
researchers, and most frequently visited when they left their offices were identified based on the follow-up surveys. The environmental qualities and reasons for use of these spaces cited by URC5 researchers were then tabulated, and associated with convex spaces on floor plans of URC5 territory (Figure 6.3.5.11).

Two of the most cited convex spaces for frequently meeting colleagues were office core convex space S01 and the kitchen in URC5. Initially, it was noted that while office core convex space S01 was on the global integration core of URC5, the kitchen had a direct connection to it. Therefore these two citations supported previous findings about the global integration core of the system: both spaces were configurationally accessible and highly visible,
and facilitated coincidental consultations. A number of semi-fixed and non-fixed feature level environmental qualities also supported these findings. For the kitchen, URC5 researchers indicated that its central location to all offices, multifunctionality and convenience were positive environmental qualities. For the office core convex space S01, researchers indicated that it was an “open space” and easily accessible. However, the researchers also mentioned that S01 could cause distractions to those working close to this space. These citations indicated that at the fixed-feature space level, configurational integration, and at the semi-fixed feature level, high visibility and perceived convenience were attractive to URC5 researchers, and facilitated face-to-face technical consultations.

The reasons cited for using these spaces were also informative. At the semi-fixed feature space level, researchers indicated that they frequently used the kitchen in order to get drinks and lunch. For office core convex space S01, the indicated reasons for use were checking mail and using the copier in the neighboring reception area. Therefore, semi-fixed feature level elements such as material conveniences (i.e. food, drink) and access to business equipment (i.e. access to the copier) attracted researchers to use these spaces. Consequently, when such features were combined with positively perceived environmental qualities and configurational accessibility, it was evident that these two spaces were facilitating face-to-face technical consultations.

Previous findings about the conference room 1513 were also further supported by the findings from the follow-up surveys. URC5 researchers mentioned that the central location, availability for concentrated reading and presence of reading material (periodicals library) were positive environmental qualities of this space. However, researchers also indicated that conference room 1513 was “not a good area for casual discussion”. When compared with the family room of URC1, conference room 1513 did not feature material conveniences such as a coffee machine or eating facilities. In addition, as opposed to informal furnishing, this space was equipped with a formal “meeting table”. Therefore, this space reflected a more formal atmosphere. This was further supported by the indicated reasons for use of this space. URC5 researchers indicated that they used this space for meetings, to use the periodicals library and to read. Evidently, this space was a concentrated, formal work area rather than an informal gathering space; a result that also helped further explain the separating effects of this space on the two office cores. Therefore, the formal atmosphere of this space did not permit coincidental consultations, but facilitated formal group meetings, as also indicated by the activity log findings. As a result, conference room 1513 further supported the necessity of having an informal common space in URC territories in order to facilitate face-to-face technical consultations.
Finally, citations about the shared second floor lobby L02 further supported previous findings about this space. URC5 researchers indicated that this space was “cold, uncomfortable and far removed”. It was the material conveniences of this space (i.e. vending machines) that was attracting researchers to this space, but not its atmosphere. These citations once again indicated that rather than having shared but unoccupied informal common spaces, it was much more efficient to have such spaces within a URC territory in order to facilitate face-to-face technical consultations.

To summarize, the results indicated that business tools, access to food, drink and the possibility of meeting other researchers were the most frequently cited reasons for space use in URC5. When environmental qualities of those spaces where URC5 researchers most frequently met others were considered, configurational integration, increased visibility and perception of an informal environment were mostly cited as positive environmental qualities that attracted researchers, therefore facilitated face-to-face technical consultations. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation” in Table 6.3.5.3.

Table 6.3.5.3. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC5. Examples of URC5 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td>Configurational integration (i.e. “centrally located to all offices”)</td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td>Increased visibility (i.e. “open space”)</td>
</tr>
<tr>
<td></td>
<td>Material conveniences (i.e. “access to food / drink”)</td>
</tr>
<tr>
<td></td>
<td>Access to business tools (i.e. “to use copier”)</td>
</tr>
<tr>
<td><strong>Non-fixed feature space</strong></td>
<td>Perception of an informal environment (i.e. “not a good area for casual discussion”)</td>
</tr>
<tr>
<td></td>
<td>Concentrated work (i.e. “to read, to use library”)</td>
</tr>
<tr>
<td></td>
<td>Meeting others / breaks</td>
</tr>
</tbody>
</table>

6.3.5.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC5

A summary of findings of the relationships between fixed-feature space and technical consultations in URC5 is shown in Table 6.3.5.4.
Table 6.3.5.4. Summary of findings: relationships between fixed-feature space and technical consultations in URC5. (*) indicates negative correlations.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>SYNTACTICAL PROPERTIES OF SPACE</th>
<th>WALKING DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RRAn</td>
<td>CONN</td>
</tr>
<tr>
<td>UNSCHEDULED OFFICE VISITS</td>
<td>$r^2=0.53$</td>
<td>p=0.0006</td>
</tr>
<tr>
<td>COINCIDENTAL CONSULTATIONS</td>
<td>$r^2=0.45$</td>
<td>p=0.0066</td>
</tr>
</tbody>
</table>

Data analysis in the case of URC5 confirmed the effects of fixed-feature, semi-fixed feature and non-fixed feature space on technical consultations among researchers.

First, it was found that face-to-face technical consultations were preferred significantly more than consultations through e-media. Therefore, face-to-face technical consultations formed the main medium for information exchange in URC5.

Findings of the study in URC5 indicated that at the fixed-feature space level, spatial configuration and walking distances significantly affected the number and locations of unprogrammed encounters (unscheduled office visits and coincidental consultations). The results showed that higher global integration, higher local integration, higher visibility and lower point depth from the maximum globally integrated space increased chances of unscheduled office visits. Higher levels of global integration, local integration, connectivity, control value, visibility, and lower levels of point depth from the maximum globally integrated space increased chances of coincidental consultations.

These results showed that configurationally more accessible and highly visible offices had a higher probability of receiving unscheduled office visits. Office core convex spaces that were centrally located, configurationally more accessible and highly visible facilitated coincidental consultations. As found in previously discussed URCs, the
results indicated that shorter walking distances increased the chances of higher numbers of unscheduled office visits among URC 5 researchers.

The findings indicated that the conference room in URC5 hindered unprogrammed encounters between researchers that occupied offices connected to different office cores by increasing walking distances and decreasing visibility. On the other hand, while many group meetings were held in the conference room, results showed that because of the lack of an informal atmosphere, no coincidental consultations were occurring in this common space. URC5 researchers further confirmed this in the follow-up surveys. Therefore, these results supported the idea that providing an informal common space within the territory of a URC could facilitate coincidental consultations.

As in previously discussed URCs, it was also confirmed that prescheduled office visits were mainly related to the researchers targeted for discussions and their individual roles, rather than any spatial properties of their offices.

As a result, while at the fixed-feature space, syntactical properties of space and walking distances affected unprogrammed encounters, at the semi-fixed and non-fixed feature space, access to desired functions, and increased visibility facilitated patterns of space use for face-to-face technical consultation. In conclusion, findings in the case of URC5 about the effects of space on technical consultations supported previous findings in Category 1 and Category 2 URCs.

6.3.6. URC6 (CATEGORY 3)

At the time of data collection, 16 researchers were working with URC6, all of whom responded to the activity logs and follow-up surveys. The responses of URC6 researchers to the activity logs and follow-up surveys were analyzed according to the data analysis procedure described in Chapter 5. Initially, reported research related technical consultations were tabulated across technical consultation types. During the five weekdays in which activity logs were completed, 271 research related technical consultations were reported in URC6.

Fifty-six percent of the reported technical consultations were unscheduled office visits, 24% were coincidental consultations, 5% were prescheduled group meetings, 3% were prescheduled office visits and 1% were unscheduled group meetings. Therefore, 89% of all the reported technical consultations in URC6 were face-to-face technical consultations, and 11% were technical consultations through e-media. Of all the technical consultations through e-media, 7% were e-mails and 4% were telephone calls. These results indicated that along with all previously discussed URCs, face-to-face technical consultations also formed the main media for information exchange in URC6. The tabulation of technical consultations that occurred among URC6 researchers is shown in Chart 6.3.6.1.
Chart 6.3.6.1. Tabulation of research related technical consultations reported by URC6 researchers, recorded during the five weekdays in which activity logs were completed.

The reported technical consultations were then mapped on the floor plans of URC6, which made it possible to identify the types of technical consultation that occurred in convex spaces of different properties (Figure 6.3.6.1).
Figure 6.3.6.1. Behavior map of research related technical consultations reported by URC6 researchers.
6.3.6.1. Fixed-feature Space: Configurational Analysis of URC6 Territory

With its intact territory, URC6 was previously identified as a “Category 3 URC”. As in the case of URC5, URC6 territory was composed of two interconnected office cores, without laboratory convex spaces. However, URC6 was also the only case which had a building exclusively designed and designated for its use. The two-floor building of URC6 featured an office core and a number of cellular offices on both floors.

A configurational analysis of URC6 territory was conducted using space syntax methods in order to understand the relationships between technical consultations and spatial configuration of URC4 territory. Global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the most globally integrated space (Depth RRAn), mean depth (MD), intelligibility (I), and visibility (mean isovist area / MeanISO) were calculated for each single convex space within URC6 territory. Color-coded plans of URC6 territory were then prepared in order to represent the syntactical properties of each space graphically (Figure 6.3.6.2).
Figure 6.3.6.2. Global integration (RRAn) of convex spaces within URC6 territory.

Configurational analysis of URC6 territory indicated that the global integration core of the entire system overlapped the intersection of convex spaces C201, C204, the journal lounge (JL), the stairs, and the interaction space (IS). Therefore, the journal lounge on the second floor and the interaction space on the first floor were two informal common spaces on the global integration core of URC6 system. It was also identified that those cellular office spaces with direct connection to the global integration core had higher global integration values than those without direct connection. The visibility of URC6 convex spaces was also calculated by using space syntax.
methods. As in previously discussed URCs, during the calculation process, transparent surfaces and those furnishings below eyesight were excluded in calculations, since they did not form obstacles to visibility. Figure 6.3.6.3 shows the visibility (MeanISO) of convex spaces within URC6 territory.

![Mean ISO Visibility Map](image)

**Figure 6.3.6.3.** Mean isovist areas (MeanISO) of convex spaces within URC6 territory.

Visibility analysis indicated that the highest visibility convex spaces of URC6 territory were those on the global integration core of the second floor. The journal lunge (JL), convex spaces C201, C203 and C204, as well as the conference room 217 were highly visible convex spaces. The sliding glass doors of conference room 217 were
greatly influential on the high visibility of this space. On the first floor, on the other hand, the interaction space (IS) and the shared office 102 were highly visible convex spaces, although their visibility were less than those on the first floor.

Therefore, configurational analysis indicated that the second floor convex spaces journal lounge (JL), C201, C203 and C204 were highly centrally located, configurationally accessible, and highly visible. On the first floor, highly visible and configurationally accessible convex spaces were the interaction space (IS) and the shared office 102.

6.3.6.2. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC6: Syntactical Properties of Space and Walking Distances

The identical data analysis protocol applied to previously discussed Category 1 and Category 2 URCs was also applied to URC6 in order to understand the relationships between fixed-feature space and technical consultation patterns. In doing so, the relationships between syntactical properties of space and technical consultations were examined. Following this analysis, the relationships between walking distances and technical consultations were examined.

**Unscheduled office visits in URC6.** Syntactical properties of URC6 convex spaces were compared to the numbers of unscheduled office visits reported for each convex space. Therefore, the effects of syntactical properties of each space on the numbers of reported unscheduled office visits for each space were analyzed. Figure 6.3.6.4 shows the behavior map of unscheduled office visits in URC6 territory.
Figure 6.3.6.4. Unscheduled office visits and their locations in URC6 territory.

The behavior map indicated that the majority of unscheduled office visits in URC6 occurred on the first floor office convex spaces. It was identified that those office convex spaces with higher global integration and visibility values received a higher number of unscheduled office visits. However, first floor office convex spaces 109 and 111 were spotted with comparatively higher number of unscheduled office visits than other offices on the same floor.
floor. Bivariate analyses of syntactical properties of space and unscheduled office visits were conducted (Figure 6.3.6.5).

In this initial analysis, no significant correlations were identified between unscheduled office visits and syntactical properties of space. However, also as noted on the behavior map, it was identified that office spaces 109 and 111 on the first floor of the building (shown with blue squares on the scatterplots) received a high number of unscheduled office visits despite their low global integration and visibility values. Since unscheduled office visits occur as visits to specific individuals in their offices, the important point was whether this high number of unscheduled office visits reported in these two offices were due to the individual roles of those researchers, or the syntactical properties of their offices. This question was also important in order to interpret the relationships between unscheduled office visits and syntactical properties of convex spaces in the entire system.

In order to understand whether the reason for this result was the individual role of these researchers or syntactical properties of their offices, social network analysis of URC6 technical consultation network was conducted based on the data collected through the activity logs. Social centrality values of URC6 researchers were calculated based on the number of directional relations of each researcher. This analysis revealed the relative social centrality of each researcher. A higher social centrality value for a researcher indicated that, that particular researcher had directional relations with a higher number of researchers compared to his/her
colleagues in URC6. The social centrality values of URC6 researchers are tabulated in Chart 6.3.6.2, where each researcher is represented by the space code of his/her office.

![URC6 Researchers: Social Centrality](chart.png)

**Chart 6.3.6.2.** Social centrality of URC6 researchers based on the number of directional relations of each researcher. R109 and R111 were key communicators, with the highest social centrality values calculated through social network analysis.

Social network analysis indicated that researchers occupying offices 109 and 111 on the first floor had the highest social centrality values among their colleagues. When the distribution of social centrality values of URC6 researchers was analyzed, these two researchers were noted as outliers. Therefore, the high numbers of unscheduled office visits reported in the offices of these two researchers were an effect of their individual roles rather than syntactical properties of their offices. In fact, these two researchers were a computer analyst and a researcher, both of whom had specialization on certain subjects. This situation further explained their social centrality in URC6 technical consultation network, as well as the reason for the high number of unscheduled office visits in these offices. In order to focus on the effects of spatial configuration on unscheduled office visits and maintain the internal validity of the study, the previously conducted bivariate analyses were repeated for unscheduled office visits by removing the key communicators from the data tables as shown in Figure 6.3.6.6.
Bivariate analyses of the relationships between unscheduled office visits and syntactical properties of convex spaces in URC6, after the key communicators were removed from the data set. When the key communicators were removed from the data set, it was identified that syntactical properties of space actually correlated with the numbers of reported unscheduled office visits. While none of the syntactical properties exhibited correlations with unscheduled office visits when key communicators were included in the data set, statistically significant correlations were found after the key communicators were removed from the data set. Bivariate analyses indicated that numbers of reported unscheduled visits in URC6 positively correlated with global integration (RRAn), local integration (RRA3), visibility (MeanISO), and negatively correlated with point depth from the maximum globally integrated space (DEPTH RRAnMAX).

These results indicated that URC6 researchers that occupied more centrally located, configurationally accessible, and visible offices had a higher chance of receiving unscheduled office visits from their colleagues. In this respect, the effects of syntactical properties of space on unscheduled office visits was confirmed, since the results paralleled those found in Category 1 and Category 2 URCs.

Coincidental Consultations in URC6. Following unscheduled office visits, the syntactical properties of URC6 convex spaces were compared to the numbers of coincidental consultations reported for each convex space. In doing so, the effects of syntactical properties of each space on the numbers of reported coincidental consultations for each space were sought. Figure 6.3.6.7 shows the behavior map of coincidental consultations in URC6 territory.
Figure 6.3.6.7. Coincidental consultations and their locations in URC6 territory.

The behavior map indicated that the majority of coincidental consultations in URC6 occurred in globally integrated and highly visible convex spaces. In addition, it was observed that most of these coincidental consultations took place on the second floor rather than the first floor. Bivariate analyses of the relationships between coincidental consultations and syntactical properties of space yielded significant correlations (Table 6.3.6.1).
Table 6.3.6.1. Bivariate analyses of the relationships between coincidental consultations and syntactical properties of convex spaces in URC6.

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAn)</td>
<td>$r^2= 0.57$, $p=0.0003$</td>
</tr>
<tr>
<td>CONNECTIVITY (CONN)</td>
<td>$r^2= 0.31$, $p=0.01$</td>
</tr>
<tr>
<td>LOCAL INTEGRATION (RRA3)</td>
<td>$r^2= 0.29$, $p=0.02$</td>
</tr>
<tr>
<td>POINT DEPTH FROM RRAnMAX (DEPTH RRAnMAX)</td>
<td>$r^2= 0.48$, $p=0.001$</td>
</tr>
<tr>
<td>MEAN DEPTH (MD)</td>
<td>$r^2= 0.36$, $p=0.008$</td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>$r^2= 0.61$, $p=0.0002$</td>
</tr>
</tbody>
</table>

Bivariate analyses indicated that statistically significant positive correlations were present between global integration (RRAn), connectivity (CONN), local integration (RRA3), and visibility (MeanISO) values of convex spaces, and numbers of reported coincidental consultations. Negative statistically significant correlations were found between point depth from the maximum globally integrated space (DEPTH RRAnMAX) and mean depth (MD) values of convex spaces and numbers of reported coincidental consultations.

It was also noted that a minimal amount of coincidental consultations had been reported in the first floor interaction space (IS), while a very high amount of coincidental consultations had been reported in the second floor journal lounge (JL). Previously, configurational analyses had indicated that the journal lounge (JL) was more globally integrated and more visible than the interaction space (IS). Therefore, syntactical properties of space were capable of providing some explanation for this phenomenon. On the other hand, further explanations of this situation were vital in order to understand which features of space induced coincidental consultations. In this respect, further discussions about the reasons for this finding will be done at the levels of semi-fixed and non-fixed feature space.

These results were parallel to those found in previously discussed URCs, and indicated that coincidental consultations were occurring in centrally located, configurationally accessible, and highly visible convex spaces. Thus, previously reached findings were repeated in the analyses of the relationships between coincidental consultations and syntactical properties of space.

**Unscheduled and Prescheduled Group Meetings in URC6.** Of the reported technical consultations in URC6, 1% were unscheduled group meetings and 5% were prescheduled group meetings (Figure 6.3.6.8). All of these consultations were reported in the conference room 217; therefore, no statistical analyses were conducted. As a centrally located and highly visible convex space neighboring the journal lounge (JL), conference room 217 was used for all group meetings, indicating that this space met all the requirements for such meetings.
Along with URC5, the amount of group meetings in URC6 was one of the highest among all URCs that participated in the study. This finding indicated that the presence of a formal conference room within the territory of a URC facilitated prescheduled group meetings.

**Prescheduled Office Visits in URC6.** Three percent of all the reported technical consultations were prescheduled office visits. No statistical analyses were conducted between prescheduled office visits and
syntactical properties of space due to the low amount of such consultations. As found in previously discussed URCs, in URC6 prescheduled office visits were related to the individual roles of researchers, rather than any spatial property of the offices in which such consultations occurred.

**Technical Consultations Through E-media (telephone calls and e-mails) in URC6.** Findings about technical consultations through e-media indicated that these technical consultations showed no relation to syntactical properties of space in URC6. However, the low amount of such consultations in URC6 (11%) confirmed the previous findings that face-to-face technical consultations were the first priority and that the amount of technical consultations through e-media were less in Category 1 and Category 3 URCs than Category 2 URCs. This result also confirmed that researchers in non-intact territory URCs (Category 2) relied more on technical consultations through e-media than their colleagues in intact territory (Category 1 and Category 3) URCs.

**The Relationships of Walking Distances to Numbers of Unprogrammed Encounters within URC6 Territory.** Statistical analyses of the relationships between numbers of technical consultations and walking distances indicated that as the walking distance between the origin and destination of unprogrammed encounters increased, the number of unprogrammed encounters decreased. There was a higher chance of being involved in unprogrammed encounters within closer walking distances for researchers in URC6 (Table 6.3.6.2).

<table>
<thead>
<tr>
<th>BIVARIATE RELATIONSHIPS</th>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>TOTAL NUMBER OF UNPROGRAMMED ENCOUNTERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>WALKING DISTANCE</td>
<td>$r^2=0.20$, $p=0.09$</td>
<td>$r^2=0.39$, $p=0.01$</td>
<td>$r^2=0.37$, $p=0.01$</td>
</tr>
</tbody>
</table>

This analysis indicated that the majority of coincidental consultations and unscheduled office visits occurred within a 25-feet distance interval in URC6. As distance intervals increased, the number of coincidental consultations and unscheduled office visits drastically decreased. This situation also caused smaller correlation coefficients between walking distances and types of unprogrammed encounters. In this analysis, it seemed that, greater distances, especially inter-floor walking distances caused lower unprogrammed encounters. In order to verify this, origins and destinations of all reported unprogrammed encounters were traced and then tabulated as inter-floor or intra-floor consultations (Chart 6.3.6.3).
This tabulation indicated that the majority (84%) of unprogrammed encounters in URC6 had originated and ended on the same floor. Fifty-four percent of these were reported to originate and end on the second floor, indicating that the second floor office core was a hub of such activity. Moreover, when the 16% inter-floor unprogrammed encounters were considered, it was noted that 15% had started on the first floor and ended on the second floor, indicating that even when there is an inter-floor trip, the direction of movement was towards the first floor.

These findings indicated that, first, as in previously discussed URCs, if there is a level difference, the majority of unprogrammed encounters originated and ended on the same floor. This showed that researchers’ tendency was to remain on the same floor rather than changing levels (i.e. running up and down the stairs). Second, it was also noted in URC6 that the second floor was a hub of unprogrammed encounters, and even when researchers were changing levels, most of the encounters started on the first floor and ended on the second floor. Third, as in all previously discussed URCs, in the case of URC6, increased walking distances hindered unprogrammed encounters among researchers.
6.3.6.3. Fixed-feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC6: Summary of Findings

Data analyses at the fixed-feature space level indicated that syntactical properties of space and walking distances significantly affected unprogrammed encounters (unscheduled office visits and coincidental consultations) in URC6.

First, as found in previously discussed URCs, it was identified that there was a higher probability of receiving unscheduled office visits in those offices that were centrally located, configurationally accessible, and highly visible. Such office spaces corresponded to globally and locally more integrated convex spaces. The same facilitating effect of configurational integration and high visibility was identified on coincidental consultations. The majority of coincidental consultations had occurred in centrally located, configurationally accessible, and highly visible office core convex spaces. These results indicated that as in previously discussed URCs, higher global integration, lower mean depth and higher visibility facilitated unprogrammed encounters in URC6 territory.

Second, it was identified that the second floor of URC6 functioned as a hub of unprogrammed encounters. The informal common space journal lounge facilitated coincidental consultations with its centrality, configurational accessibility and high visibility. On the other hand, the first floor interaction space was not as facilitative of coincidental consultations as the journal lounge. While this was partly explained by the relatively less configurational integration of this space, semi-fixed and non-fixed feature space effects will be discussed in the following section.

Third, it was identified that as walking distances increased, the numbers of unprogrammed encounters decreased in URC6 territory. As found in previously discussed URCs, within shorter walking distances, there was a higher probability of engaging in unprogrammed encounters for URC6 researchers. The level difference between two floors in URC6 further strengthened this effect. It was found that the majority of unprogrammed encounters had originated and ended on the same floor in URC6. In addition, the majority of inter-floor unprogrammed encounters had originated on the first floor, but ended on the second floor. This finding further confirmed the role of the second floor as a hub of unprogrammed encounters.

Fourth, as in Category 1 and Category 2 URCs, face-to-face technical consultations constituted the majority (89%) of all technical consultations in URC6, indicating that face-to-face technical consultations formed the main media for information exchange. In addition, the percentages of technical consultations through e-media in URC6 was less than non-intact territory Category 2 URCs, but more than intact-territory Category 1 URCs, highlighting the different effects of these separate spatial categories on technical consultations.
6.3.6.4. Semi-fixed / Non-fixed Feature Space and Patterns of Space Use for Face-to-face Technical Consultation in URC6: Environmental Qualities and Reasons for Space Use

Following analyses of the relationships between fixed-feature space and patterns of space use for technical consultations, the relationships between semi-fixed/non-fixed feature space and patterns of space use for technical consultations were analyzed. Those spaces where URC6 researchers most frequently met other researchers and most frequently visited when they left their offices were identified based on the follow-up surveys. The environmental qualities and reasons for use of these spaces cited by URC6 researchers were then tabulated and associated with convex spaces on floor plans of URC6 territory (Figure 6.3.6.9).
Figure 6.3.6.9. The relationships between semi-fixed and non-fixed feature space and technical consultations in URC6, based on the follow-up surveys. Red colored texts indicate environmental qualities, and blue colored texts indicate reasons for space use as indicated by URC6 researchers.
Content analysis of the follow-up surveys indicated that the second floor informal common space journal lounge (JL) was the space in which URC6 researchers most frequently met their colleagues. The positive environmental qualities cited for the journal lounge clearly reflected those issues that attracted researchers to use this space. The majority of URC6 researchers indicated that the journal lounge was “within easy reach”, “centrally located”, and a space where it was “easy to meet and talk to anyone”. These citations corresponded to the configurational integration of this space. In addition, the majority of researchers thought that the journal lounge was “casual, friendly, well lit and relaxed”. Therefore, the informal atmosphere of this space and its access to daylight attracted researchers, and facilitated face-to-face technical consultations in this space. Moreover, the journal lounge’s metric proximity to the kitchen (therefore food and drinks), high visibility, reading materials, and furniture that was perceived as comfortable were listed among the positive features of this space. As a result, the journal lounge facilitated face-to-face technical consultations with its configurational integration, metric proximity to many locations within the territory, informal and casual atmosphere, high visibility, and access to material conveniences. Considering the syntactical properties of this space, these results further confirmed previous findings about informal common spaces.

In the previously discussed URCs, it was found that the presence of informal commons facilitated face-to-face technical consultations. At the level of fixed-feature space, configurational integration, and metric proximity to other convex spaces were found as spatial properties that facilitated face-to-face technical consultations in informal commons. In addition, at the level of semi-fixed and non-fixed feature space, it was noted that environmental qualities such as an informal and relaxed atmosphere, access to daylight, visibility, presence of reading opportunities, and proximity to material conveniences (i.e. food/drink) were all facilitating face-to-face technical consultations in informal commons. When all of these features were considered, it became clear that the journal lounge of URC6 was an informal common space that united all these features. Therefore, the high numbers of coincidental consultations reported were due to the presence of all these facilitating factors in the journal lounge. In essence the journal lounge was a “behavioral focal point” as termed by Bechtel (1977).

An important finding noted during this analysis was about the convex space named the “interaction space (IS)”. As discussed in Section 6.1.6.2, the interaction space was intended for facilitating face-to-face technical consultations in URC6. Several design decisions about the interaction space were entirely based on this purpose, such as maximizing visibility and providing a central location. However, during the visits to URC6, it was also mentioned by the researchers that this space was literally left empty for most of the time. Data analyses based on the activity logs strongly confirmed this situation. Only four coincidental consultations, and no other types of consultations were reported in this space. In addition, a small number of URC6 researchers mentioned the interaction space as a convex space in which they frequently met their colleagues. Given the fact
that the interaction space was specifically designated for facilitating technical consultations and even named after this these results were frustrating.

The reasons for these results were partly explained at the fixed-feature space level: the interaction space was not as configurationally integrated as the journal lounge. However, it was still among those convex spaces that were relatively highly integrated. Analyses of the follow-up surveys helped explain these findings further. URC6 researchers mentioned in the follow-up surveys that the interaction space was “difficult to use” since “there was too much light for lectures”, “it was too noisy and had an amphitheater effect”, and “it was impossible to utilize in any meaningful way”. These citations indicated that although this space was intended for facilitating face-to-face technical consultations, none of its environmental qualities attracted researchers. First, it was metrically distant from the journal lounge and the kitchen. Second, the two-floor height windows made it impossible to hold group meeting in this space, especially because it was not possible to use projectors. Third, the amount of noise was distracting. Fourth, it was not proximate to any of the material conveniences (i.e. food and business equipment) that were found to be usually very attractive to researchers. This also further explained the popularity of the journal lounge, which had a direct connection to the kitchen. Therefore, a “flexible” space without any of the attractive environmental qualities did not really facilitate any face-to-face technical consultations among URC6 researchers.

The findings about the journal lounge and interaction space were informative for this study, since they both reflected very convenient examples of “do's and don'ts” when facilitating encounters among researchers is considered. In this respect, these findings strongly confirmed previous results about facilitating factors on face-to-face technical consultations among researchers.

Many of the positive environmental qualities cited for the journal lounge were also mentioned for other convex spaces in URC6. For example, the copy room was cited as a space where researchers met their colleagues, and both its proximity to other spaces and the equipment provided in this space were cited as positive environmental qualities. The entrance lobby (LOB) was positively cited for its “home-like atmosphere” and perceived comfort – two environmental qualities that were also found to be attractive for researchers in other URCs discussed. The presence of other colleagues was cited as a positive environmental quality for many convex spaces, such as the entrance lobby and the journal lounge. Finally, high visibility, as found in previously discussed URCs, was frequently cited as a positive environmental quality in URC6, usually using the phrase “openness”.

To summarize, the results indicated that metric proximity to other spaces, configurational integration, higher visibility, perceived environmental comfort, awareness of the presence of other colleagues, an informal, friendly, “home-like” atmosphere, access to daylight, proximity to material conveniences such as food and drinks, and
proximity to business tools were all factors that attracted researchers. In this respect, those convex spaces that featured these environmental qualities and reasons for use attracted more researchers and facilitated more face-to-face technical consultations. These findings are summarized as a list of “best predictors of space use for face-to-face technical consultation” in Table 6.3.6.3.

Table 6.3.6.3. Best predictors of space use for face-to-face technical consultation based on the results of the follow-up survey conducted in URC6. Examples of URC6 researchers’ nomenclature are presented in parentheses.

<table>
<thead>
<tr>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td></td>
</tr>
<tr>
<td>Configurational integration (i.e. “centrally located”)</td>
<td>Material conveniences (i.e. “access to food / drink”)</td>
</tr>
<tr>
<td>Metric proximity to other convex spaces (i.e. “within easy reach”)</td>
<td>Access to business tools (i.e. “to use copier, to check mail”)</td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>Increased visibility (i.e. “openness”)</td>
<td>Concentrated work (i.e. “to read”)</td>
</tr>
<tr>
<td>Furnishings (i.e. “tables/chairs”)</td>
<td>To see other resarchers (i.e. “to meet colleagues”)</td>
</tr>
<tr>
<td>Access to daylight (i.e. “well-lit, bright”)</td>
<td></td>
</tr>
<tr>
<td>Multifunctionality (i.e. “access to articles and journals”)</td>
<td></td>
</tr>
<tr>
<td>Network access (i.e. “no Ethernet hookups”)</td>
<td></td>
</tr>
<tr>
<td><strong>Non-fixed feature space</strong></td>
<td></td>
</tr>
<tr>
<td>Perception of an informal environment (i.e. “very relaxed and friendly”)</td>
<td></td>
</tr>
<tr>
<td>Awareness of the presence of other colleagues (i.e. “easy to meet and talk to anyone”)</td>
<td></td>
</tr>
<tr>
<td>Feeling of possession (i.e. “home-like, it’s home”)</td>
<td></td>
</tr>
</tbody>
</table>

6.3.6.5. Summary: The Effects of Space on Patterns of Space Use for Face-to-face Technical Consultations in URC6

A summary of findings of the relationships between fixed-feature space and technical consultations in URC5 is shown in Table 6.3.6.4.
Data analysis in the case of URC6 confirmed the effects of fixed-feature, semi-fixed feature, and non-fixed feature space on technical consultations among researchers.

First, it was found that face-to-face technical consultations were preferred significantly more than consultations through e-media. Therefore, face-to-face technical consultations formed the main medium for information exchange in URC6, as found in all the previously discussed URCs.

Findings of the study in URC6 indicated that at the fixed-feature space level, spatial configuration, and walking distances significantly affected the number and locations of unprogrammed encounters (unscheduled office visits and coincidental consultations). The results showed that higher global integration, higher local integration, higher visibility, and lower point depth from the maximum globally integrated space increased chances of unscheduled office visits. Higher levels of global integration, local integration, connectivity, visibility, and lower levels of point depth from the maximum globally integrated space and lower mean depth increased chances of coincidental consultations. These results indicated that there was a higher chance of engaging in unprogrammed encounters for URC6 researchers in centrally located, configurationally accessible, and highly visible convex spaces.

Data analysis in the case of URC6 also confirmed the effects of distance on unprogrammed encounters. As walking distances increased between two locations, the number of unprogrammed encounters between researchers in two such locations decreased. In addition, findings about the effects of level differences in
previously discussed Category 2 URCs were confirmed in URC6. The majority of unprogrammed encounters in URC6 originated and ended on the same floor, indicating that level differences in URC territories hindered unprogrammed encounters even when the territory is intact.

Findings about informal common spaces in URC6 were very informative. The information about URC6’s two informal common spaces confirmed all the previous findings about informal common spaces in previously discussed URCs. The presence of informal common spaces facilitated face-to-face technical consultations in URC6. In addition, the journal lounge of URC6 indicated the formation of a behavioral focal point, and the factors effective on such a formation paralleled all the previous findings about how fixed-feature, semi-fixed feature and non-fixed feature space facilitate face-to-face technical consultations. In general, configurational integration, metric proximity, high visibility, access to business tools and material conveniences, an informal and friendly atmosphere, perceived environmental comfort, and awareness of the presence of other researchers were the factors that facilitated face-to-face technical consultations in the journal lounge of URC6.

As a result, results of URC6 as a case study supported previous findings about the effects of space on face-to-face technical consultations. In addition, this individual case study also further illuminated the differences between Category 1, Category 2 and Category 3 URCs. In the following chapter, findings from all six URCs discussed in this section will be summarized, and matching patterns as well as differences among the URCs in three predefined categories will be presented.
CHAPTER 7

PATTERNS OF FINDINGS ACROSS INDIVIDUAL CASES

Six university research centers across three spatial categories were studied as individual cases. Fixed-feature, semi-fixed feature, and non-fixed feature elements that formed patterns of relationships to types of technical consultation were identified. In this respect, “best predictors of space use for face-to-face technical consultation” were formed by building interconnected explanations about how fixed-feature, semi-fixed feature, and non-fixed feature elements of space facilitated or hindered technical consultations among researchers across the six participating URCs.

This section discusses these findings repeating across individual cases. First, the priority of different types of information resources for researchers in these six URCs will be discussed in order to place the findings about space – technical consultation relationships into perspective. Second, those syntactical properties of space that repeatedly yielded significant relationships with certain types of technical consultations will be discussed, and the extent to which these syntactical properties of space addressed similar or different issues will be identified. Third, how each of the predefined technical consultations consistently exhibited relationships to certain spatial properties will be discussed. In doing so, those spatial properties that repeatedly related to a technical consultation type will be discussed together, rather than being classified into fixed, semi-fixed, and non-fixed feature space.

7.1. PRIORITY OF INFORMATION RESOURCES FOR RESEARCHERS ACROSS SIX URCS

It was indicated in the previous section that, out of the 1763 technical consultations reported by 85 researchers from six URCs, 88% were face-to-face technical consultations, and 12% were technical consultations through e-media. This cumulative data indicates the importance of face-to-face technical consultations as an information resource for researchers.

Individual case study reports indicated that face-to-face technical consultations constituted a high percentage of the total number of technical consultations reported across six URCs. Regardless of which spatial category they were in, face-to-face technical consultations formed the main media of information exchange in all six URCs. The minimum percentage of face-to-face technical consultations was reported in URC3 (83%), and the maximum percentage was reported in URC2 (95%). These results indicate that face-to-face technical consultations were a major information resource for researchers in the six URCs.
While high percentages of face-to-face technical consultations were informative, how researchers prioritized different types of information resources was another important issue. Evidently, high numbers of usage of a certain information resource (i.e. engaging in a face-to-face technical consultation) did not guarantee that it was the most important information resource for a researcher. Consequently, researchers in the six URCs were asked in the follow-up surveys to prioritize the importance of different information resources.

Researchers in the six URCs were provided with eight choices of information resources to prioritize: literature (books, professional and trade journals, and other publicly accessible written material), vendors (representatives of, or documentation generated by, suppliers or potential suppliers of equipment / design components), customers (representatives of, or documentation generated by, the agency / institution / firm for which the project is performed), external sources (sources outside the research center that do not fall into any of the above categories), previous research conducted in the URC under consideration (any other project performed previously in the research center), personal experience (ideas that you used previously and were recalled directly from memory), and experimentation (ideas that are the result of tests or experiments with no immediate input of information from any other source). In addition, they were also offered an “other” choice in order to identify any other important information resources.

The mean degree of priority was calculated for each of the information resources within each URC. Findings indicated that face-to-face technical consultation was selected as the first priority information resource in all six URCs. Literature was selected as the second priority, and personal experience was selected as the third priority information resource. The remaining information resources had a lower priority. In the “other” section, internet search was frequently cited, but was rated as the last priority information resource.

These results clearly indicated that face-to-face technical consultations formed the most important information resource for researchers across six URCs, followed by literature search and personal experience. When researchers recognized a lack of knowledge, their first choice was to engage in face-to-face technical consultations with their colleagues, second choice was to search the existing literature, and third choice was to rely on their personal experience. The finding that 88% of all reported technical consultations in URCs were face-to-face technical consultations was accurate, since it corresponded with the researchers’ priorities. These findings were important for this study at three points. First, face-to-face technical consultations were the most reported, and highest priority rated information resources. Second, individual case study reports indicated that certain features of space showed significant and consistent relationships to face-to-face technical consultations. Third, it was evident that identification of those spatial features that facilitated face-to-face technical
consultations would help design decisions that facilitate not only face-to-face technical consultations, but also overall information consumption in URCs, which is ultimately a facilitator of innovation.

7.2. SYNTACTICAL PROPERTIES OF SPACE AND PATTERNS OF RELATIONSHIPS

Throughout the cumulative data analyses as well as the individual case study reports, it was identified that most syntactical properties of space exhibited significant relationships to coincidental consultation and unscheduled office visits. Therefore, it was identified that syntactical properties of space mainly related to unprogrammed encounters rather than programmed encounters.

Eight syntactical properties of space were considered during cumulative data analyses and individual case studies. These were global integration (RRAn), connectivity (CONN), control value (CV), local integration (RRA3), point depth from the maximum globally integrated space (DEPTH RRAnMAX), mean depth (MD), intelligibility (I) and visibility (MeanISO). Each of these syntactical properties was calculated for each convex space in all six URCs. Consequently, the correlation matrices discussed in each individual case study included a high number of variables: eight syntactical properties of space on one axis, and seven types of technical consultations on the other axis.

The results of these matrices indicated that a high number of syntactical properties related to unscheduled office visits and coincidental consultations. One of the concerns at this point was the extent to which these syntactical properties addressed similar or different issues. The similarity between two variables is measured by the strength of the correlation between the two, and is termed “multicollinearity”. If there were certain levels of multicollinearity between a number of these syntactical properties, they might have been measuring similar properties. Therefore, by omitting those syntactical properties exhibiting high levels of multicollinearity with others, the results could be conveyed in a simpler but much more effective manner.

A multivariate analysis of syntactical properties of space was conducted in order to see the extent to which these syntactical properties addressed similar or different issues. A data table combining all the syntactical properties of each convex space across all URCs was prepared, where each single convex space was attributed eight syntactical properties. The extent to which these syntactical properties of space measured the same phenomena was analyzed using multivariate analysis.

The results of this multivariate analysis indicated that control value and connectivity exhibited a high level of multicollinearity (r=0.9720). Similarly, intelligibility and connectivity (r=0.9114), global integration and local integration (r=0.7194), mean depth and point depth from the maximum globally integrated space (r=0.6234) exhibited high levels of multicollinearity. These results indicated that these pairs of syntactical properties
measured similar phenomena. For example, with their high level of multicollinearity, control value and connectivity measured very similar properties. Therefore, those syntactical properties of space that did not show multicollinearity among themselves were selected as better predicting syntactical properties. In this respect, four syntactical properties that best measured spatial configuration of URCs were identified as:

1. GLOBAL INTEGRATION (RRAn)
2. CONTROL VALUE (CV)
3. POINT DEPTH FROM THE MAXIMUM GLOBALLY INTEGRATED CONVEX SPACE (DEPTH RRAnMAX)
4. VISIBILITY (MeanISO)

These syntactical properties of space exhibited minimum multicollinearity among themselves, but exhibited high multicollinearity with those syntactical properties that were not selected. In this respect, these four selected syntactical properties of space accurately covered the span of all configurational properties of space in URCs. Global integration (RRAn) was measuring the relationship of a convex space to all others in a system, which was a measure of configurational accessibility compared to all other convex spaces in a system. Therefore, it was a global measure. Control value (CV) was a local measure, capable of measuring the relationship of a space with its immediate neighbors based on the number of available connections. Point depth from the maximum globally integrated space (DepthRRAnMAX) measured how segregated a space was from the integration core of a system. Visibility measured the amount of area that was possible to see and be seen from a certain convex space. Therefore, the repeating patterns of relationships between syntactical properties of space and face-to-face technical consultations will be discussed using these syntactical properties rather than the set of eight variables.

### 7.3. BEST PREDICTORS OF FACE-TO-FACE TECHNICAL CONSULTATIONS IN UNIVERSITY RESEARCH CENTERS

In the literature review, it was found that information was the most important and facilitating resource for innovation (i.e. Kanter, 1988; Sonnenwald and Lievrouw, 1996, among others). Previous literature indicated that among numerous information resources, face-to-face technical consultations formed a major resource for innovation. The findings of this study up to this point confirmed the reviewed literature (i.e. Allen, 1984; Sonnenwald, 1999). Researchers that participated in the study in all URCs mentioned that face-to-face technical consultations formed the most important information resource for them. Then, according to the purpose and
research questions of this study, an important point was to identify those spatial features that facilitated face-to-face technical consultations in URCs. This section will discuss best predictors of face-to-face technical consultation according to types of technical consultations.

7.3.1. The Effects of Space on Unscheduled Office Visits across Six URCs

The relationships of spatial properties to unscheduled office visits were analyzed by examining fixed-feature, semi-fixed feature, and non-fixed feature space. Initially, syntactical properties of space were considered. Based on the activity log data, it was noted that three syntactical properties of space and walking distances consistently exhibited relationships to unscheduled office visits in all URCs (Table 7.3.1).

Table 7.3.1. Relationships between syntactical properties of space and unscheduled office visits across the six URCs that participated in the study. (*) indicates a negative correlation.

<table>
<thead>
<tr>
<th>UNSCHEDULED OFFICE VISITS</th>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>URC1</td>
<td>URC2</td>
<td>URC3</td>
<td>URC4</td>
</tr>
</tbody>
</table>
| GLOBAL INTEGRATION (RRAn) | $r^2=0.49$  
$p=0.0002$  | $r^2=0.52$  
$p=0.005$  | $r^2=0.54$  
$p<0.0001$  | $r^2=0.28$  
$p=0.0031$  | $r^2=0.53$  
$p=0.0006$  | $r^2=0.42$  
$p=0.01$  |
| POINT DEPTH FROM MAXIMUM GLOBALLY INTEGRATED SPACE (DEPTH RRAnMAX) | $r^2=0.43$ (*)  
$p=0.0007$  | $r^2=0.33$ (*)  
$p=0.02$  | $r^2=0.14$ (*)  
$p=0.03$  | $r^2=0.12$ (*)  
$p=0.07$  | $r^2=0.56$ (*)  
$p=0.0004$  | $r^2=0.29$ (*)  
$p=0.04$  |
| VISIBILITY (MeanISO)     | $r^2=0.32$  
$p=0.074$  | $r^2=0.71$  
$p=0.0001$  | $r^2=0.46$  
$p<0.0001$  | $r^2=0.27$  
$p=0.0034$  | $r^2=0.34$  
$p=0.01$  | $r^2=0.28$  
$p=0.06$  |
| WALKING DISTANCE         | $r^2=0.68$ (*)  
$p=0.0017$  | $r^2=0.55$ (*)  
$p=0.0087$  | $r^2=0.23$ (*)  
$p=0.0038$  | $r^2=0.23$ (*)  
$p=0.006$  | $r^2=0.54$ (*)  
$p=0.0044$  | $r^2=0.39$ (*)  
$p=0.01$  |

These patterns showed that researchers occupying offices with the following properties had a higher chance of receiving unscheduled office visits. First, it was noted that researchers occupying more globally integrated offices had a higher chance of receiving unscheduled office visits. This relationship was confirmed both by statistical analysis and by behavior maps. The integration cores of all six URCs were more centrally located, and had access to a high number of spaces. Consequently, it was possible to see a higher number of moving people on integration cores. In non-intact territory URCs, the same effect was noted on the integration cores of within territorial sectors on each floor. Thus, in all URCs, it was noted that more unscheduled office visits were reported in offices that had a direct connection to the integration core of the system, and were therefore globally highly
integrated. This pattern of relationship in all six URCs indicated that the more configurationally accessible an individual researcher’s office is, the higher chance she/he had to receive an unscheduled office visit.

Second, it was identified that as an office became deeper from the maximum globally integrated space, the number of reported unscheduled office visits dropped. This finding actually supported the effect of global integration. From an office space, as the number of steps to reach the maximum globally integrated space increased, researchers on the maximum globally integrated space had to pass through more spaces to reach the office. This indicated that such an office was configurationally less accessible, and there was a smaller possibility of receiving unscheduled office visits in such offices. Both behavior maps and statistical analysis confirmed this relationship in all URCs. Therefore, it was identified that as one’s office becomes less accessible from the maximum globally integrated space of a system, the probability of receiving unscheduled office visits decreases.

Third, it was identified in all URCs that more unscheduled office visits were reported in more visible offices. Previous literature review had indicated that direct eye contact increased chances of encounters among people (Backhouse and Drew, 1992). The finding in this study supported this, showing that as the visibility of an office increases, the possibility of receiving unscheduled office visits increases.

Fourth, the results of the study showed that in all URCs, walking distances had a negative effect on the number of unscheduled office visits. As the walking distance between two researchers increased, the number of unscheduled office visits they made to each other decreased. This indicated that researchers’ tendency was to remain within a certain walking distance when they left the spaces they occupied. The effects of walking distances were much stronger in non-intact territory URCs. In category 2 URCs, where not only horizontal distances, but also changing floors was usually an issue to reach people, it was identified that researchers on different floors rarely made unscheduled office visits. In two Category 2 URCs, 63% to 81% of all unscheduled office visits started and ended on the same floor. These findings point out that, as walking distances increase, the possibilities of unscheduled office visits decrease.

An important issue about unscheduled office visits was the roles of individual researchers. Although such office visits were “unscheduled”, they could still be specifically related to an individual because of his/her role in a URC. Therefore, the found space - unscheduled office visit relationships could be affected by individual roles rather than spatial properties. In order to confirm this, a social network analysis was conducted in all URCs. Key communicators were identified if any existed, and tests were repeated without key communicators in the analyses. In doing so, the effects of key communicators’ individual roles were neutralized, and internal validity of the study maintained.
Researchers also cited a number of semi-fixed and non-fixed feature issues in URCs that could have an effect on unscheduled office visits. The most frequently cited issues were the spaciousness, access to daylight, and access to outside view. While these frequent citations indicated researcher’s likes and dislikes about individual offices, no relationship was found between such citations and the amount of reported unscheduled office visits.

To conclude, unscheduled office visits in all six URCs were mainly affected by fixed-feature space. Those offices that were highly integrated, closer to maximum integration convex spaces, and highly visible have higher chances of receiving unscheduled office visits. In addition, repeating patterns of relationships indicated that as walking distances between origins and destinations increased, the numbers of reported unscheduled office visits decreased. Then, higher global integration, lower point depth from maximum integration convex spaces, higher visibility and lower walking distances facilitate unscheduled office visits among researchers in university research centers.

7.3.1.1. Multivariate Analysis and Aggregated Effects of Syntactical Properties of Space on Unscheduled Office Visits

Upon identification of the best predictors of unscheduled office visits, a multivariate analysis of the relationships between syntactical properties of space and unscheduled office visits was conducted, by preparing an aggregated data table, combining all data points from all six URCs. The main objective of this analysis was to understand the relative effects of the selected syntactical properties of space. Those syntactical properties of space that showed patterns of relationships to unscheduled office visits in all six URCs (global integration – RRAn, point depth from maximum integration convex spaces – DepthRRAnMAX, visibility – Mean ISO) were defined as factors (predictors), and numbers of unscheduled office visits per researcher was defined as the predicted. The findings of this analysis were as follows.

Initially, the analysis was conducted without considering the effects of key communicators. In this analysis, the multivariate model indicated that these syntactical properties of space had a combined effect with a correlation coefficient of $r^2 = 0.26$, $p < 0.0001$ on the numbers of unscheduled office visits, aggregated from each URC. This analysis also showed that global integration (RRAn) had the largest contribution to this effect, with a scaled estimate (standardized beta weight) of 1.22, and $p$-value smaller than 0.0001. The second largest contribution to this overall effect was by visibility (MeanISO), with a scaled estimate (standardized beta weight) of 0.33, and $p$-value of 0.02. The smallest contribution, on the other hand, was by point depth from maximum integration convex spaces (DepthRRAnMAX), with a scaled estimate (standardized beta weight) of negative 0.31, and $p$-value of 0.08.
In addition to the patterns found in Section 7.3.1, these results indicated that the relative effect of these syntactical properties differed from each other at an aggregate level. Accordingly, the largest contribution to an overall effect on unscheduled office visits was provided by higher global integration (RRAn), followed by higher visibility (MeanISO) and lower point depth from maximum integration convex spaces (DepthRRAnMAX). Therefore, these findings showed that a combination of these factors (with global integration’s largest contribution) significantly predicted the number of unscheduled office visits: researchers in globally integrated, highly visible offices which were shallow from the maximum globally integrated space received more unscheduled office visits from their colleagues.

These effects were even stronger when the roles of key communicators were taken into account. The identical analysis was repeated by removing the key communicators from the data set, in order to focus on the effects of spatial configuration. This analysis yielded an even higher combined effect by syntactical properties of space, with a correlation coefficient of \( r^2 = 0.56, p < 0.0001 \). The significance of the individual contributions of syntactical properties also increased. Higher global integration (RRAn) had the largest contribution to this effect, with a scaled estimate (standardized beta weight) of 0.95, and p-value smaller than 0.0001. The second largest contribution to this overall effect was by high visibility (MeanISO), with a scaled estimate (standardized beta weight) of 0.55, and p-value smaller than 0.0001. The smallest contribution, on the other hand, was by lower point depth from maximum integration convex spaces (DepthRRAnMAX), with a scaled estimate (standardized beta weight) of negative 0.098, and p-value of 0.09.

While these results were parallel to those found before removing key communicators from the data set, they also showed that this pattern of effects were still observable after removing the key communicators from the data set, with a higher overall contribution. As a result, both existing patterns in all URCs, and aggregated multivariate analysis showed the effects of syntactical properties of space on unscheduled office visits. While higher global integration provided the largest contribution to facilitating unscheduled office visits, visibility and point depth from the maximum globally integrated space provided smaller contributions. The conclusion was that, higher global integration, higher visibility and lower point depth from the maximum globally integrated space facilitated unscheduled office visits in university research centers.

7.3.2. The Effects of Space on Coincidental Consultations across Six URCs

Coincidental consultations were the type of face-to-face technical consultations to which all features of space exhibited maximum relationships. The relationships of space to coincidental consultations were analyzed by examining fixed-feature, semi-fixed feature, and non-fixed feature space. Initially, syntactical properties of space
were considered. Based on the activity log data, it was noted that three syntactical properties of space and walking distances consistently exhibited relationships to coincidental consultations in all six URCs (Table 7.3.2).

<table>
<thead>
<tr>
<th>COINCIDENTAL CONSULTATIONS</th>
<th>CATEGORY 1 URCs</th>
<th>CATEGORY 2 URCs</th>
<th>CATEGORY 3 URCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>GLOBAL INTEGRATION (RRAₙ)</td>
<td>r²=0.49 p=0.0002</td>
<td>r²=0.54 p=0.0002</td>
<td>r²=0.40 p=0.0007</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CONTROL VALUE (CV)</td>
<td>r²=0.49 p=0.0002</td>
<td>r²=0.67 p&lt;0.0001</td>
<td>r²=0.65 p&lt;0.0001</td>
</tr>
<tr>
<td></td>
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</tr>
<tr>
<td>POINT DEPTH FROM MAXIMUM GLOBALLY INTEGRATED SPACE (DEPTH RRANMAX)</td>
<td>r²=0.41 (*) p&lt;0.0001</td>
<td>r²=0.21 (*) p=0.0072</td>
<td>r²=0.16 (*) p=0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VISIBILITY (MeanISO)</td>
<td>r²=0.54 p=0.0002</td>
<td>r²=0.56 p=0.0004</td>
<td>r²=0.27 p=0.0092</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WALKING DISTANCE</td>
<td>r²=0.36 (*) p=0.04</td>
<td>r²=0.90 (*) p&lt;0.0001</td>
<td>r²=0.23 (*) p=0.006</td>
</tr>
</tbody>
</table>

These patterns showed that convex spaces with the following properties facilitated coincidental consultations more than others. Researchers in all URCs reported coincidental consultations in configurationally more integrated, more visible convex spaces within shorter walking distances. Since coincidental consultations are the type of face-to-face technical consultations least affected by factors other than space, the responses of researchers were informative in understanding which features of space facilitated them.

In a similar finding with unscheduled office visits, a positive significant relationship was found between global integration of convex spaces and coincidental consultations in all six URCs. In addition, the correlations found between coincidental consultations and global integration were stronger than the correlations found between unscheduled office visits and global integration. Global integration mainly measured the configurational accessibility of a convex space with respect to all other spaces in the system. In this respect, coincidental consultations were mostly reported in central spaces in all URCs. In category 2 URCs, where the territory was separated into several sectors, globally integrated spaces within the territory were mostly reported as locations of coincidental consultations. Therefore, in all URCs, the more globally integrated a space was, the more coincidental consultations occurred there.
The results in all URCs indicated that control values of convex spaces exhibited a positive significant relationship to numbers of reported coincidental consultations. The higher the control value of a convex space, the more the reported coincidental consultations were in all URCs. The control value of a convex space measures the level of permeability from its neighbors. The more immediate neighbors a convex space has, the more it is controlled by its neighbors. Consequently, in all six URCs, those convex spaces connected to a higher number of other convex spaces had higher control values. Consequently, a higher control value facilitated coincidental consultations. For example, many centrally located office core convex spaces in URCs had higher control values, since many other convex spaces were connected to them (i.e. office core of URC3). Therefore, convex spaces with higher control values facilitate coincidental consultations among researchers in URCs.

It was identified that in all URCs, point depth from the maximum globally integrated space negatively correlated with the number of coincidental consultations. As a convex space gets deeper from the maximum globally integrated space of a system, its configurational accessibility decreases. Therefore, that convex space becomes more segregated from the rest of the system. In the case of the six URCs in this study, this syntactical property hindered coincidental consultations. Convex spaces deeper from the maximum globally integrated space were not frequently reported as locations of coincidental consultations. On the other hand, those convex spaces that are shallow from (i.e. directly connected to) the maximum globally integrated space were most frequently reported as locations of coincidental consultations. In this respect, the higher point depth a convex space had from the maximum globally integrated space of a system, the smaller possibility there was for a coincidental consultation to happen in that convex space.

In all URCs, it was found that more coincidental consultations were reported in highly visible convex spaces. In highly visible convex spaces, there was a higher possibility of eye contact and the initiation of a conversation between individuals. Consequently, researchers in all six URCs reported that they engaged in coincidental consultations in high visibility convex spaces. Particularly in the central convex spaces of office cores, higher visibility was measured across the six URCs. Therefore, such areas formed an effective example for high visibility – coincidental consultation relationship. Furthermore, when high visibility convex spaces overlapped with high global integration values, very high numbers of coincidental consultations were reported. Therefore, higher visibility in URC convex spaces facilitated coincidental consultations.

A negative relationship was identified between walking distances and the number of reported coincidental consultations. In all URCs, the walking distance between the origins and destinations of all coincidental consultations were measured, revealing that the majority of coincidental consultations occurred within a walking distance of fifty feet. This was associated with the researchers’ tendency to remain within a short walking
distance when they left the spaces they occupied. Moreover, this effect was further strengthened when the territory of a URC was divided into several sectors on separate floors. Therefore, the results of the study indicated that longer walking distances decreased the possibility of coincidental consultations among researchers in URCs.

These findings indicated that syntactical properties of space and walking distances affected coincidental consultations. However, there were other factors that also affected coincidental consultations in the six URCs. These factors were most frequently related to the informal common spaces in URC territories. A number of informal commons were present in the URCs studied. Some of these were within URC territories, while others were shared with other organizations.

7.3.2.1. Multivariate Analysis and Aggregated Effects of Syntactical Properties of Space on Coincidental Consultations

Upon identification of the best predictors of coincidental consultations, a multivariate analysis of the relationships between syntactical properties of space and coincidental consultations was conducted, by preparing an aggregated data table, combining all data points from all six URCs. The main objective of this analysis was to understand the relative effects of the selected syntactical properties of space. Those syntactical properties of space that showed patterns of relationships to coincidental consultations in all six URCs (global integration – RRAn, control value – CV, point depth from maximum integration convex spaces – DepthRRAnMAX, visibility – Mean ISO) were defined as factors (predictors), and numbers of coincidental consultations per researcher was defined as the predicted. The findings of this analysis were as follows.

The multivariate model indicated that these syntactical properties of space had a combined effect with a correlation coefficient of $r^2 = 0.58$, $p < 0.0001$ on the numbers of coincidental consultations, aggregated from each URC. This analysis also showed that global integration (RRAn) had the largest contribution to this effect, with a scaled estimate (standardized beta weight) of 0.32, and $p$-value of 0.0024. The second largest contribution to this overall effect was by visibility (MeanISO), with a scaled estimate (standardized beta weight) of 0.25, and $p$-value of 0.0002. The third largest contribution to this overall effect was by control value (CV), with a scaled estimate (standardized beta weight) of 0.22, and $p$-value of 0.0083. The smallest contribution, on the other hand, was by point depth from maximum integration convex spaces (DepthRRAnMAX), with a scaled estimate (standardized beta weight) of negative 0.01, and $p$-value of 0.07.

In addition to the patterns found in Section 7.3.2, these results indicated that the relative effect of these syntactical properties differed from each other at an aggregate level. Accordingly, the largest contribution to an
overall effect on coincidental consultations was provided by higher global integration (RRAn), followed by higher visibility (MeanISO), higher control value (CV), and lower point depth from maximum globally integrated convex spaces (DepthRRAnMAX). Therefore, these findings showed that a combination of these factors (with global integration’s largest contribution) significantly predicted the number of coincidental consultations: those convex spaces which were globally integrated, highly visible, had a high control value and had a low point depth from the maximum globally integrated space facilitated coincidental consultations.

As a result, both existing patterns in all URCs, and aggregated multivariate analysis showed the effects of syntactical properties of space on coincidental consultations. While higher global integration provided the largest contribution to facilitating coincidental consultations, high visibility, high control value and low point depth from the maximum globally integrated space provided smaller contributions. The conclusion was that, higher global integration, higher visibility, higher control value and lower point depth from the maximum globally integrated space facilitated coincidental consultations in university research centers.

7.3.2.2. Informal Common Spaces and Their Effects on Coincidental Consultations

Those informal common spaces within URC territories were found to facilitate coincidental consultations. URC1 and URC6 had informal common spaces located within their territory. The remaining URCs had access to informal commons, however, these spaces were open to other organizations’ use, and were not exclusively within their territory. Informal common spaces were usually characterized by relaxing furniture, conveniences such as food / drink facilities, reading materials, and rarely a semi-formal meeting-oriented table. Those informal common spaces that remained within a URC’s territory (i.e. URC1’s family room, URC6’s journal lounge) were usually “customized” by the researchers according to their needs. However, those informal common spaces that were not exclusively within a URC territory (i.e. second floor lobby L02 in Building 1, second floor lounge U206 in Building 2) did not carry any other items than provided by the management of the building.

A noteworthy example of informal common spaces within a territory was URC1’s family room. Equipped with comfortable furniture, professional periodicals, a kitchen, coffee machines, and a whiteboard, the family room was reported as the location of many coincidental consultations in the activity logs (Figure 7.3.1). Moreover, the family room was not located in a configurationally integrated convex space. However, URC1 researches mentioned in the follow-up surveys that the informal environment, and material conveniences such as the coffee machine attracted them to the family room. Furthermore, URC1 researchers indicated that it would have been better if the family room were in a configurationally integrated location, mentioning, “they could have been a more cohesive group in that case”.

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Another example of informal commons within a territory was URC6’s journal lounge. Similar to the family room of URC1, URC6’s journal lounge was equipped with relaxing furniture, professional periodicals, a kitchen, and coffee machines. However, the journal lounge was on the integration core of the URC6 system, and also had one of the highest visibility values. In addition, URC6 researchers indicated that the “central location”, “casual environment”, “open”, “relaxed, friendly”, “well-lit”, “comfortable” environment of the journal lounge was very attractive to them. The kitchen and periodicals were also frequently cited as positive qualities of this space. Consequently, a very high number of coincidental consultations were reported in the journal lounge, which was relatively higher than URC1’s family room (Figure 7.3.2).

Figure 7.3.1. The informal common space of URC1, the “family room”. Top right: signs of coincidental consultations on the whiteboard. Bottom left: the kitchen directly connected to the family room was providing material conveniences that made the family room more attractive to URC1 researchers.
Other informal commons that were not as successful in facilitating coincidental consultations as the journal room or the family room were also noteworthy examples for learning from past experiences. The second floor lobby L02 of Building 2 (shared by URC2, URC3 and URC5) was a case in point (Figure 7.3.3). This informal common was originally intended for facilitating face-to-face technical consultations among researchers. However, because it was shared by more than one organization, it was outside the territory of all organizations that shared it. Despite its integrated location, and the vending machines and other equipment provided in this space, it was rarely used. Many URC3 and URC5 researchers indicated that this space was “cold”, “far removed”, “not homey”, “uncomfortable”. Consequently, a very low number of coincidental consultations were reported in this space. In fact, only three coincidental consultations were reported here by URC3 researchers who did not have a kitchen within their territory, and thus had to use this space.
Figure 7.3.3. The second floor lobby L02 of Building 2 (shared by URC2, URC3 and URC5), which was cited as a cold, uncomfortable space.

A similar example was URC6’s “interaction space” (Figure 7.3.4), which was intended for facilitating all types of face-to-face technical consultations in URC6. This space was located on an integrated axis, and within URC6 territory. However, no material conveniences were provided in this space. In addition, the journal lounge on the upper floor created a more attractive alternative to the interaction space with its features. URC6 researchers indicated that it was “impossible to use in any meaningful way”. For group meetings, “too much light was making it impossible to use projectors”. For concentrated work, it was “too noisy”. Finally, they had to “go upstairs to the journal lounge to get a coffee”. As a result, a very low number of coincidental consultations were reported in this space.

Figure 7.3.4. URC6’s “interaction space”.


The last two examples of such informal convex spaces were URC4’s first floor lounge 114 and the second floor lounge U206 (Figure 7.3.5). The first floor lounge was intended mainly for facilitating coincidental consultations, according to URC4 director. Business equipment and material conveniences such as a kitchenette were also located in this space. However, the space was configurationally very segregated, it was located outside URC4 territory, and lacked any amenities: furnishing was not relaxed and comfortable, and no reading material was provided. The space was mainly used for one to two minute visits to check the mailbox. Consequently, a very low number of coincidental consultations were reported in this space. The second floor lounge, on the other hand, was configurationally integrated and comfortably furnished, but located outside URC4 territory, without any material conveniences. No coincidental consultations were reported by URC4 researchers in this space.

As a result, informal common spaces provided a great source for facilitating coincidental consultations. Findings of the study indicated that informal common spaces did facilitate coincidental consultations when they were within the territory of a URC, providing a casual, relaxed, and friendly atmosphere, equipped with material conveniences, located on the global integration core of the URC’s system, and highly visible. However, when informal common spaces lacked one or two of these features, they were either entirely unoccupied, or a very small number of face-to-face technical consultations took place within them.

In addition to informal common spaces, in some cases, spaces designated for business equipment facilitated coincidental consultations, such as URC6’s copy room (Figure 7.3.6). As a small convex space, the copy room was equipped with a copier, a fax machine, and printers. It was directly connected to highly integrated corridor. Since this equipment was used frequently, locating them on an integrated axis increased the probability of
coincidental consultations. Consequently, a high number of coincidental consultations were reported in the copy room. Those spaces equipped with business equipment in other URCs were also usually cited for frequent visits.

Another semi-fixed and non-fixed space feature that attracted researchers was identified as the awareness of the presence of other researchers. In all six URCs, the majority of researchers indicated that they visited a convex space either because they knew they would see their colleagues, or because they were satisfied with the presence of many researchers around. At the non-fixed feature level, this finding indicated that awareness of the presence of their colleagues had a facilitative effect on coincidental consultations. Moreover, when informal common spaces are considered, this finding indicates that as the number of people using an informal common space increases, its possibility of attracting more researchers also increases.

As a result, the following conclusions are drawn as the effects of space on coincidental consultations:

1. The factors that facilitated coincidental consultations at the fixed feature space level were higher global integration, smaller point depth from the maximum globally integrated space, higher control value, higher visibility, and shorter walking distances.
2. Those informal commons that are within URC territories, which are also located on a globally integrated convex space, highly visible, equipped with material conveniences, comfortably furnished, and which have an informal, relaxed atmosphere, facilitated coincidental consultations.

3. Since business equipment and material conveniences attracted researchers, their location on highly globally integrated and highly visible convex spaces facilitated coincidental consultations. The location of such equipment in informal common spaces further facilitated coincidental consultations as an added attraction to the informal commons.

4. At the non-fixed feature space level, awareness of the presence of other researchers was a facilitative factor for researchers to visit spaces such as informal common spaces, and therefore engage in coincidental consultations.

7.3.3. The Effects of Space on Prescheduled Office Visits across Six URCs

A small percentage of prescheduled office visits were reported in all six URCs. However, no relationships between space and prescheduled office visits were found in any of the URCs. In those URCs with key communicators, the majority of prescheduled office visits had taken place in key communicators' offices. In other URCs, prescheduled office visits were not related to any social or spatial factors. The findings therefore indicated that prescheduled office visits were directed towards individual researchers. The role of individual researchers was the main influence on prescheduled office visits, rather than any spatial properties of the office they occupied.

7.3.4. The Effects of Space on Prescheduled and Unscheduled Group Meetings across Six URCs

Prescheduled and unscheduled group meetings formed a small percentage of the reported technical consultations in all URCs. The highest number of group meetings was reported in URC1, where 4% of technical consultations were prescheduled group meetings and 6% were unscheduled group meetings. The lowest number of group meetings was reported in URC4, where 2% of the entire technical consultations were prescheduled group meetings and no unscheduled group meetings were reported. Due to the small numbers of group meetings in all six URCs, statistical analyses between group meetings and syntactical properties of space was not possible. However, it was noted that those URCs that had in-territory informal or formal common spaces had a higher number of group meetings. URC1, URC5 and URC6 were good examples for this identification.

Ten percent of the reported technical consultations were group meetings in URC1, where it was noted that about half of the unscheduled group meetings, and almost all of the prescheduled group meetings were held in the
family room. Eight percent of the reported technical consultations were group meetings in URC5, where all group meetings except one were held in the formal common space, the conference room. 6% of the reported technical consultations were group meetings in URC6, where all group meetings were held in the formal common space, the conference room.

On the other hand, those URCs that did not have an informal or formal common space within their territories held a smaller percentage of group meetings. Three percent of the reported technical consultations were group meetings in URC2, where all group meetings were held in a shared office space. Three percent of the reported technical consultations were group meetings in URC3, where all prescheduled group meetings were held in the shared conference room on the third floor of Building 1. Two percent of the reported technical consultations were prescheduled group meetings in URC4, which were held in the first floor formal teleconference room. No unscheduled group meetings were reported in URC4.

Two main conclusions were drawn from these findings. First, results indicated that those URCs that had either an informal or formal common space within their territories held relatively more group meetings than other URCs that shared their common spaces with other organizations. Second, if informal common spaces are within the URC territory, comfortably furnished and frequently used, prescheduled and unscheduled group meetings tend to be held more in these spaces. URC1’s family room was a clear example of this situation, where this space not only facilitated coincidental consultations, but also attracted prescheduled and unscheduled group meetings with its informal atmosphere. As a result, this was noted as another advantage of locating an informal common space within a URC territory.

7.3.5. The Effects of Space on Technical Consultations Through E-media across Six URCs

A small percentage of technical consultations through e-media were reported in all six URCs. It was not possible to identify a pattern of relationships between space and technical consultations through e-media across the six URCs. In two URCs, (URC1 and URC3) it was identified by significant correlations that e-mails and telephone calls originated from segregated and less visible spaces. The same levels of significance were not noted in the remaining URCs. However, in the remaining four URCs, the directions of relationships were the same as in URC1 and URC3, although statistical significance did not exist. Since the number of data points was low in all cases, this indicated that a certain tendency was repeating across all cases. Overall, it was identified across all URCs that technical consultations through e-media were not preferred as much as other media in all six URCs.
7.4. FACILITATING FACE-TO-FACE TECHNICAL CONSULTATIONS IN UNIVERSITY RESEARCH CENTERS: A SHORT SUMMARY

The following effects of space on face-to-face technical consultations were consistently identified in all URCs that participated in the study.

7.4.1. Fixed-feature Space

1. Relationships between syntactical properties of space and unprogrammed encounters were identified in all URCs. Higher global integration, higher control value, lower point depth from the maximum globally integrated space, and higher visibility facilitated coincidental consultations and unscheduled office visits in all URCs.

2. Relationships between walking distances and unprogrammed encounters were identified in all URCs. Shorter walking distances facilitated coincidental consultations and unscheduled office visits in all URCs.

3. Findings of the study indicated that informal common spaces facilitated coincidental consultations when they were within the territory of a URC, providing a casual, relaxed, and friendly atmosphere, equipped with material conveniences, located on the global integration core of the URC’s system, and highly visible. In such cases, it was identified that group meetings were also held in informal common spaces.

4. Prescheduled office visits were related to individual roles of researchers rather than spatial properties of the offices they occupied.

5. It was identified that those URCs that had informal or formal commons within their territories had a tendency to hold more unscheduled and prescheduled group meetings.

6. In two URCs, most e-mails and telephone calls originated in segregated and less visible convex spaces. Although no significance was found in the remaining four URCs, the same tendency of relationships was identified.

Table 7.4.1 exhibits the list of best predictors of face-to-face technical consultations for fixed-feature space.
Table 7.4.1. Best predictors of face-to-face technical consultations at the level of fixed feature space.

<table>
<thead>
<tr>
<th>SYNTACTICAL PROPERTIES OF SPACE</th>
<th>METRIC PROPERTIES OF SPACE</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher global Integration</td>
<td>Shorter walking distances</td>
<td>Availability of informal commons</td>
</tr>
<tr>
<td>Higher control value</td>
<td></td>
<td>Availability of formal commons</td>
</tr>
<tr>
<td>Lower point depth from the maximum globally integrated space</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Higher visibility</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.4.2. Semi-Fixed and Non-fixed Feature Space

The majority of semi-fixed and non-fixed feature space level predictors of face-to-face technical consultations were predictors of coincidental consultations, and related to either informal commons or other spaces designated for business equipment. Therefore, these semi-fixed and non-fixed feature space level predictors ought to be considered in accordance with the fixed-feature space level predictors. However, the following were identified in semi-fixed and non-fixed feature space.

In the follow-up surveys, researchers also mentioned a number of fixed-feature space properties as desired environmental qualities. These citations (i.e. higher configurational integration, metric proximity) supported the findings of this study at the level of fixed-feature space. Higher visibility, perceived environmental comfort, access to daylight, multifunctionality, and ethernet network connections were the most frequently cited environmental qualities for informal commons.

Perception of an informal environment, awareness of the presence of other colleagues, visual quality, and feeling of possession affected researchers’ frequent use of informal common spaces positively. These desired environmental qualities were repeatedly cited in most URCs. Material conveniences such as access to food / water / coffee also attracted researchers. Access to such conveniences was the most frequently cited reason for space use in all URCs. Meeting other colleagues was frequently cited as a reason for space use across all URCs. Business tools were another frequently cited reason for space use in URCs. It was identified that business equipment such as printers, fax machines, and copiers attracted researchers during the course of their work.

These citations by researchers indicated that those informal common spaces equipped with material conveniences, and perceived as comfortable, visible, and spacious had a higher possibility of being used by researchers. Moreover, the awareness of the presence of other colleagues further encouraged researchers to
use such spaces, creating a further facilitating effect. Similarly, those spaces that accommodated frequently used business tools had a higher chance of being visited by researchers.

Therefore, it was identified that such semi-fixed and non-fixed feature space elements that were predictors of researchers’ space use and face-to-face technical consultation were in close relation with fixed-feature space findings. In this respect, these best predictors at the level of semi-fixed and non-fixed feature space were found to be exhibiting similar patterns to fixed-feature space findings in all URCs. Table 7.4.2 lists the best predictors of face-to-face technical consultations at the level of semi-fixed and non-fixed feature space.

<table>
<thead>
<tr>
<th>Type</th>
<th>Desired environmental qualities</th>
<th>Reasons for space use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fixed-feature space</strong></td>
<td>Configurational integration within the territory for common spaces (4)</td>
<td>Access to open air (2)</td>
</tr>
<tr>
<td></td>
<td>Metric proximity to desired functions (4)</td>
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</tr>
<tr>
<td></td>
<td>Integration of offices and laboratories, metric proximity (5)</td>
<td></td>
</tr>
<tr>
<td><strong>Semi-fixed feature space</strong></td>
<td>Visibility (4)</td>
<td>Access to business tools (2)</td>
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<tr>
<td></td>
<td>Perceived environmental comfort / furnishing (3)</td>
<td>Material conveniences (6)</td>
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<tr>
<td></td>
<td>Access to daylight (5)</td>
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<td></td>
<td>Multifunctionality</td>
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<td></td>
<td>Network access</td>
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<tr>
<td><strong>Non-fixed feature space</strong></td>
<td>Perception of an informal environment (5)</td>
<td>Concentrated work (5)</td>
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<tr>
<td></td>
<td>Awareness of the presence of other colleagues (3)</td>
<td>Meeting colleagues (5)</td>
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<td>Available amount of personal workspace (2)</td>
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<td></td>
<td>Visual quality (2)</td>
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<tr>
<td></td>
<td>Feeling of possession (2)</td>
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</tbody>
</table>

The findings about repeating patterns across six URCs discussed in this chapter identified those spatial properties that facilitated face-to-face technical consultations, therefore information consumption. Thus, rather than comparing URCs according to their spatial categories, this chapter identified specific spatial properties that related to similar phenomena consistently. In the next chapter, a cross-case comparison of findings will be conducted, where URCs will be compared across and within spatial categories.
CHAPTER 8

CROSS-CASE COMPARISONS ACROSS SPATIAL CATEGORIES

The four major research questions of this study aimed at, first, understanding the effects of space on three information consumption indicators:

(i) patterns of space use for face-to-face technical consultation,

(ii) technical consultation networks among researchers, and

(iii) information consumption patterns,

and second:

(iv) innovation process outcomes.

In the preceding chapters, six URCs that participated in the study were introduced, and findings from each URC were discussed. Then, those spatial properties that consistently affected certain types of face-to-face technical consultations across all six URCs were identified. Repeating patterns of space and face-to-face technical consultation relationships were discussed. Therefore, the effects of space on patterns of space use for face-to-face technical consultation were identified.

This chapter will focus on the comparisons between the six URCs. The objective is to compare how URCs identified with different spatial categories affect technical consultation networks among researchers and information consumption patterns. Finally, how innovation process outcomes relate to information consumption of URCs across three categories will be compared. In doing so, the objective of this chapter is to understand the effects of space on the remaining information consumption indicators and innovation process outcomes through a series of comparisons.

8.1. INTACT vs. NON-INTACT URC TERRITORIES

Category 1, Category 2, and Category 3 URCs were introduced in Chapter 4: Category 1 URCs have intact territories with both offices and laboratories; Category 2 URCs have non-intact territories with both offices and laboratories; and Category 3 URCs have intact territories with offices only (Figure 8.1.1).
The term “non-intact territory” indicates that a URC’s territory has been separated into at least two sectors, connected with one or more “primary circulation” spaces composed of corridors or stairways open to people who are not affiliated with that URC. Therefore, while researchers in Category 2 URCs have to pass through a series of primary circulation spaces in order to move from one part of their territory to another, researchers in Category 1 and Category 3 URCs remain within their territory.

The “intact” vs. “non-intact” territory dichotomy indicates important differences between URCs of different spatial categories. Whether a URC’s territory is “intact” or “non-intact” has strong effects on three vital issues: walking distances, its spatial configuration, and face-to-face technical consultation patterns among its researchers.

8.1.1. Differences in the Walking Distances of Category 1, Category 2 and Category 3 URCs

Walking distances within URCs varied according to spatial categories. The differences in walking distances were mainly based on whether the territories of URCs under consideration were intact or non-intact. Non-intact territory URCs (Category 2) had longer distances among their convex spaces, since their territories were separated within and across floors. Intact territory URCs, on the other hand, had shorter walking distances among their convex spaces. Since the patterns of relationships indicated that shorter distances facilitated face-to-face technical consultations, non-intact URC (Category 2) territories were less advantageous for information consumption.

8.1.2. Differences in the Spatial Configurations of Category 1, Category 2 and Category 3 URCs

As discussed in the individual case study reports, whether a URC’s territory is “intact” or “non-intact” affects its overall spatial configuration. In Category 1 and Category 3 URCs with intact territories, there are no non-territorial convex spaces separating territorial convex spaces. Consequently, the maximum globally integrated convex space is within the territory. The maximum globally integrated convex space is a territorial convex space.
However, in Category 2 URCs with non-intact territories, non-territorial convex spaces separate territorial convex spaces, since the entire territory is separated into sectors. Consequently, the maximum globally integrated convex space is outside the territory, consequently, the maximum globally integrated convex space is a non-territorial convex space. This indicates that in Category 2 URCs, the global integration core of the entire system becomes publicly accessible, or a primary circulation space.

Individual case study reports have indicated the consistent result that highly globally integrated convex spaces facilitate face-to-face technical consultations. Evidently, in Category 2 URCs, when the maximum globally integrated convex space is non-territorial, a disadvantage for overall information consumption appears. It is possible to identify this disadvantage by means of a syntactical property of entire spatial systems: intelligibility.

Intelligibility of an entire spatial system is a measure of how all convex spaces are highly integrated and highly connective to other spaces at the same time. Higher intelligibility of an entire system indicates that the majority of its convex spaces are highly integrated, and highly connective to each other. Based on the individual case study results, higher intelligibility of a URC territory indicates further facilitation of face-to-face technical consultations. For facilitating information consumption, a territory with high intelligibility is more advantageous.

Intelligibility of an entire system is a correlation coefficient resulting from bivariate analysis of the connectivity and global integration values of all its convex spaces. Higher correlation coefficients indicate higher intelligibility, whereby convex spaces of the system are more configurationally accessible, more connective to each other, more integrated, therefore, the system is facilitative of face-to-face technical consultations. The differences in the spatial configurations of Category 1, Category 2, and Category 3 URCs exist clearly when their intelligibility values are calculated. Figure 8.1.2 exhibits the intelligibility values, floor plans, and abstracted permeability graphs of all six URCs across the three spatial categories.
Figure 8.1.2. Intelligibility values, floor plans, and abstracted permeability graphs of all six URCs across the three spatial categories.

**Category 1 URCs (URC1 and URC2).** In URC1, the office core and the laboratory were connected by one door, such that one axis went through both. However, in URC2, the office core and the laboratory were connected by three doors, where three axes went through both. When the intelligibility values of the two Category 1 URCs were compared, the findings indicated that URC2 territory had an intelligibility of $I = 0.5262$, whereas URC1 territory had an intelligibility of $I = 0.5188$. Consequently, it was noted that the connection difference between the office cores and laboratories of the two URCs caused a slight difference in their intelligibility values. URC2, with three connections between its office core and laboratory, had a higher intelligibility value than URC1, which had one connection between its office core and laboratory.

**Category 2 URCs (URC3 and URC4).** Both URC3 and URC4 were separated into three floors, within buildings that were shared by other organizations. URC3 had an office sector on the first floor, and two laboratory sectors on the second and third floors respectively. URC4 had an office sector and laboratory sectors on all three floors. The only difference between the two was about their office cores. In URC3, the office core served only the offices of URC3, and did not function as a passageway for non-URC3 individuals. URC4’s office cores, on the other hand, double-functioned: they not only served URC4 offices, but also functioned as passageways for non-URC4 individuals. When the intelligibility values of both URCs were compared, the findings indicated that URC3
had an intelligibility value of $I=0.1581$, while URC4 had an intelligibility value of $I=0.1010$. The low intelligibility values of Category 2 URCs compared to Category 1 URCs indicated how scattered the territories of Category 2 URCs were. When the global integration core of these systems shifted towards primary circulation spaces that usually connected lower numbers of convex spaces (low connectivity), the intelligibility values dropped.

**Category 3 URCs (URC5 and URC6).** Both URC5 and URC6 were intact-territory URCs. However, while the two office cores of URC5 were on the same floor, the two office cores of URC6 were on two different floors. Thus, in URC5, there were two connections between the two office cores, but in URC6, there was only one. Intelligibility values of URC5 and URC6 were calculated and compared. The results indicated that URC5, with two connections between its office cores, had an intelligibility value of $I=0.4446$, whereas URC6, with a floor difference and only one connection between its office cores, had an intelligibility value of $I=0.4275$. Therefore, similar to Category 1 URCs, in Category 3 URCs, higher number of connections between two parts of the territory resulted in higher intelligibility.

These results indicated that Category 1 URCs had highest levels of intelligibility, followed by Category 3 URCs with smaller levels of intelligibility. Category 2 URCs, however, had the lowest levels of intelligibility among all. Therefore, it was identified that Category 2 URCs had the most scattered non-intact territories. Category 1 URCs, on the other hand, had highly integrated, configurationally accessible, and intact territories, and had higher levels of intelligibility. Based on the patterns of spatial configuration – face-to-face technical consultation relationships found in Chapter 6, these findings indicated that Category 1 URCs had the highest possibility of facilitating face-to-face technical consultations, followed by Category 3 URCs, and last, Category 2 URCs.

**8.1.3. Differences among Category 1, Category 2 and Category 3 URCs at Semi-fixed and Non-fixed Feature Space**

Walking distances and spatial configuration were not the only identifiable differences between URCs that had intact or non-intact territories. In all URCs that participated in the study, about 1% of all 1551 reported face-to-face technical consultations had occurred in non-territorial convex spaces. This meant that even less than 1% of the entire 1763 technical consultations had occurred in non-territorial convex spaces. The implication of these findings was clear: researchers in all six URCs preferred to remain within their URC’s territory as much as possible. They rarely left the territory of their URCs, and consequently rarely engaged in face-to-face technical consultations outside the territory of their URCs.

This finding was further supported by the positive and negative environmental qualities cited by researchers in all URCs, which were discussed in Chapter 6. Researchers usually described non-territorial convex spaces using
expressions such as “cold”, “sterile”, “bland”, “not homey”. A number of examples and comparisons clarify this issue.

In Building 1, which was shared by URC1, URC2, URC3 and URC5, the corridors (primary circulation spaces) on the two floors were non-territorial convex spaces for all URCs. Researchers from these URCs indicated in their follow-up surveys that these corridors were cold and sterile. In URC1, while researchers were not generally satisfied with the second floor shared corridor, they were very satisfied with the corridors within URC1 territory, and indicated that the corridors within URC1 territory were “homey” spaces where they “always ran into someone”. Similar results were found in URC2, URC3 and URC5. Visual documentation of these convex spaces clearly exhibits what the researchers pointed out (Figure 8.1.3).

Figure 8.1.3. Non-territorial primary circulation spaces of Building 1 vs. territorial corridors of URC1. Top left: first floor shared corridor (primary circulation) in Building 1. Top right: second floor shared corridor (primary circulation) in Building 1. Bottom left: territorial corridor in URC1 (B01). Bottom right: territorial corridor in URC1 (B04).
Figure 8.1.3 shows the differences between non-territorial and territorial convex spaces. URC1 researchers use office core convex space B04 (bottom right) to reach their laboratory. Researchers in URC3 have to use shared corridors (top left and right) in order to reach their laboratories from their offices. Visual documentation and researchers’ citations in the follow-up surveys indicated that non-territorial convex spaces were left “cold and sterile”, while territorial convex spaces were “possessed” by the researchers of the URC to which they belonged.

In Building 2, researchers of URC4 indicated that the shared corridors (primary circulation spaces) were “bland and sterile”. A minimal amount of coincidental consultations were reported in these corridors, when their levels of global integration were considered (Figure 8.1.4).

Researchers reported that non-territorial convex spaces (i.e. corridors) were usually unattractive since they were not “customized” according to the needs of their URCs. These findings further pointed to the limitations of non-intact territories for URCs. Researchers of non-intact territory URCs had to use primary circulation spaces that were not only syntactically less connective, but also described as “cold, sterile, and not homey” in order to reach from one sector to another.

Therefore, while the possibility of face-to-face consultations in non-territorial spaces was much lower than territorial spaces, the tendency to move from one floor to another using these non-territorial spaces was also much lower in non-intact territory URCs. As a result, non-intact URC territories had limitations not only in terms of higher walking distances and lower intelligibility, but also perceptually when facilitating face-to-face technical consultations were considered.
8.1.4. Summary

Further analyses of Category 1, Category 2, and Category 3 URCs indicated that intact territories were much more advantageous than non-intact territories based on the findings from individual case study reports. Intact URC territories (Category 1 and Category 3) were syntactically more intelligible, featured shorter walking distances, and territorial convex spaces. Non-intact URC territories (Category 2), on the other hand, were syntactically less intelligible, caused longer walking distances, and were separated by primary circulation spaces that were negatively perceived by researchers. Consequently, based on the findings from individual case study reports, Category 1 URCs had a higher possibility of facilitating face-to-face technical consultations than Category 3 URCs. Category 2 URCs, on the other hand, were the most disadvantageous among the three categories defined in this study. Then, how did URCs in different spatial categories actually affect face-to-face technical consultations among researchers?

8.2. SOCIAL CONNECTIVITY OF URC TECHNICAL CONSULTATION NETWORKS ACROSS SPATIAL CATEGORIES

“Technical consultation networks” were defined as networks of researchers exhibiting regular patterns of research related technical consultation (Allen, 1984). Dense technical consultation networks exhibit higher levels of technical consultation, therefore higher levels of information consumption. Review of previous literature in Chapter 2 had indicated that since higher information consumption levels facilitate innovation, higher density technical consultation networks are advantageous for organizations to facilitate innovation.

A social network analysis was conducted in order to measure the density of URCs’ technical consultation networks. For this purpose, “social connectivity” of each of the six URCs was measured, which made it possible to compare the technical consultation networks of each URC that participated in the study. As opposed to “social centrality”, which was measured for individual researchers, “social connectivity” was measured for each single URC, and indicated the density of the technical consultation network of a URC. Therefore, each URC was attributed one social connectivity value. **Social connectivity of a URC technical consultation network** was calculated by dividing the actual sum of researchers’ number of relational ties among researchers by the total number of possible ties. Figure 8.2.1 exhibits the social connectivity of technical consultation networks in all URCs.
The results of this analysis indicated that Category 1 URCs had the highest-connectivity technical consultation networks, followed by Category 3 and Category 2 URCs. A higher social connectivity value for a URC indicated that researchers in that particular URC had directional relations (technical consultation ties) with a high number of other researchers. Thus, a URC2 researcher had technical consultation ties with a higher number of researchers than a URC4 researcher. In this respect, higher information consumption was possible in URCs that had highly connective technical consultation networks.

An immediate note at this point was that, high-intelligibility, short-walking distance, intact-territory URCs exhibited much more connective technical consultation networks than low-intelligibility, long-walking distance, non-intact territory URCs. As a second step, spatial intelligibility values of the six URCs were compared to each other and their social connectivity values. It was identified that as the spatial intelligibility of URCs increased,
their social connectivity increased. URC2, with the highest intelligibility value, also had the highest social connectivity. URC2 was followed by URC1, URC4, URC6, URC3 and URC2. Despite the small number of data points, a bivariate analysis of spatial intelligibility and social connectivity was conducted in order to measure the level of statistical significance of this relationship (Figure 8.2.2).

![Figure 8.2.2. Bivariate analysis of spatial intelligibility and social connectivity of the six URCs that participated in the study.](image)

Bivariate analysis yielded an R-square value of 0.60, and a p-value of 0.07. Although there were six data points (one for each URC) in the scatterplot, a significance at the level of \( \alpha = 0.1 \) was still achieved. Therefore, a positive correlation was identified between spatial intelligibility and social connectivity of the six URCs.

**Category 1 URCs (URC1 and URC2).** Configurational analyses of URC1 and URC2 territories had indicated that URC2 territory was more intelligible than URC1 territory because of its higher number of connections between office core convex spaces and laboratory convex spaces. Moreover, URC2 territory featured shorter walking distances compared to URC1 territory. When social connectivity of URC1 and URC2 technical consultation networks were compared, it was noted that URC2, with its higher intelligibility territory, also exhibited higher social connectivity within its technical consultation network compared to URC1.

**Category 2 URCs (URC3 and URC4).** Configurational analyses of URC3 and URC4 territories had indicated that URC3 territory was more intelligible than URC4 territory. While URC3 territory was forming territorial sectors on each floor of its building, URC4 office core convex spaces also permitted individuals that were not affiliated with URC4. Moreover, URC3 territory featured shorter walking distances compared to URC4 territory. When social connectivity of URC3 and URC4 technical consultation networks were compared, it was noted that URC3, with its higher intelligibility territory, also exhibited higher social connectivity within its technical consultation network compared to URC4.
**Category 3 URCs (URC5 and URC6).** Configurational analyses of URC5 and URC6 territories had indicated that URC5 territory was more intelligible than URC6 territory, due to the higher number of connections between its two office cores. In addition, URC5 territory featured shorter walking distances compared to URC6 territory. When social connectivity of URC5 and URC6 technical consultation networks were compared, it was noted that URC5, with its more intelligible territory, also exhibited higher social connectivity within its technical consultation network compared to URC6.

The result of this analysis therefore indicated that across spatial categories, Category 1 URCs had more connective technical consultation networks than Category 3 URCs, who had more connective technical consultation networks than Category 2 URCs. When individual URCs were compared, it was identified that as spatial intelligibility of URC territories increased, the connectivity of their technical consultations increased. These findings confirmed the previously discussed findings about the facilitating effects of intact and highly intelligible URC territories on technical consultations among researchers.

*As a result, it was identified that higher intelligibility in URC territories facilitated social connectivity of technical consultation networks. In addition, it was noted that Category 1 URCs' technical consultation networks were more socially connective than Category 3 URCs’, whose technical consultation networks were more socially connective than Category 2 URCs.*

**8.3. INFORMATION CONSUMPTION PATTERNS OF URCs ACROSS SPATIAL CATEGORIES**

It was previously identified that face-to-face technical consultations were the most frequently occurring technical consultations in all URCs. In addition, it was also found that face-to-face technical consultations were the highest priority information resource for researchers in all URCs. Therefore, how space related to information consumption patterns across the six URCs was analyzed. The objective was measure how space affected the highest priority information resource: face-to-face technical consultation.

Initially, the percentage of face-to-face consultations within the total number of reported technical consultations were calculated in each URC, in order to see to the extent each URC had face-to-face consultations or consultations through e-media (Chart 8.3.1).
Comparison among URCs indicated that the highest percentage of face-to-face technical consultations occurred in Category 1 URCs, followed by Category 3 and Category 2 URCs. In addition, when these percentages were compared to the spatial intelligibility values of URCs, the identical relationship pattern in Section 8.2 was found, whereby, as spatial intelligibility values of URCs increased, their percentage of face-to-face technical consultations increased. These findings indicated that intact-territory, spatially more intelligible URCs with shorter walking distances had more face-to-face technical consultations. On the other hand, researchers in Category 2 URCs, whose territories were non-intact, walking distances were longer, and territories were spatially less intelligible, relied on technical consultations more than their colleagues in Category 1 and Category 3 URCs.

Individual case studies had indicated that space had no relationship to prescheduled office visits. In order to focus on those technical consultations that related to space, prescheduled office visits were omitted from the data set, and the same analysis were repeated only among face-to-face technical consultations whose relationships to space were identified in individual case studies (Chart 8.3.2).
The results of this analysis yielded a similar pattern of findings as compared to the previous analysis. Category 1 URCs had the highest percentage of unprogrammed encounters and group meetings, followed by Category 3 and Category 2 URCs.

**Category 1 URCs (URC1 and URC2).** When Category 1 URCs were compared, the following findings were achieved. With its more intelligible territory and more connective technical consultation network, URC2 utilized a higher percentage of face-to-face technical consultations than URC1, whose territory was less intelligible and technical consultation network was less connective.

**Category 2 URCs (URC3 and URC4).** When Category 2 URCs were compared, it was identified that URC3, with a more intelligible territory and more connective technical consultation network, utilized a higher percentage of face-to-face technical consultations than URC4, whose territory was less intelligible and technical consultation network was less connective.

**Category 3 URCs (URC5 and URC6).** When Category 3 URCs were compared, the following findings were achieved. URC5, with its more intelligible territory and more connective technical consultation network, utilized a
higher percentage of face-to-face technical consultations than URC6, whose territory was less intelligible and technical consultation network was less connective.

As a result, it was identified that higher intelligibility in URC territories facilitated face-to-face technical consultations. In addition, Category 1 URCs’ percentages of face-to-face technical consultations were higher than Category 3 URCs’, whose percentages of face-to-face technical consultations were higher than Category 2 URCs. Moreover, it was noted that those researchers in Category 2 URCs that had low intelligibility, non-intact territories with longer walking distances relied more on technical consultations through e-media compared to their colleagues in Category 1 and Category 3 URCs.

8.4. INFORMATION CONSUMPTION ACROSS SIX URCs

In the conceptual model of this study, three indicators of information consumption were identified: patterns of space use for face-to-face technical consultation, technical consultation networks among researchers, and information consumption patterns. The discussion starting with the individual case study reports, up to this point have identified the relationships between space and the three information consumption indicators:

1. At the individual case study level, it was identified that higher global integration, higher control value, lower point depth from the maximum globally integrated space, higher visibility, shorter walking distances, and in-territory informal commons facilitated patterns of space use for face-to-face technical consultation. In addition, further effects of combinations of these factors were identified and discussed in the previous chapter in detail.

2. At the cross-case comparison level, it was identified that higher intelligibility, shorter walking distances, having an intact territory increased social connectivity of URC technical consultation networks.

3. At the cross-case comparison level, it was also identified that higher intelligibility, shorter walking distances, having an intact territory facilitated face-to-face technical consultations in URCs. In those URCs whose territories did not parallel these criteria, researchers’ reliance on technical consultations through e-media were much higher. In this respect, it was identified at the cross-case comparison level that space significantly affected information consumption patterns. Figure 8.4.1 exhibits the information consumption patterns of the six URCs that participated in the study.
Figure 8.4.1. Information consumption patterns of the six URCs that participated in the study.

Therefore, the findings of this study have shown that the spatial properties of a URC affect its information consumption by their influences on patterns of space use for face-to-face technical consultation, technical consultation networks among researchers, and information consumption patterns.

Since information consumption is the major resource for innovation in basic science and research settings, the crucial question at this point is the innovation process outcomes of all URCs that participated in the study.
8.5. INNOVATION PROCESS OUTCOMES ACROSS SIX URCs

The outcomes of innovation processes in the URCs were measured through judgmental and non-judgmental ratings. The main objective of such an approach was to use triangulation as a tool to maintain the reliability of innovation process outcomes measurements. In the follow-up surveys, researchers in the six URCs were asked to record the number of various outcomes they have produced (i.e. number of papers), and rate the research processes they participated in by using 7-point Likert scales (i.e. innovativeness) as described in the methodology of the study.

In order to make cross-case comparisons, an average value of non-judgmental ratings was calculated for each URC. For this purpose, the total number of outcome items (i.e. number of books, papers written) reported by each researcher was initially summed, and the total number of non-judgmental outcomes produced in each URC was calculated. Then, the average time (months) researchers have been working with each URC was calculated. Finally, for each URC, the total number of non-judgmental outcomes was divided by the number of researchers and the average number of months researchers have been working with that URC. Thus, each URC was attributed an “aggregate number of outcome items per researcher, per month”. Similarly, average values for judgmental ratings of researchers were calculated for each URC. The researchers rated their URC and the research processes across four judgmental scales: “creativity and innovativeness of research conducted in the URC”, “the URC’s overall contribution to the field”, “the URC’s recognition / reputation”, and “overall satisfaction with the research processes in the URC”. Mean values of the ratings were calculated for each scale in each URC. Thus, each URC was attributed four ratings on a 7-point Likert scale. Findings were then compared across cases (Table 8.5.1).
Table 8.5.1. Comparison of technical consultation networks, information consumption patterns, and innovation process outcomes across six URCs in three spatial categories.

<table>
<thead>
<tr>
<th>URC</th>
<th>CATEGORY 1</th>
<th>CATEGORY 2</th>
<th>CATEGORY 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>TERRITORY TYPE</td>
<td>INTACT</td>
<td>INTACT</td>
<td>NON-INTACT</td>
</tr>
<tr>
<td>SPATIAL INTELLIGIBILITY OF TERRITORY</td>
<td>0.5188</td>
<td>0.5262</td>
<td>0.1581</td>
</tr>
<tr>
<td>SOCIAL CONNECTIVITY OF TECHNICAL CONSULTATION NETWORKS</td>
<td>0.462</td>
<td>0.659</td>
<td>0.230</td>
</tr>
<tr>
<td>% INFORMATION CONSUMPTION THROUGH FACE-TO-FACE TECHNICAL CONSULTATION</td>
<td>92%</td>
<td>95%</td>
<td>84%</td>
</tr>
<tr>
<td>Outcomes per researcher per month</td>
<td>0.315</td>
<td>0.330</td>
<td>0.263</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY 1</th>
<th>CATEGORY 2</th>
<th>CATEGORY 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creativity and innovativeness of research conducted in the URC</td>
<td>6.00</td>
<td>5.86</td>
</tr>
<tr>
<td>The URC’s overall contribution to the field</td>
<td>6.29</td>
<td>6.57</td>
</tr>
<tr>
<td>The URC’s recognition / reputation</td>
<td>6.57</td>
<td>6.29</td>
</tr>
<tr>
<td>Overall satisfaction with the research processes in the URC</td>
<td>6.43</td>
<td>6.00</td>
</tr>
</tbody>
</table>

The cross-case, cross-category comparison yielded the same pattern of relationships previously discussed in this chapter. Category 1 URCs indicated the highest measures of innovation process outcomes. Category 3 URCs followed Category 1 URCs. Finally, Category 2 URCs indicated the lowest measures of innovation.
process outcomes. Overall, the identical pattern of relationships was observable in Figure 8.5.1, where all cross-case level findings are summarized.

Figure 8.5.1. Summary of cross-case findings and repeating patterns of relationships found in the study.
8.5.1. Possible Effects of Organizational Context on Innovation Process Outcomes

In order to maintain the validity of the study, two sets of case selection criteria were identified in methodology. The first set was about spatial categorization of URCs: two URCs were selected from each spatial category. The second set of criteria was related to the organizational contexts of URCs to be selected. Based on these criteria, URCs with similar organizational contexts were selected as individual cases, in order to focus on the effects of space. Structured interviews were conducted with URC directors to gather information about the organizational context of each of the participating URCs. Therefore, the six URCs selected as individual cases were similar in terms of organizational context.

However, to ensure that none of the found innovation process outcomes were affected by the organizational contexts of URCs, and to further strengthen the validity of the study, a second check was conducted. The objective of this second check was to understand whether any of the organizational context properties related to any of the innovation process outcomes.

Bivariate analyses between all organizational variables defined in the methodology of the study and all innovation process outcomes were conducted in pairs. The results of this bivariate analyses indicated that none of the organizational variables defined in the methodology of the study showed any significant relationships to innovation process outcomes. Therefore, it was identified that the findings of the study as discussed up to this point were not biased by any organizational factors. In this respect, the concerns about the validity of findings were eliminated.

8.6. UNIVERSITY RESEARCH CENTERS: FROM SPACE TO INNOVATION PROCESS OUTCOMES

Therefore, cross-case analyses across cases and spatial categories indicated that those URCs with high-intelligibility, intact territories with shorter walking distances had socially more connective technical consultation networks, higher percentages of face-to-face technical consultation, and higher measures of innovation process outcomes.

Individual case study reports and cross-case comparisons in all URCs revealed a number of key findings. Initially, it was found that certain features of space affected information consumption indicators.

1. Within individual case studies, it was identified that fixed-feature, semi-fixed feature, and non-fixed feature space affected *patterns of space use for face-to-face technical consultation*.

2. Intact-territory URCs had more intelligible territories than non-intact territory URCs.
3. Those URCs with intact, more intelligible territories had socially more connective technical consultation networks. Category 1 and Category 3 URC technical consultation networks had higher social connectivity values compared to those of Category 2 URCs.

Thus, by facilitating face-to-face technical consultations, and increasing the connectivity of such technical consultation networks, Category 1 and Category 3 URCs were supporting information consumption, therefore innovation. Furthermore, those URCs within the same category, but with higher intelligibility territories, were facilitating higher connectivity levels in their technical consultation networks.

4. A cross-case, cross-category comparison showed that those URCs with highest intelligibility values had reported the highest percentages of face-to-face consultation. In this respect, Category 1 URCs had reported the highest, Category 3 URCs had reported the second, and Category 2 URCs had reported the least percentages of face-to-face technical consultations. Thus, a relationship between spatial categories and information consumption patterns was identified. Moreover, researchers of all six URCs had indicated that face-to-face technical consultations were the first priority information resources for them.

Thus, researchers in high-intelligibility, intact territory URCs had better access to their first priority information resource, face-to-face technical consultations, which evidently was reflected on their information consumption patterns. The effects of space on patterns of space use for face-to-face technical consultation, technical consultation networks and information consumption patterns were therefore identified.

5. A final cross-case, cross-category comparison revealed that those URCs with intact, high intelligibility territories indicated higher innovation process outcome measurements. These corresponded with Category 1 URCs. Consequently, the same pattern of relationships was found: Category 1 URCs had yielded higher innovation process outcomes, followed by Category 3 and Category 2 URCs.

As a result, the findings of this study made it possible to assert that, as the spatial intelligibility of a URC increased, its social connectivity of technical consultation network increased, which induced higher utilization of face-to-face technical consultations, and therefore facilitated higher measures of innovation process outcomes. In this respect, the findings of this study confirmed that (i) information consumption was a major resource for innovation, (ii) among numerous information resources, face-to-face technical consultation was the most utilized and prioritized information resource, and (iii) appropriate utilization of space could facilitate face-to-face technical consultations. Then, space was a variable in the innovation process.
CHAPTER 9

CONCLUSION: EFFECTS OF SPACE ON INNOVATION PROCESSES IN BASIC SCIENCE AND RESEARCH SETTINGS

The main purpose of this study was to understand the relationships between space and innovation process outcomes within basic science and research settings. A multiple case study of six university research centers with similar organizational contexts, but identified in different spatial categories was conducted. An analysis of the relationships of space to three information consumption indicators and innovation process outcomes indicated that space was a variable in the innovation process. This chapter will discuss the conclusions drawn from the findings of this study, followed by a discussion of future prospects.

9.1. THE SIGNIFICANCE OF FACE-TO-FACE TECHNICAL CONSULTATIONS FOR INNOVATION PROCESSES

Throughout the review of previous literature, it was identified that many researchers subscribed to the idea that increased information consumption in organizations facilitates innovation processes. Moreover, among numerous information resources, face-to-face technical consultations were indicated as major information resources in facilitating innovation by an extensive number of studies.

The findings of this study confirmed results of the review of previous literature. In the activity logs conducted in six university research centers, researchers indicated that almost 90% of all technical consultations were face-to-face technical consultations. Moreover, 82% of the 104 researchers that participated in the study across six URCs pointed out that face-to-face technical consultations were their highest priority information resource. Then, appropriate organization of space can facilitate face-to-face technical consultations, therefore information consumption and innovation in university research centers:

1. **Face-to-face technical consultations are the most valuable information resources, and e-media communications have not replaced face-to-face modes of communication among researchers in university research centers.** Results of this study have shown that the idea that “e-media communications are replacing face-to-face modes of communication, and there is no need to be at the same place, at the same time” is misleading. On the contrary, URC directors and researchers indicate that increasing the probabilities of face-to-face consultations in a friendly atmosphere is much more desirable. In fact, this study has shown that with new techniques of analysis and advanced architectural programming, space is even more important for URCs than conceived before. Many URCs are
allocating informal common spaces and requesting intact territories rather than relying on e-media communications. URC directors are trying to enhance consultations among researchers by designating spaces such as the “family room” and “journal lounge” as discussed in this study.

9.2. EFFECTS OF SPACE ON PATTERNS OF SPACE USE FOR FACE-TO-FACE TECHNICAL CONSULTATION IN UNIVERSITY RESEARCH CENTERS

In this study, space was defined at three proxemic levels: fixed-feature space, semi-fixed feature space, and non-fixed feature space. Fixed-feature space was defined by spatial configuration and walking distances in university research centers. Semi-fixed and non-fixed feature space, which also included movable and semi-movable elements, were defined based on respondents’ citations of environmental qualities and reasons for space use. The results of the study indicated that space, at all proxemic levels, could affect patterns of space use for face-to-face technical consultation in university research centers.

While unscheduled office visits constituted the majority of face-to-face technical consultations, coincidental consultations constituted the second highly utilized face-to-face technical consultations among researchers in university research centers. Therefore, unprogrammed encounters (unscheduled office visits and coincidental consultations) provided the main information resource in all URCs.

Spatial configuration and walking distances strongly affected unprogrammed encounters in all URCs. Configurational accessibility, visibility, and walking distances highly related to quantities of reported unprogrammed encounters. Those researchers occupying configurationally more accessible and highly visible offices reported higher numbers of unscheduled visits in their offices. In all URCs, researchers whose offices were close to each other reported higher quantities of unscheduled office visits to each other. Higher configurational accessibility and higher visibility spaces in URCs also facilitated coincidental consultations. Those spaces located in configurationally central and highly visible areas in URC territories were hot spots of coincidental consultations among researchers. Moreover, researchers reported higher numbers of coincidental consultations within a shorter walking distance from their offices. In addition, the location of business equipment had a magnetic effect on researchers. Those spaces where business equipment was located were found to cause coincidental consultations among researchers, who bumped into each other on their way to a printer, a fax machine, or a similar piece of equipment.

2. It is possible to facilitate unprogrammed encounters among researchers by decision-making processes about spatial configuration, space allocation and functional interrelationships.
3. **For office spaces in university research centers, direct connections to configurationally accessible circulation spaces and high visibility facilitate unscheduled office visits.** In addition, shorter walking distances increase numbers of unscheduled office visits. In order to facilitate unscheduled office visits in university research centers, it is important to configure the system of spaces such that office spaces have increased visibility and direct connections to configurationally accessible circulation spaces.

4. **Configurationally accessible and highly visible office core convex spaces and laboratory convex spaces facilitate coincidental consultations.** In order to facilitate coincidental consultations, providing centrally located, configurationally accessible circulation spaces in office cores and laboratories to which researchers make frequent trips will increase the probability of encounters. Locating related business equipment, such as pin-up boards, printers, fax machines within the vicinity of such configurationally accessible spaces can further facilitate such frequent trips.

5. **Shorter walking distances in URC territories facilitate unprogrammed encounters.** As walking distances within URC territories increase, quantities of unprogrammed encounters decrease. Therefore, spatial configuration, space allocation and functional interrelationships between offices and laboratories need to be minimizing walking distances.

6. **Higher numbers of connections between laboratories and those circulation spaces to which offices are connected in university research centers facilitate unprogrammed encounters.** Findings of this study have shown that higher quantities of unprogrammed encounters are possible when the numbers of connections between office core convex spaces and laboratory convex spaces are increased. Therefore, rather than a single circulation space connecting the two, two or more circulation spaces between office core convex spaces and laboratory convex spaces are more advantageous for facilitating unprogrammed encounters, therefore information consumption.

The location and availability of informal common spaces played an important role in facilitating face-to-face technical consultations. It was found that those informal commons within the territory of URCs, perceived as friendly settings, featuring material conveniences such as food and coffee, facilitated face-to-face technical consultations. When such spaces were configurationally accessible and highly visible, their facilitating effects on face-to-face technical consultations were even stronger. Such informal common spaces not only facilitated coincidental consultations, but also group meetings among researchers. On the other hand, when informal common spaces were outside URC territories, and were shared by other organizations, they were perceived as cold, unfriendly spaces. In such cases, these spaces were not as attractive to the researchers, and small
numbers of coincidental consultations occurred in them. These findings indicated that providing university research centers with common spaces shared with other organizations did not bring the anticipated advantages for face-to-face consultations among researchers. Moreover, many researchers from different URCs indicated that they liked those spaces in which their colleagues could be found. This caused them to visit such spaces to chat with their colleagues. When spatial factors facilitated researchers to use a space, their very presence in that space facilitated its use even further.

7. **Informal common spaces within URC territories facilitate face-to-face technical consultations.** In addition to allocating informal common spaces, such spaces should convey a friendly, relaxed atmosphere in which researchers can informally meet. Based on the results of this study, the best ways to provide a friendly, relaxed atmosphere in informal common spaces are furnishing such spaces with comfortable and homey furniture, and providing material conveniences such as food, coffee, and the like. In addition, for informal common spaces, configurationally accessible, and highly visible locations have to be selected. Results of this study indicated that a combination of such factors facilitates coincidental consultations, increases group meetings, and therefore nurtures information consumption. Findings also indicate that when informal common spaces are strongly possessed by researchers, it is even possible that formal group meetings occur in informal common spaces rather than formal spaces such as conference rooms and meetings rooms.

8. **Providing informal common spaces outside URC territories that are shared by multiple URCs and other organizations does not have any positive effects on information consumption.** Researchers’ main tendency is to remain within their URC’s territory, and such shared informal common spaces are very rarely used. Findings of this study have indicated that shared informal common spaces outside URC territories are also perceived as unfriendly, cold, and inconvenient. Moreover, researchers from different URCs rarely consult with each other in such spaces. Therefore, the idea that providing informal common spaces shared by a number of university research centers can facilitate information consumption is largely misleading.

### 9.3. TERRITORIES OF UNIVERSITY RESEARCH CENTERS

Territories of the university research centers differed from each other in terms of their spatial configurations. Each URC was identified in one of the three spatial categories defined in the methodology of this study.

URCs identified with intact territories (Category 1) included offices and laboratories, where researchers did not have to go through publicly accessible spaces in order to move from one territorial space to another. Such URCs
featured shorter walking distances in their territories. In the URCs identified with the third category, there were no laboratories but offices. However, similar to the first category, their territories were intact. In the URCs identified with the second category, there were both offices and laboratories. However, their territories were non-intact; therefore, their spaces such as laboratories and offices were separated from each other on different floors of buildings. This indicated that the researchers in non-intact territories had to go through spaces accessible to public (i.e. shared corridors, halls, etc.) in order to move from one territorial space to another (i.e. from offices to laboratories). Consequently, in non-intact territory URCs, researchers walked longer distances when navigating the URC territory.

The differences between intact and non-intact URC territories were not limited to their spatial configuration and walking distances. Findings within individual URCs showed that in non-intact territory URCs, non-territorial spaces were perceived as cold and unfriendly. The main tendency of researchers was to remain within their URC’s territories as much as possible. Therefore, non-intact territory URCs not only had configurational and metric, but also perceptual disadvantages for their researchers’ consultations among each other.

9.4. EFFECTS OF SPACE ON TECHNICAL CONSULTATION NETWORKS AND INFORMATION CONSUMPTION PATTERNS IN UNIVERSITY RESEARCH CENTERS

The differences among URC territories exhibited effects on their technical consultation networks. Intact-territory URCs had highly connective technical consultation networks. This meant that their researchers consulted with a high number of colleagues. Researchers in non-intact territory URCs were separated from each other by scattered spaces, and therefore consulted with a small number of colleagues. In addition, it was identified that higher numbers of direct connections between offices and laboratories further facilitated socially connective technical consultation networks. In those URCs that had only offices, closely connected office cores supported social connectivity of technical consultation networks. These results indicated that there was a higher chance of information consumption in intact URC territories. Space did affect URC technical consultation networks.

The differences among URC territories also affected their information consumption patterns. Intact-territory URCs reported more face-to-face technical consultations than non-intact territory URCs. Researchers in non-intact territory URCs utilized technical consultations through e-media more than their colleagues in intact-territory URCs. Social connectivity of technical consultation networks and the amounts of face-to-face technical consultations increased at corresponding rates.

These findings indicated differences among URCs of different categories: their levels of utilizing face-to-face technical consultations – which was the highest priority information resource – were different. Furthermore, the
patterns of relationships between space and information consumption patterns across spatial categories were the same as other information consumption indicators. Therefore, by affecting the amounts of face-to-face technical consultations among researchers, space did affect information consumption patterns in URCs.

9. **Providing intact territories for university research centers facilitates face-to-face technical consultations among their researchers, which results in more connective technical consultation networks and more information consumption.** When a URC territory is separated into more than one sector, researchers have to move through spaces that do not belong to the URC. This not only causes researchers to use non-territorial spaces that they describe as “unfriendly and cold”, but also increases walking distances. Then, researchers that occupy spaces on one of the sectors tend to remain in that sector rather than going back-and-forth between several sectors. Frequencies of unprogrammed encounters among researchers decrease, and those researchers in one sector tend to consult to each other rather than consulting to their colleagues in other sectors. Therefore, not only face-to-face technical consultations, but also connectivity of technical consultation networks decrease. Moreover, since the number of colleagues with which researchers consult decreases, the possibility of generating new ideas, receiving new messages decreases. Consequently, non-intact URC territories inhibit face-to-face technical consultations, decrease connectivity of technical consultation networks, and negatively affect information consumption. On the other hand, in intact URC territories, shorter walking distances, increased probability of coincidental consultations and higher frequencies of face-to-face technical consultations increase connectivity of technical consultation networks. Researchers not only engage in more face-to-face technical consultations, but also consult with more colleagues. The possibility of generating new ideas and receiving new messages increases. Consequently, intact URC territories facilitate face-to-face technical consultations, increase connectivity of technical consultation networks, and positively affect information consumption.

10. **Buildings shared by more than one URC form the common convention for contemporary university research centers.** Contacts with numerous URCs during the course of this study have shown that due to various reasons, URCs have to share buildings with other URCs. A frequently observed decision given by facility managers and architects is providing “shell structures” to several URCs, and expect them to occupy the spaces in the building on a first-come-first-serve basis. The “shell structures” exist most commonly as buildings whose façades are designed, and interiors left void for future division. Visits to numerous URCs, interviews with an extensive number of URC directors and researchers, and results of this study have shown that such decisions only result in URCs occupying spaces that do not meet their work patterns and requirements. In fact, non-intact URC territories are
mostly results of such decisions. Therefore, it must be noted that, even if the sharing of a building by a number of URCs is unavoidable due to various reasons, providing space on a first-come-first-serve basis is inherently disadvantageous. Through architectural programming, it is possible to provide intact territories that also meet the requirements of URCs within a shared building. Results of this study have shown that the problem of accommodating university research centers is not about the quantities of space provided, but about work patterns, URC requirements, and facilitating information consumption for innovation. Therefore, without detailed architectural programming and analyses of social and spatial issues, providing an “appropriate quantity” of space to a number of URCs within a building, and expecting a “highly interactive” environment just because researchers are physically in the building, is largely misleading.

9.5. EFFECTS OF SPACE ON INNOVATION PROCESS OUTCOMES IN UNIVERSITY RESEARCH CENTERS

Then, could space affect innovation in university research centers? A comparison of the innovation process outcomes among all URCs confirmed this question. Cross-case comparisons between URCs indicated that those URCs with configurationally more integrated territories and high levels of face-to-face technical consultations were high performers in innovation process outcomes. Intact-territory URCs yielded the maximum innovation process outcomes, followed by non-intact territory URCs. The repeating pattern of findings indicated that higher amounts of face-to-face technical consultations, more connective technical consultation networks, and overall increased information consumption were accompanied with higher innovation process outcomes, all of which were observed in intact-territory URCs. These results were further confirmed by an analysis indicating that organizational contexts of these URCs were similar, and did not affect the differences among their innovation process outcomes. Therefore, this study confirmed that space, at three proxemic levels, is a variable in innovation processes in university research centers.

11. Increasing information consumption in university research centers facilitates innovation. Face-to-face technical consultations are the most utilized and first priority information resources for researchers in university research centers. In order to facilitate innovation in university research centers, information consumption has to be increased by facilitating face-to-face technical consultations and therefore by widening information horizons of researchers. Findings of this study have indicated that by appropriate utilization of spaces in which university research centers are accommodated, it is possible to facilitate face-to-face technical consultations, strengthen the connectivity of technical
consultation networks, and increase information consumption, all of which facilitated innovation process outcomes.

9.6. DISCUSSION: SPACE FOR INNOVATION, ARCHITECTURE FOR SCIENCE?

The results of this study have provided important conclusions that will be supportive for decision making about the design of university research centers in the future. These conclusions are important not only for meeting university research centers’ work pattern requirements through design decisions, but also for facilitating innovation through information consumption.

A recent survey conducted by the author and Dr. Denis Gray of NCSU Department of Psychology indicated that, among 34 National Science Foundation Industry-University Collaborative Research Centers (I-UCRCs), the majority (62%) was accommodated in non-intact territories with laboratories and offices. On the other hand, 24% were accommodated in intact territories with laboratories and offices, and 14% were accommodated in intact territories with only offices. Analysis of an extensive number of URC floor plans also revealed similar results. Therefore, it is possible to assert that the group of URCs analyzed in this study effectively represents contemporary university research centers. However, it is evident that the majority of contemporary URCs are accommodated in non-intact territories, where researchers are scattered across floors of buildings, or even among several buildings. The results of this study have shown that it is advantageous to provide university research centers with spaces that can facilitate their information consumption, and support their work patterns through efficient workspace research and architectural programming.

**Workspace Research.** The findings of this study have paralleled the shift of attention in workspace research from the issue of workspace satisfaction to accommodating work patterns. It was discussed earlier in this study that the findings of previous research about workspace satisfaction and productivity in work organizations had been subtle, and recent approaches in workspace research had started to consider work pattern as a critical issue. The findings of this study supported the idea that those workspaces that support work patterns have facilitating effects on the goals of organizations. In this respect, it is possible to assert that, in addition to focusing on the subjective evaluations of individuals in work organizations, studying how space relates to the overall work flow has a high potential of yielding beneficial results for work organizations.

**A knowledge-based approach for the design of University Research Centers.** The question of facilitating innovation processes in university research centers is in fact a question of supporting work patterns of work organizations by providing appropriate workspaces through a knowledge-based approach. In this study, the work organizations under consideration were university research centers, and the workspaces were their territories.
Findings indicated that it is possible to facilitate innovation in university research centers through architectural programming with a focus on work patterns. The question of space was handled with a special focus on the ultimate aim of the work organization: knowledge generation, or within this study’s terminology, innovation process outcomes. The inquiry process basically focused on how to facilitate the ultimate objective of the work organization under consideration. Indicators of the ultimate objective were first identified, and it was noted that innovation process outcomes were facilitated by information consumption. Then, how space could facilitate information consumption, and ultimately innovation, was studied. Referring back to the original conceptual model of the study, the findings indicated that in university research centers, decision making processes about spatial configuration, space allocation, and functional interrelationships need to focus on facilitating face-to-face technical consultations, highly connective technical consultation networks and information consumption, which will collaboratively facilitate innovation process outcomes (Figure 9.1).

Figure 9.1. Proposed decision-making process about the spatial configuration, space allocation, and functional interrelationships within university research centers.

9.6.1. A Knowledge-Based Approach for Workspace Design

The questions and findings of this study put forward a case for a knowledge-based approach for workspace design: in order to increase the efficiency of work organizations, a clear understanding of their work patterns, and a spatial organization that will support their work patterns are required. The importance of a knowledge-based approach in workspace design can be clearly understood when previous workspace design experiences in the United States and Europe are briefly reviewed.
Increasing the efficiency of work organizations through appropriate spatial organization has been discussed especially since the second half of twentieth century. However, the approaches proposed and implemented have usually failed in meeting the requirements of work organizations.

The European office buildings of 1950’s and 1960’s, for example, have been organized based on the “functionalist” ideas of the era, and mostly on environmental comfort criteria (i.e. visual, thermal and acoustic) with mainly cellular offices connected to main corridors. In a short period of time, it was understood that focusing on environmental systems and intuitive functional relationship diagrams did not really meet work organizations' requirements, and caused many obstacles in work flow, such as blocking face-to-face interactions among employees (Duffy, 1997).

Another model proposed in Europe in late 1960’s, named “burolandschaft” or “office landscaping”, was based on the idea that if all walls would be eliminated in a workspace, work flow could be much more efficient. This approach proposed floor plans with absolutely no walls, but open office arrangements. The result was another failure, where totally open office spaces created many problems of workspace satisfaction, such as hindering the concentration of employees on their work due to distractions (Duffy, 1997).

The speculative office buildings, mainly built in the United States by contractors, on the other hand, focused on “shell structures” where the floors would be left unarticulated, and tenants would divide and utilize the amount of space they rent on a first-come-first-serve basis. The results were very similar to the previous two examples, where intuitive space divisions did not meet work organizations’ requirements (Duffy, 1997).

Examples of such buildings were also encountered in this study, where “shell structures” allocated for a number of university research centers apparently did not satisfy their work pattern requirements. Other similar cases of misfits between workspaces and work pattern requirements can frequently be found in the related literature, such as the office environments discussed by Sanoff (1992).

The common point in all the examples discussed above is the lack of a knowledge base for workspace design. Intuitively proposed workspace design models without a clear understanding of the needs and requirements of work organizations, in all examples, have formed stories of failure.

Evidently, decision-making about spatial configuration, space allocation, and functional interrelationships in workspaces needs to focus on understanding work patterns of contemporary work organizations, in addition to subjective satisfaction indicators of individuals. By focusing on the ultimate goals of a work organization, and considering its needs and requirements, a decision making process that will support the organization’s work patterns is possible. How can a knowledge-based approach for workspace design be built?
The four key elements in a knowledge-based decision making process are, first, the ultimate objective of the organization, second, indicators of issues that support these objectives, third, the social organization of individuals, and finally, spatial organization. The question, then, is how to gather and analyze information about these key elements, and how to implement decisions founded on this knowledge base.

A decision-making process about spatial configuration, space allocation, and functional interrelationships in workspaces needs to be founded on three major stages: analyzing the existing situation of a work organization, identifying future requirements, and spatial planning with involvement of users. The process from the start of analyzing the existing situation of a work organization to the end of identifying future requirements is frequently termed “post-occupancy evaluation” in the related literature. For example, Sanoff (1992) identifies four phases within the post-occupancy evaluation process: documentation, data collection, data analysis and recommendations. While similar discussions about the post-occupancy evaluation process can be found elsewhere (i.e. Preiser et. al., 1988; Pena, 1977), the common issue is to gain a clear understanding of the requirements of work organizations and evaluating the appropriateness of their workspaces for these requirements.

**Analyzing the existing situation of a work organization.** The two critical points in this phase are, first, understanding organizational goals, and second, understanding spatial goals. Understanding organizational goals requires work pattern analysis, including information gathering about work and information flow. A frequently used technique for information gathering about work and information flow is the use of surveys and activity logs. By developing such instruments, members of a work organization can be requested to keep a log of their work-related interactions, or to record decision-making processes. This information can then be analyzed through conducting social network analysis, which yields information about centrality of individuals, amount and direction of information flow. Other techniques to gather information about work and information flow include interviews or workshops with employees or department heads, in order to understand how the organization works.

Understanding spatial goals requires space use analysis, which is composed of information gathering about uses and specifications of existing spaces, and subjective evaluations of individual employees. Space use patterns can be identified by using activity logs, where employees can record the locations of their work related interactions with their colleagues, or identify frequently used spaces. Alternatively, direct observations of space use, or tracking techniques such as use of cameras can be helpful in understanding space use patterns. It is possible to identify specifications of existing spaces by using space inventory sheets, on which employees can record the furniture and equipment provided, environmental requirements, in addition to recording activities.
taking place in their workspaces. Other techniques to gather information about specifications of existing spaces include walk-through assessments by designers or decision-makers, interviews with employees, or survey instruments on which employees can record such information. A commonly used technique for gathering subjective valuations of employees about their workspaces is survey instruments. Through using such surveys, employees can evaluate the appropriateness of their workspaces for their daily work activities by using rating scales or open-ended questions.

**Identifying future requirements.** The critical point following information gathering is the interpretation of this information. A comparison of organizational and spatial goals yields the fits and/or misfits that exist between the two, and points out future organizational and spatial requirements. For example, by examining subjective evaluations and specifications of existing workspaces, it becomes possible to identify possible problems of misfit between work requirements and workspaces provided for them. Similarly, by examining information flow and space use patterns, it becomes possible to identify criteria for space allocation for specific functions. Configurationally less accessible spaces can be proposed for concentrated work, while centrally located spaces can be proposed for social interaction spaces such as lounges. In doing so, distractions can be minimized in the workspace. Based on the results of social network analysis, organizationally active departments’ locations, or frequently interacting individuals’ workspaces can be proposed accordingly. For example, walking distances between frequently interacting individuals can be minimized, or departments that do not closely relate to each other can be located in distant areas.

While examples of such requirements can be extended, the critical outcome of this phase is that, it reveals the organizational and spatial requirements of a work organization, and yields a knowledge base and criteria for decision-making about spatial configuration, space allocation, and functional interrelationships in workspaces.

**Spatial planning with involvement of users.** The crucial issue in space planning is involving users throughout the planning process. While the previously discussed stages provide a solid knowledge base for decision-making, maintaining the awareness of users about the alternatives and decisions made provides further feedback, and enhances user satisfaction (Sanoff, 1992). An array of participatory techniques have been proposed and implemented by Sanoff (1992) for spatial planning. For example, workshops have proven to be effective participatory processes, in which alternatives can be shared with future users. Recommendations developed based on the two previously discussed stages can be prioritized by the employees in group discussions. Computer simulations or three-dimensional models can be utilized to help employees visualize the outcomes of alternative decisions. In this respect, the members of a work organization become familiar with the
decision-making processes, and have further chances for becoming a part of the entire workspace design process.

This three-stage knowledge-based approach can be applied in two scenarios. In case of a relocation or rearrangement problem, both the organizational and spatial goals can be analyzed in the existing situation. On the other hand, in case of a need for a brand-new workspace environment, space-planning decisions can be founded on an analysis of the planned work organization that is supposed to occupy the provided workspaces. In both cases, frequent feedback loops among the three stages further enhance the efficiency of the process. Figure 9.2 graphically represents this proposed knowledge-based approach for workspace design.

Figure 9.2. A knowledge-based approach for workspace design.
In the current study, the existing situation in six university research centers was analyzed, and fits and misfits between organizational and spatial goals were identified in each case, with respect to the ultimate goal of each of these organizations: innovation. The findings indicated clear conclusions about the workspace requirements of university research centers, and underlined the importance of a knowledge-based approach in providing workspaces for such organizations.

Evidently, the importance of a knowledge-based approach is not limited to university research centers. Providing workspaces for work organizations is a complex task, including the needs and requirements both at the organizational and individual level. Findings of this study, and lessons from the previous experiences discussed in related literature clearly indicate that intuitive workspace design decisions result in the highest cost to pay for work organizations: hindering the ultimate organizational goals. The clear conclusion is that, providing efficient workspaces for work organizations requires a knowledge-based approach, and utilizing space as a knowledge-based tool.

9.6.2. Future Prospects

In this study, only a part of the innovation realm was analyzed: university research centers. The entire technological innovation process involves many different organizations and stakeholders such as government research and development organizations, private firms, and their research and development activities. Moreover, collaborative organizations among these contribute to contemporary technology development activities. In addition to basic science and research activities, product development, deployment, adaptation, implementation, and routinization are all parts of technological innovation processes, each of which are subject to extensive research in various fields. Evidently, the spaces provided for accommodating such activities require further research in order to see the requirements of each activity. In this respect, an important future prospect is to focus on private firms and their research and development activities. With many different role players, and many more levels of analysis, understanding how space is related to innovation processes in private sector is a future challenge. Particularly, those parts of the research and development activities, which are in a cyclic relationship with basic science and research, such as product development constitute further challenges about understanding the role of space in research and development activities of private firms within a much larger technological innovation realm.

University research centers as basic science and research settings continue to introduce new ideas, methods and devices, many of which are deployed, adapted, implemented and routinized in time. This is the process in which contemporary technologies, today’s “knowledge-based tools” are born. Each of these knowledge-based tools makes people’s lives easier, advances nations, and enhances the way we live. Knowledge, the most
valuable commodity of contemporary societies, is generated in these spaces. The objective of this study was to understand if space could be a variable in the innovation process, or affect the processes of “introducing new ideas, methods and devices”. The results showed that space is indeed a vital part of this process. Using the knowledge of how space affects innovation processes, it is possible to make design decisions that will facilitate the introduction of “new ideas, methods and devices”. In other words, the following challenge is to utilize space itself as a “knowledge-based tool”, or as a technology.

Evidently, providing today’s cutting edge basic science and research settings with shell structures is not the biggest challenge for contemporary architecture. Instead, it is possible to work with the cutting edge researchers in these URCs and present them space itself as a product of cutting edge research, through architectural programming. If contemporary architecture is going to take its place among those disciplines which are “introducing new ideas, methods and devices”, instead of being an “end-user” of their “end products”, presenting space as the knowledge-based tool must be the challenge.
REFERENCES


APPENDICES
ACTIVITY LOG

PhD PROGRAM IN DESIGN
SCHOOL OF ARCHITECTURE
COLLEGE OF DESIGN
NC STATE UNIVERSITY

PLEASE COMPLETE THIS ACTIVITY LOG DURING THE COURSE OF YOUR FOLLOWING FIVE
WORK DAYS.
YOUR COOPERATION IS SINCERELY APPRECIATED.

INSTRUCTIONS

For each day, please record any RESEARCH-RELATED CONSULTATIONS you have engaged in with
fellow researchers within (NAME OF URC). In doing so, please:

Consider ONLY those consultations YOU INITIATED, which were CONCERNED WITH RESEARCH
(RESEARCH-RELATED discussions, comments, questions, etc.).

1. For each consultation, check the appropriate box for its particular TYPE OF CONSULTATION (i.e.
   pre-scheduled office visit, unscheduled office visit, coincidental consultation, pre-scheduled group meeting,
   call for a group meeting).

2. Enter the LOCATION of these consultations by entering the space code for that space in the
   appropriate column. You can find the space codes in boxes on the floor plans.

3. Enter the TIME SPENT for these consultations in the appropriate column.

4. Consultations through e-mail and telephone (within (NAME OF URC)): Please enter the number of
   your e-mails and telephone calls within (NAME OF URC) for each day.

OTHER MEDIA: Consultations through fax and videoconferencing (with parties outside (NAME
OF URC)): Please enter the location of, and time spent for your such consultations.

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<tr>
<td>Phone call</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sample 1**
- X
- AAA
- 5

**Sample 2**
- X
- 999
- 10
FOLLOW-UP SURVEY
SCHOOL OF ARCHITECTURE – COLLEGE OF DESIGN – NCSU

PART 1. INFORMATION ABOUT YOUR WORKSPACES

Please examine the floor plans of (NAME OF URC).

1. By drawing small dots (•), please indicate on (NAME OF URC) floor plans:
   - where you most frequently meet / come across others within (NAME OF URC), excluding pre-scheduled appointments.
   What do you like best about these spaces?

2. By drawing small crosses (X), please indicate on (NAME OF URC) floor plans:
   - where you go within (NAME OF URC) regularly when you leave your office.
   Why?

3. All in all, how satisfied are you with (NAME OF URC) overall physical work environment (please circle one)?

<table>
<thead>
<tr>
<th>Very Unsatisfied</th>
<th>Unsatisfied</th>
<th>Slightly Unsatisfied</th>
<th>Neutral</th>
<th>Slightly Satisfied</th>
<th>Satisfied</th>
<th>Slightly Satisfied</th>
<th>Very Satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

   What do you like best about (NAME OF URC) overall physical work environment?

   What do you like least about (NAME OF URC) overall physical work environment?
### APPENDIX B (continued). SAMPLE FOLLOW-UP SURVEY PAGE 2.

#### PART 2: INFORMATION ABOUT YOU

2.1. Please indicate the number of papers, books, etc. that you have produced as of (NAME OF URC) (please include those in press / forthcoming). In parentheses, please also mention how many of these were produced after moving to the new building (if applicable).

<table>
<thead>
<tr>
<th>Books:</th>
<th>Book Chapters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Articles:</td>
<td>Papers:</td>
</tr>
<tr>
<td>Project proposals:</td>
<td>Conference papers:</td>
</tr>
<tr>
<td>Technical manuscripts:</td>
<td>Patents:</td>
</tr>
<tr>
<td>New algorithms:</td>
<td>New applications:</td>
</tr>
<tr>
<td>Blueprints:</td>
<td>Reports / working papers:</td>
</tr>
<tr>
<td>Experimental prototypes:</td>
<td>Other (please specify):</td>
</tr>
</tbody>
</table>

2.2. Please enter the office number of those colleagues in (NAME OF URC) with whom you most frequently discuss research related matters (at least once a week):

1. 
2. 
3. 

2.3. Please enter the office number of those colleagues from (NAME OF URC) that you meet most frequently in social occasions (weekends, etc.):

1. 
2. 
3. 

2.4. Imagine you encountered a technical obstacle or problem during your research project or task. Please rate the priority of the following information resources as potential references for you. Enter ratings in the spaces provided to the left (1 = highest priority, 9 = lowest priority).

<table>
<thead>
<tr>
<th>PRIORITY</th>
<th>INFORMATION RESOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Face-to-face consultation with a colleague</td>
</tr>
<tr>
<td></td>
<td>Literature (books, professional, and trade journals, and other publicly accessible written material)</td>
</tr>
<tr>
<td></td>
<td>Vendors (representatives of or documentation generated by suppliers or potential suppliers of equipment / design components)</td>
</tr>
<tr>
<td></td>
<td>Customers (representatives of or documentation generated by the agency / institution / firm for which the project is performed)</td>
</tr>
<tr>
<td></td>
<td>External sources (sources outside the research center that do not fall into any of the above categories)</td>
</tr>
<tr>
<td></td>
<td>Previous research conducted in (NAME OF URC) (any other project performed previously in the research center)</td>
</tr>
<tr>
<td></td>
<td>Personal experience (ideas that you used previously and were recalled directly from memory)</td>
</tr>
<tr>
<td></td>
<td>Experimentation (ideas that are the result of tests or experiments with no immediate input of information from any other source)</td>
</tr>
<tr>
<td></td>
<td>Other (Please specify):</td>
</tr>
</tbody>
</table>

2.5. How many months have you been working with (NAME OF URC)?

2.6. Your latest degree and its year:
### PART 3: YOUR ASSESSMENT OF THE RESEARCH CENTER

Please circle the appropriate rating for each item.

- **VP** = very poor
- **P** = poor
- **SP** = slightly poor
- **N** = neutral
- **SG** = slightly good
- **G** = good
- **VG** = very good

| Creativity and innovativeness of research conducted in the center | VP | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| The center’s overall contribution to the field | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| The center’s recognition/reputation | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| All in all, how satisfied are you with the research processes in [NAME OF URC]? | 1 | 2 | 3 | 4 | 5 | 6 | 7 |