EXPLORING EVOLVING PROGRAMS IN ARCHITECTURE:

A DETAILED ANALYSIS AND DESIGN FOR FUTURE PROOFING SINGAPORE'S CHANGI AIRPORT.

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ABSTRACT

Architecture and technology have a constrained relationship in part to their diverging principal-qualities (permanence vs speed, respectively). Buildings, while often designed with technical integration in mind, are rarely designed to take advantage of or to anticipate future trends or technologies. This misappropriation of technological progress in architecture materializes in form of retrofits, additions, and expansions – a chase in which architecture lags behind technology and its resulting and profound influence on culture and behavior. Architectural design and building programs may benefit from a deeper consideration and anticipation of evolving technological elements early in the design process. There may be no better building typology to understand past, present, and future design approaches than airports and their sequentially constructed terminals – true case studies of design thought and influences in contained and chronological configuration; snapshots of architectural and technological dependencies. This dissertation examines the past, current and proposed terminal designs at Singapore's Changi Airport in order to understand the influences, technological contribution, and passenger experience goals throughout the terminal design process. The dissertation concludes with an alternative design to the currently proposed Terminal 5 design and aims to conceptually unify and prepare each current terminal for additional terminals as the airport expands.

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Introduction

New technology is developed to improve and enhance our quality of life. Advances in technology, including innovative products or services, often undergo complete and radical transformations in very short amounts of time, yet in architecture the development of new programs are primarily considered from conventional understanding of current or past technology. In order to keep up with the rate of technological innovation designers today need to anticipate future developments and technological advances and incorporate them early in the design process. The possibility of utilizing technological offerings and integrating them within an architectural program is not only possible, but should be a driving force throughout the design process. This is especially true for building programs that tightly align with technological advances, such as travel and aviation.

This dissertation addresses two questions:

1. What influences have affected current architectural thought which adhere technological advances to architecture, and how are they used to reimagine spaces? 2. How can we use lessons learned from studying previous iterations of programmatic development in design to better anticipated design for future growth?

Modern technology can improve architectural spaces and demanding architectural programs. By integrating technological potential within the design process, rather than having them become additive to architecture, current architectural programs can anticipate tech advances that impact how spaces may be changed and used in the future. By redesigning the program to an operational ideal, technology and architecture can work together rather than remain isolated in independent and novel configurations.

To understand the current integration of technology within architecture, the typology of airports was chosen for its value use of updated technology and the designer's insight in reconfiguring spaces to accommodate said innovations. The case study of Singapore's Changi International Airport reveals how architects are heavily influenced by trends and information in their designs. Rather than anticipating and designing for future integration, each expansion and renovation were driven from previous events that led the design approach. Often economical but always singular in approach, technological influence at Changi airports drive the design of each new or updated terminal. The frequent upgrades only aim to improve familiar programs. Thus, the potential technology offers is restrained from the start. Changi provides a great basis for understanding the influences of past and present design approach. In addition, future enhancements and projects have already begun allowing the dissertation to delve into the designer's mind in how future airport operations in Singapore are expected to become. Through the analysis of the previous three terminals and the almost completed fourth, criticism and suggestions are applied onto the fifth terminal to improve and utilize

the technological potential airports may undertake for the design for passenger experiences. The result reimagines the airport program and suggests an architectural destination rather than an inconvenient stop prior to travel.

The dissertation is organized in two parts. The first part analysis the influences that have affected current architectural thought, and the second part uses those lessons to reimagine Singapore's Changi Airport's program in order to anticipate for future adaptations and use. Chapter 1 discusses the introduction and recent study of place. Theories developed from professions outside of architecture have influenced place, the term given to an emotional connected space, is the goal of many architects since its theoretical inception. Place, as we understand it, are based from spatiality theories that were developed from aesthetic and empathy theories of psychology. However, our current understanding of places is limited to our physical senses and the adaptations/associations we create through them.

Our physical senses (sight, sound, touch, smell, and taste), discussed in Chapter 2, reviews how we perceive our environments and interpret through our individual lenses. The interpreted senses of adaptations and associations however are little understood in architecture design. This dissertation introduces major contributors to our interpreted meaning of places, our social culture and desires being one of them.

Perhaps our biggest social contribution over the last few decades has been the introduction of modern technology. Describing the current overwhelming cultural shift by technology and new media, the Digital Renaissance in Chapter 3, is defined as the rebirth or rediscovery of old ideas in a new context. Like the original Renaissance (14th-17th century), most innovations and improvements regarding human life were manufactured as an answer to the way of life of the Middle Ages. If we keep our renaissance-based sensibilities and awareness, we have the advantage towards enormous amounts of cultural progress. The current use of technological advances has contributed to human being's perceptions of the world. Architectural technologies are central to buildings as they are the systems that enhance the experience of the physical environment. These technologies have become imperative to our places and the collective human sensorium and applied mildly to enhance our perceptions of space.

Architects primarily view technology as an afterthought to space creation. However, modern technology and architecture has become inseparable from each other and must be accepted as so. Typically, newer technologies are not designed for the space within architecture, and the architecture never imagined such technology within its spaces during the design phases resulting in constrictive architectural experiences.

In Chapter 4, Singapore's Changi Airport is analyzed chronologically and mapped to show each influence and change that technology had upon the airport design process. The terminals were built, renovated, or expanded upon; all with technological influences behind their changes. The mapping of Changi airport's design intent reveals the retrofitting nature of each expansion, and how little thought future influences technology would have within the architecture. The closed thought results in nearly identical programmatic use from its beginnings in 1981 to its most current. In fact, an

argument is made that it has only moved backwards in passenger experiences, polar opposites of technological innovation goals.

The dissertation then shifts to understand how we can use these technological advantages to reimagine programs, spaces, and improve the architecture. To start, Chapter 5 further analysis Changi's upcoming projects as they are currently planned. Starting with Terminal 4, to be completed in late 2017, we see a step towards passenger experience in terms of the departing passenger. Switching to a centralized security scheme from its decentralized schemes in the earlier three terminals, passengers are funneled through the transit mall. Commercial opportunities being highlighted in Terminal 4 can be traced to the significant global growth of duty free products. However, the passenger experience seems to end with the departing passenger, as arrivals and transit become more difficult in the process.

Another positive user experience comes at the hands of the planned Jewel of Changi. A large indoor garden and commercial complex to provide locals, transit passengers, and flyers an incomparable retail experience. The 10-story complex located centrally of Terminal 1, 2, and 3 and aims to connect the three independent-like terminals.

The late 2020's Terminal 5's proposal however, has no clear passenger experience design goal or purpose that the Jewel of Changi and Terminal 4 attempts. Designed to maximize passenger capacity through linear satellites such as Atlanta Hartsfield-Jackson Airport, the terminal aims to double the capacity of Terminal's 1-4 combined. As each terminal currently suffers from acting as individual airports, Terminal 5 only intensify the separation and sprawl of Singapore's Changi International Airport.

The disserntation then shifts to offer solutions to the problems observed up to this point. In Chapter 6, the dissertation investigates how programs can be updated for the future through existing modern technologies. In doing so, anticipating the design and infrastructure for future terminals and technologies. The proposal aims to vastly improve the fundamental airport experience from the foundational programs set decades ago. Seeing automated technology proved successful at other locales, and projecting for improvements, many of the cumbersome tasks and stresses an airport forces upon one can be either managed or mitigated. New infrastructural programs for baggage and ticketing handled prior to arrival and levels of unobtrusive security layouts that allow the public to traverse throughout the airport provides potential experiences of an airport missing today.

Improved and reimagined concepts of the airport experience such as: having direct path to the boarding gate, in-transit (layover) passengers having a centralized node to navigate through the airport on top of enjoying amenities, and having your loved ones accompany you to the entrance of the boarding gate. This potential itself, alongside the retail opportunities give an array of benefits alongside the potential of having the airport reimagined as the final place before departure rather than an airport being a quick transit hurdle in-between destinations.

Seeing qualities of architecture to how airports have been constructed and designed, the dissertation applies its learnt technological influences and anticipates the potential technology brings to introduce a different yet more efficient, economical, and

enjoyable airport experience. All the lessons learned and discussed in this dissertation are to be understood throughout the architectural design process.

CHAPTER 1. PLACES IN ARCHITECTURAL DESIGN

Architecture has many specialized fields that layer its knowledge. The profession consists of landscape architects, residential architects, and industrial architects, and much more; with many more subsets and consultants within the field who further bring unique elements of knowledge into the collective profession. The network of knowledge related to architecture is vast, though most architects share a mutual goal—namely to create an emotional association and adaptation to the ranges of space within a given built environment. Understood as *place*, architectural theorists, philosophers, sociologists, psychologists, and urban design theorists have focused on the relationship between place within its construct in space. Formative theorists such as Martin Heidegger, Maurice Merleau-Ponty, John Brinkerhoff Jackson, Marc-Antoine Laugier, and Eugene Viollet-le-Duc have contributed to a deep understanding of the features used to describe place and the effects of place being central and impactful in a person's life. In addition, Gottfried Semper, Adolf Loos, Emanuel Kant, Grant Hildebrand, Theodor Lipps, and August Schmarsow, among many others, have set up the basis for understanding the founding architectural ideas of space and spatiality in which place theories later developed from. In the digital age, electronic and digital mediums have managed to, both, quietly and not so quietly embed themselves in the field of contemporary architecture. An in-depth investigation into more philosophical perceptions of the components of place is essential to understanding the true impact and influence the less perceived aspects of the digital age have truly had on the nature of space and place.

1.2 Place

Places suit our most intimate moments as well as to offer the setting for our most sociable activities.[1] Each day flows in an ordered rhythm from the quiet privacy of the home to the busiest and most socially active places returning, at

[1] Ellen J. Pader, *Inside Spatial Relations* (Architecture Et Comportement/Architecture & Behaviour 1988).

the end of the day, to the intimate. An individual's home is the base for the appreciation of privacy and the expression of one's individuality. People move from the security of their home to the peak of their daily interactions, and back to their privacy throughout their days. For most people, this includes school or work. After we accommodate our school or work responsibilities (or elements of recreation), we dedicate our spare time to more personally pleasurable activities in a more intimate and preferable setting. For some, shopping at malls, movie-going, gathering with friends, and other enjoyments indulged in before the eventual journey back home. Deviations from our routines through added responsibilities and/or further hobby preferences. However, our formation of place become influenced by our social behaviors and preferences of activities through levels of boundaries within space and architecture. Creating emotionally invested places, architectures individualized influence, are only consciously formed by understanding how humans adapt with, function in, and associate to place.

In classical Roman religion, *Genius Loci* was the protective spirit of place which transitioned into a constant theme in architectural discourse. In "A Sense of Place, a Sense of time", John Brinkerhoff Jackson criticizes the modern translation of Genius Loci. He believes the term is becoming widely misused with the field of architecture to describe the *character* goal of the project.[2] He writes that the term too often used, (chiefly by architects but taken over by urban planners, interior decorators, and realtors)[3] to the point that it has lost its genius. Jackson describes the original and classical definitions as "the guardian divinity," while the eighteenth century Latin phrase translates to "the influence of place." Today, architects use the term to define the character or quality of a given place, but per Jackson and other nineteenth and twentieth century architectural philosophers, places should reveal to individuals their meaning and influence. If architects are to organize places, they should understand their purposes, components, and definitions.

[2] John Brinckerhoff Jackson, *a Sense of Place, a Sense of Time* (Yale University Press, 1994).
[3] Ibid.

Theories of place gained popularity among architects between 1970 and 1990 with Martin Heidegger's theory of phenomenology and particularly with Kenneth Frampton's Critical Regionalism – architecture tied to geographical and cultural context – and place theorist Christian Norberg-Schulz's ideas on Genius Loci, per Kim Dovey.[4]

Twentieth-century German philosopher Martin Heidegger developed widely influential philosophical, hermeneutic theories still reflected upon today. He wrote that *dwelling* is the action of being a part of the world, and through dwelling, places are formed.[5] For Heidegger, architecture would then be established as a process of building that holds pivotal the idea of dwelling as inhabitation (i.e., human-oriented); "buildings result from the intent to dwell—and the action of dwelling—and in so doing creates place."[6] He viewed space as a locale, and place being created by the presence of an object within it. He gives an example of a stretch of riverbank that "comes only into existence only by the virtue of the bridge."[7] Out of the many areas (space) along the river, the construction of a bridge deliberate (place) formed on the site gives meaning to. Although Heidegger never discusses the human element regarding the creation of place, he writes that a riverbank is purely a locale without the use of a bridge to reveal the potential of the riverbank. Heidegger's comments directed towards the field of philosophy, rather than architecture, and it was not until "The Poetics of Space," by Norberg-Schulz and Gaston Barchelard, that Heidegger's writing became interpreted through an architecture attitude. It was, however, the lack of acknowledgement of the human intervention in the account of place that provoked Maurice Merleau-Pont's expansion of place theory.

In "Phenomenology of Perception," Merleau argues the need to recognize the boundaries of one's own spatiality. He tells, "far from my body's being for me no more than fragment of space, there would be no space at all for me if I had no

[4] Kim Dover, *Framing Places: Mediating Power in Built Form* (Psychology Press, 1999).
[5] Martin Heidegger, *In Poetry, Language, Thought* (Harper Perennial*, 1971),* 350-351.
[6] Martin Heidegger and John Macquarrie, *Being and Time* (Harper Perennial, 1927).
[7] Ibid.

body."[8] Given his proposal, an emphasis on the human element became doctored into place theory. Zimmerman echoes the thinking of Heidegger, Merleau-Ponty, and Barchelard by writing that learning to be mortal is the essence of dwelling. In essence, relationships to our built environment are rooted in experience.[9] These theorists' writings postulate that we act on our environments, thus we are aware of the environment, in practice and in thought.[10] The human element is architecture, they surmise. Without dwelling and the associated human experience, architecture, as humans understand it, would be no more than an organized pile of materials fashioned complexly; we would be no different than the beaver whose dam is simply less sophisticated and less conscious exploitation of the environment solely for habitation.

As Merleau, Barchelard, and Zimmerman have written that place would not exist without the human body, similarly yet expanded upon, Lefebvre conceptualizes the philosophy of the mind in space: In *Production of Space*, first published in French in 1974, Lefebvre poses, "the mind thinks of space, but it does so within a space, a space that it is at once both conceptual, but also physical, a space that is embodiment of social relations, and of ideology. One of the aims of the world is to expose the nature of the relationship between the space produced by thought, and the space within which thought happens."[11] Place in this dissertation, referenced as *Social Space* by Lefebvre, is the cultural life in which societies "secrete" space, producing and appropriating as they go along.[12] It is a feature of modern society to reduce this complex space, which is at once perceived through our physical interactions, conceived as thoughts, and lived as experiences.[13]

[8] Maurice Merleau-Ponty and Colin Smith, *Phenomenology of perception* (Motilal Banarsidass Publishe, 1996), 146.
[9] *Barry* J. *Zimmerman, The Development of "Intrinsic" Motivation: a Social Learning Analysis* (Annals of Child Development, 1985)
[10] Colin Richards and Michael Parker Pearson, *Architecture and Order: Approaches to Social Space* (Routledge, 2003).
[11] Adrian Forty, *Words and Buildings: A Vocabulary of Modern Architecture* (Thames & Hudson, 2004), 19.
[12] Henri Lefebvre, *The Production of Space* (Wiley-Blackwell 1992), 38.
[13]Forty, *Words and Buildings,* 17.

Unlike Heidegger, Lefebvre connects his philosophical theories specially to architecture. He rephrases social space—to create wordplay—as “architectural space” and introduces “space of architects”, the architect’s hand in space. On the “space of architects”, Lefebvre writes, “Architecture produces living bodies, each with its own distinctive traits. The animating principle of such a body, its presence, is neither visible nor legible as such, nor is it the object of any discourse, for it reproduces itself within those who use the space in question, within their lived experience.”[14] Places are not physically defined, nor are they visible. The distinction between space and place can only understood by the individual it affects. Clear architectural design removes the distractions and allow our minds to conceptualize place.

The space for architects to design, place, is the manipulation of space affected by architects in their professional practice, and the discourse in which that activity occurs. Place making architects may have all alluded to architecture not being specific to buildings, but Lefebvre releases the bounds of architecture from purely a profession for physical construction and into a conceptual abstraction of place. “All disciplines are involved in space, and there is no sense in which architecture, by its relation to buildings, has any more right to space than any other discipline.”[15] Architecture is not for the architect. Fashion designers are architects in the manner they navigate the human body and see the qualities of materials. Some fabrics have structural integrity that allows the designer to use the body as a foundational piece and invoke the space around them, while other materials conform to the bodily curves and environment. Similarly, laptop designers must consider many factors that building architects must consider such as heat circulation, power efficiency, spatial dimensions, program unity, and structural integrity. Laptop designers creatively push the boundaries of hardware in attempt to maximize the efficiency and ease of use for the human user. In both examples, the designer should make deliberate and contemplated decisions around the space of the human body, its use, and scale.

[14] Lefebvre, *The Production of Space,* 137.
[15] Ibid., 107.

What separates the architect from the other design professions should be the understanding of the place making qualities of architectural space.

Places, architecture psychologist Alain de Botton asserts, are the spaces we associate ourselves to—the spaces in which we are the most comfortable. We have adapted to our places. It is a human psychological trait to shape our spaces to legitimize our own ideals. We need our homes to embrace us, to be a part of who we are, and conform to our personalities. Place shelter our psychological sense as much as in the physical—to compensate for the individual's vulnerability; as a refuge to shore up our states of mind.[16] Place design incorporates many factors. Understanding the areas—spaces and built environments—in relation to the psychological and sociological factors of adaptation and association is essential to the understanding of architectural places.

1.3 Space and Spaciality

Today, in the world of architecture, space manipulation and organization is the fundamental skill of the architect. Understanding spatial formation will allow the architect to design with intent of place making. Place making is a relatively new concept in architecture. Before the 1890s, volume and void constructed space, and was only briefly discussed among German philosophers who wrote about the topic of architecture. The term for architectural space was blind to the English-speaking world until the translation of Bauhaus professor Laszlo Moholy-Nag's "The New Vision" in 1930. The philosophical discourse of architectural space before its becoming a theme in architectural circles is best summarized in two specific discourses written between 1890 and 1930, both of which define space as enclosure and as a psychological construct.

The first instance of spatial theory came from the German architect Gottfried Semper. Adrian Forty writes in "Words and Buildings" that German architectural circles briefly discussed space before the 1940s, no one went as far

[16] Alain de Botton, *The Architecture of Happiness* (New York: Pantheon Books, 2006).

as Semper to suggest that spatial enclosure is fundamental to architecture. He states, “The first impulse for architecture was the enclosing of space. The material components are only secondary to spatial enclosure, so the wall is that architectural element that formally represents and makes visible the enclosed space.” [17] Semper argues that the task of the architect is to create an enclosing space, and the wall as a tool allows this to be realized, noting that the material of the wall is secondary to the actual enclosing of space. Semper would later term this as volumetric theory in in Germany.

Although Semper’s writings on the idea of space are brief, those who Forty calls the “German-speaking proto-modern architects”—Adolf Loos, H. P. Berlage, and Peter Behrens—first articulated the subject of architectural space in the late nineteenth and early twentieth centuries. In 1898, Loos writes, in “The Principle of Cladding,” “The architect’s general task is to provide a warm and livable space.” He continues, “[E]ffects are produced by both the material and the form of space.” Creating boundaries and deliberate nodes to produce livable place are the basis of constructing spaces per Loos. Sixteen years later, Loos expanded upon the original idea and developed the expressive term *raumplan* to describe spatial planning. Creating the 1928 Villa Muller, Loos writes, “As a man will one day succeed in playing chess on a three-dimensional board, so too other architects will solve the problem of the three-dimensional plan.”[18] He believed that, one day, plans, sections, and elevations would not be the tools from which space would form from.

In a 1905 lecture published in German and translated as “Thoughts on Style,” Hendrick Petrus Berlage states that architecture is “the art of spatial enclosure”.[19] He says that architects must emphasize the architectonic nature of space, in both a constructive and a decorative sense. He was speaking to the façade-oriented architects who understood buildings primarily from the outside.[20]

[17] Forty, *Words and Buildings*.
[18] Adolf Loos, *Principle of Cladding* (Neue Freie Presse, 1989).
[19] Hendrik Petrus Berlage, *Thoughts on Style* (Getty Center for the History of Art and Humanities, 1996), 152.
[20] Ibid.

In a later 1909 article, he declares even more categorically, "[T]he purposes of architecture is to create place, and it should thus proceed from space."[21] Space is the architectural material configured to create place.

In similar consideration, Peter Behrens published "Art and Technology" in 1910. The architect's disregard for the space within structure and less concerned with the aesthetics of the outside of the building concerned Behrens. He writes, "For architecture is the creation of volumes, and its task is not to clad but essentially to enclose space."[22] The contents and use within space is much more profound than the visual connections we tend to seek in architecture.

These three architectural writers had significant influence on generations of the 1920s modernist movements based on Semper's model of enclosed space. Forty believes that the architects from that period found it easiest to view space as an enclosure and to apply it to practical terms.[23] Specific to this period, the modernist movement took foothold within Western societies producing rapid growth of cities and industrialism. Thus, enforcing the theory of space as enclosure being the widely-accepted model in architectural concepts still present today, though profounder meanings of spatial theories would later develop.

Influence of spatial theory also has origins in philosophy. In the 1781 "Critique of Pure Reason," philosopher Immanuel Kant tried to reduce the tension between absolute space and relative space. Absolute space by Sir Isaac Newton states that space is always similar and immoveable, while relative space by Gottfried Lebinz states that space is a moveable dimension or measure of absolute space which our senses determine by its position to bodies.[24] Kant states that space is not an empirical concept that has been derived from external experiences, nor does it represent any property of objects in themselves or in their relation to one another.[25] Kant is speaking of two objects in relation to each other defining space. He continues by proposing that space exists in the mind as

[21] Ibid., 209.
[22] Peter Behrens, *On Art and Technology* (1910), 217.
[23] Forty, *Words and Buildings.*
[24] Erdem Ungur, *Space: The undefinable space of architecture* (2011).
[25] Forty, *Words and Buildings,* 68-71.

intuition. Prior experiences determine the relationships between space and object and can be only understood from a human perspective. Only humans can speak of space, thus the mind makes the world intelligible. While Kant introduces the conceptualization of space within the human mind, he did not develop its use for aesthetic judgments.[26] Three essays written in around the same time did.

The first of these essays comes from German sculptor Adolf Hildebrand in his 1893 “The Problem of Form in Painting and Sculpture.” He writes that the attention to the “process of perception” of things in the world might itself “lead to grasping inherent themes not only of sculpture but also of painting and of architecture”.[27] His knowledge of architecture is based on Semper’s teachings of enclosed space; however, for Hildebrand, space is a “three-dimensional mobility or kinesthetic activity of our imagination.”[28] Space is a dynamic force conceptualized within the mind. He continues as follows.

> If we now set for ourselves the task of making visible the appearance of this natural space as a whole, we first have to imagine it three-dimensionally as a void filled in part by the individual volumes of object and in part by the air. The void exists not as something externally limited but rather as something internally animated. Just as the boundary or form of an object indicates its volume, it is also possible to compose objects in such as way that they evoke the idea of a volume of air bounded by them. The boundary of an object is, strictly speaking, also the boundary of the body of air surrounding it.[29]

Hildebrand suggests that space itself as the subject matter of art, that it is a continuum animated from within. Forty suggests that Hildebrand established three major theories of space that would become especially significant throughout the modern era: space as the subject matter of art, space as a

[26] Ungur, *Space; The undefinable space of architecture* (2011), 3.
[27] Ibid., 4.
[28] Adolf Von Hildebrand, *The Problem of Form in Painting* (Forgotten Books, 2015), 238.
[29] Ibid., 239.

continuum, and space is animated from within.[30] He proposes that architecture, compared to other art forms, does not need the artist to represent space by the means of figures or objects; the work of architecture itself already orients one within a given space. This theory led Hildebrand to argue that there is no need to reconstitute spatiality through objects. It is space itself that is the form with which the eye concerns. He concludes that the mind must first grasp the space as a form, and that, without doing so, one is unable to perceive the physical elements as anything other than just matter.

Space as a significant mental construct concept intrigued art historian August Schmarsow. In “The Essence of Architectural Creation.” Like Hildebrand, Schmarsow denies that the aesthetic of architecture lies in its material components, and he equates space in architecture with form.[31] His original thought is derived from the theory of empathy—that in perceiving things the mind projects into them its knowledge of bodily sensations.[32] According to Forty, Schmarsow stresses that the “spatial construct” is a property of the mind and not to be confused with the “actual geometrical space present in buildings”.[33] This concept was further developed by twentieth-century German philosopher Martin Heidegger, who was largely ignored by architects of the modern era.[34] While his writings did not have much impact on the practice of architecture as Heidegger’s audience was more interested in philosophy, it did impacted notable historians of art Alois Riegl and Paul Frankl. As Schmarsow states, “The history of architecture is the history of the sense of space.”[35] The senses perceive space, and as it has always been, Schmarsow concludes that the art of design through the senses is the purpose of architectural space.

Finally, space as a mental construct appears in 1893 through the works of “theory of aesthetics” philosopher Theodor Lipps. In his essay “Raumästhetik und Geometrish-Optische Täuschungen”, argues that there were two kinds of

[30] Forty, *Words and Buildings.*
[31] Ibid.
[32] Ibid.
[33] Ibid.
[34] Ibid.
[35] August Schmarsow, *The Essence of Architectural Creation* (1983), 296.

seeing—optical, which is concerned with matter, and aesthetic, which is concerned with what is left after matter is removed.[36] Täuschungen argues that interpretation is the power of vision. Lipps considers space as a dematerialized object.

> Since forceful or vital space is the single object of the arts of abstract space creation, nothing can prevent us from eliminating the material carrier. So it is possible that in the art of abstract representation of space, the spatial form can exist purely, immaterialized.[37]

Lipps's theory, as compared to those of Schmarsow of Hildebrand, did not contemplate any concept of space as an enclosure, however. In fact, of the three, his theories of space are the least specific in regards to architecture. Regardless, Lipps had the immediate influence (of the three) upon architects, especially in the Art Nouveau movement (1890-1905).[38] English writer Geoffrey Scott references Lipps in "The Architecture of Humanism" of 1914. In the text, Scott presents the first English-language account of the era's emerging sense of spatiality as a theme in architecture.[39]

Space—the unavoidable element in all architectural works— is the architect's primary material. Through a variety of theories derived from those established by Semper, space can be measured and enclosed through materials. Perceptual-origin psychologist Rudolph Arnheim defines space as always present and existing but experienced only through the interrelations of objects.[40] As such, these objects are organized systematically through advanced society's measurements of space.

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[36] Forty, *Words and Buildings*.
[37] Cornelis Van De Ven, *Space in Architecture: The Evolution of a New Idea in the Theory and History of Modern Movements* (Van Gorcum Ltd, 1987), 81.
[38] Geoffrey Scott, *The Architecture of Humanism* (Boston and New York: Houghton Mifflin Company, 1914), 226-230.
[39] Ibid.
[40] Rudolf Arnheim, *Art and Visual Perception: A Psychology of the Creative Eye* (University of California Press, 1974), Page 10.

The theories of Hildebran, Schmarsow, and Lipps envisioned the consideration of spatiality and eventually influenced the theories of Heidegger and Lefebvre. In built space theory, physical enclosures forms space, and the size and strength of the bordering element decide the levels of privacy. Boundaries as the tool for space forming was an important discovery for the Dutch De Stijl movement and for the Bauhaus school, specifically Russian artist and designer El Lissitsky and Hungarian painter and photographer Moholy-Nagy who saw space as a continuum—the notion that the inside and outside spaces were continuous and infinite. The development of the theme was one of the most original aspects of spatial thinking in the 1920s. The levels of boundaries are not purely physical nor are they limited to the interior of a given enclosure. Boundaries of all strengths affects one's interpretation and understanding of architecture. The formation of space, and with careful delineation place creation, are formed not by enclosure of space, but by levels of perceived boundaries.

1.4 Built Environment

Today, the built environment refers to the collection of manufactured surroundings that offer the setting for human activities. The built environment exists as the accumulation of physical materials, spatial boundaries, people, and the cultural product of human labor.[41] The concept of built environment within mainstream architecture is accepted as having five interrelated and often correlated dimensions: density, land use, connectivity, scale, and aesthetic qualities. Urban planners, sociologists, psychologists—and architects—further seek to find the subtler implications of sociality created by the built environment.

Many psychologists connect the built environment to human behavior. When we navigate the built environment, particularly an unfamiliar one, we create mental maps of the lived experience. As we explore our environments, neurons in the brain record and map familiar situations, events, and diurnal

[41] Karen Roof and Oleru Ngozi, "Public Health: Seattle and King Country's," *Special Report,* 2008, http://www.cdc.gov/nceh/ehs/docs/jeh/2008/july-aug_w_case_studies/jeh_jul-aug_08_seattle.pdf.

routines. This neurological memory bank eases our performing of repetitive tasks. For an example, typing on a keyboard becomes ingrained in our haptic mobility. The keyboards repetitive use allows our brains to easily manage the specific keystrokes and eventually allow us to type without having to think nor look at the specific key pressed. Repetitive actions become less and less realized. Like keystrokes, the more often we re-navigate the built environment, the less we think about or realize the built environment.

Our perceptions of the built environment are revisited when something challenges our ingrained understanding of it. We forget the amount of ambient noise in the office until the air-conditioning turns off, the abundance of space available until the furniture reorganized, the paint color of a neighboring building not perceived until painted over, the view of the landscape until a new development obscures it, or the effects of boundaries in architecture that skip our awareness until read in a research paper such as this. Until a sudden change or challenge of our perceptions, our cognition pushes the reality away from the forefront of our minds.

Inherently, human beings perceive the built environment in a way that suits their preferences and exists for them in a favorable manner. The built environment is an eventual process related to survival. We built to survive, today we build more to sustain. Pollical theorist Hannah Arendt gives the distinctions between work and labor to understand what separates humans from other species. She claims that labor is a “natural” activity for all organisms, as it needs the use of the entire body to meet the body’s biological needs—to feed it, bathe it, dress it, and protect it from attack. Work, on the other hand, is an “unnatural” activity; the hand and brain are used to produce an artificial, non-biological world of human artifices (e.g., skyscrapers, textbooks, paintings, highways, symphonies, and pharmaceuticals).[42] These activities, world of working through thought are only of humans. The act of work, producing architecture, is a potential only human possess.

[42] Arendt Hannah, *The Human Condition* (Basic Books, 1959).

One of Columbia's architecture, planning, and preservation graduate school founder, James Marston Fitch contemplates human beings' potential for survival without architecture.

> Theoretically, at least, he might have migrated like the bird or hibernated like the bear. There are even a few favored spots on earth, like Hawaii, in which biological survival might have been possible without modification. But, on the sheer biological existence, man builds a vast superstructure of institutions, processes and activities: and these could not survive exposure to the natural environment even in those climates in which biologically, man could.[43]

The built environment becomes interposed between one's self and the world. Fitch writes that space "[E]ven in the simplest forms, invests man, surrounds and encapsulates him at every level of his existence, metabolically and perceptually."[44] Born in 1909, Fitch held views in keeping with the architects of the time and viewed space as enclosure and was interested in behavioral effects that closed enclosures have on human psychology and perception. He views the progressive layers of boundaries of humans' skin to build space and then to environment. Which laid the groundwork for Bill Mitchel's theories of boundaries discussed later in this dissertation.

The built environment is nothing without its human inhabitant. In fact, environments built but not inhabited are eerie and uncomfortable. Impressive architectural drawings or masterplans are mere illusions, theoretical until built and inhabited. Regardless of the intelligence behind a design, unrealized environments are only shells. An architectural design, if not materialized nor designed as place, offer little value. Architecture should be experienced with a mind toward its human users, programs, activities, the environment, and related spaces. Architecture makes an individual aware of his or her surrounding

[43] Robert Gutman, *People and Buildings* (Transaction Publishers, 2009), 8-9.
[44] Ibid.

environment, and the environment makes that individual aware of its use and purpose.

1.5 Adaptation

Adaptation, the cessation of response to a stimulus after repeated exposure to it, separates our understanding of places from spaces. Our bodies become comfortable with our built environments. Our most comfortably adapted places can be navigated blindly. “Our domicile is the refuge of our body, memory, and identity” writes the dean of Helsinki University of Technology Juhanni Palasmaa.[45] We are in constant dialogue and interaction with our respective environments.

Furthermore, Rick Potts attributes our sizeable brains and capacity of adaptation to humanity’s ability to alter our situations quickly. Due to humanity’s quick migration through the environments, from being migrators to settlers, we are biologically ready to adapt to new situations. The areas we have inhabited for a significant time become secondary and quickly become comfortable. At times, our adaptations to spaces—the nature of places—becomes unincorporated and unconsidered in design.[46]

Our built environment and architecture often reveals human beings’ adaptive nature—the instinctive ability to accommodate and harmonize with the construct they inhabit or use. Per the prolific architectural writer, Steen Eiler Rasmussen, in cathedrals of old such as St. Thomas Church in Leipzig, pastors and choirs had to form their way of preaching and singing in accordance with the architecture. Because of the high vaults, spatial formations, and reverberating materials, the preacher’s voice needed to resonate in a loud yet monotonous tone, typically in the note of A-sharp. If the pastor used his natural voice and it

[45] Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses* (Wiley, 2012), Page 64.
[46] Nathaneal Massey, “Humans May Be the Most Adaptive Species.” *Scientific American.* September 25, 2013. http://www.scientificamerican.com/article/humans-may-be-most-adaptive-species/

was loud enough to reach every member, each syllable would reverberate for so long that an overlapping of whole words would occur and the message would become confusing.[47] In addition, hymnals were designed around the reverberations and echoes, leading to the development of polyphonic singing – two or more simultaneous line of independent melody, as opposed to a musical texture with just one voice. The earliest noted use of polyphonic singing in Western church dates to B.C. 900.[48] Contemporary church music would sound too garbled and indiscernible if sung in classical cathedrals.

The German composer Johann Sebastian Bach, regarded as one of the greatest composers ever, can attribute many of his musical innovations to cathedral architecture. Bach learned how to play the organ in a cathedral and honed his skills of harmonics, motivic organizations (smallest structural unit having thematic identity), and counterpoint (polyphony), among other innovative techniques, through his adaptation to the architecture.[49] His compositions were consistently played within Europe's cathedrals, and they resonated with the congregations as well as those interested solely in the creation and intricacies of his compositions.

As Rasmussen reminds us, human beings are often oblivious to how much they make definitive adaptations to their new surroundings and/or inhabited built environments. Habituation is adaptive and with the introduction of technology, so to where they adapted into our habitats. Initially having met overt skepticism, "technology" eventually integrated itself into the fabric of the lives of everyone in developed and developing countries. Unnoticeably, people assimilated technology into their respective lives and adapted to using it in their daily activities. Today, technology is widely an agent that improves humans' quality of life. The elevator is one small example of technology assimilated and welcomed. The first commercial passenger elevator was introduced in a five-

[47] Steen Eiler Rasmussen, *Experiencing Architecture* (M.I.T. Press, 1964), Page 228.
[48] Riemann Hugo, *History of music theory, books I and II: polyphonic theory to the sixteenth century* (Da Capo Press, June 1974).
[49] Steen Eiler Rasmussen, *Experiencing Architecture* (M.I.T. Press, 1964), Page 229.

story department store in New York City in 1857.[50] It revolutionized the building industry and allowed for the construction of buildings to extraordinary heights, giving convenience for high-rise dwellers, and giving an innovative, contemporary design component for architects. Today with new potential for vertical circulation, architects have planned the construction of elevators centrally in buildings, improving overall building circulation, spatial efficiency, and, through core design, structural integrity. Elevators organized within structural design have often caused architects to neglect the design placement and use of stairs. The desire to implement useful technology within buildings often neglect the complete organization of space and its volumetric potential. Elevators have become the sole means for prompt vertical circulation, relegating stairwells to the corner of buildings. Exclusively for fire egress, often these staircases become old, dusty, dark, and undesirable spaces.

A study at led by David R. Basset, from the Department of Kinesiology, Recreation, and Sports Study at the University of Tennessee Knoxville, conducted experiments with multiple buildings at UT Knoxville, researching the use of stairs in relation to their respective placement and quality.[51] The studies concluded that buildings that exclusively used stairs as fire egress had only 8% of occupants using the stairs to go up and 10% of occupants to go down.[52] All other circulation was handled by centrally organized elevators. The university then conducted research on buildings with naturally lit, central staircases. Elevators in these buildings were organized at the corners, specifically designed for Americans with Disabilities Act(ADA) purposes. Researchers found that 73% of respective building occupants used the stairs to walk up and 90% used them to go down.[53] The organization and implementation of technology have significant effects on the way people use and move through space. Our

[50] Laura Schumm, “Who invented the elevator?” *History.* April 23, 2014. http://www.history.com/news/ask-history/who-invented-the-elevator

[51] David R. Bassett, Ray Browning, Scott A. Conger, Dana L. Wolff, and Jenifer I. Flynn, “Architectural Design and Physical Activity: An Observational Study of Staircase and Elevator Use in Different Buildings," *Journal of Physical Activity & Health* 10, (2013).

[52] Ibid.

[53] Ibid.

implementation of technology must be configured and contemplated to truly design good spaces, heightening the potential of place.

A similar study conducted by the *Journal of Public Health Policy*, by Gary Nicool and Zimring titled, “Effect of Innovative Building Design on Physical Activity,” found that the that 72.8% of the employees at Caltrans District 7 Headquarter Building used the stairs daily.[54] Using a “push” strategy which directed circulation to the stairwells through circulation design, architecturally, people moved towards stairs over the elevator. Today, humans are quick to find centrally placed elevators, clearly an adaptive choice and condition of modern human beings. The study reveals that humans do not mind walking up and down stairs. However, when the design directs one to use elevators and become dependent on them, health and emotional behavior suffer. Often with the implementation These un-shocking conclusions support Winston Churchill’s published thoughts, “first, we shape our buildings and afterwards our buildings shape us.”[55]

Adaptation to a given environment is biological. All species adapt to their environment and biologically answer conditions to improve their lives. Birds, for example, use their calls to call for mates or to warn others of potential predators and rivals. In forests where sounds bounce off trees and are absorbed by the leaves, birds make a short yet consistent call to others who might have misheard the first call to easily trace the second call. Those birds who live close to the forest floor use a lower frequency to diminish distorted effects by the ground when calling upon mates. Environment, wildlife, and conservation journalist Gareth Huw Davis writes on the kakapo bird’s high reaching potential. The kakapo in the Savannah use a buzzing sound that allows the sound to travel four

[54] Gayle Nicoll and Craig Zimring, "Effect of Innovative Building Design on Physical Activity," *Journal of Public Health Policy* 30, no. 1 (2009).

[55] Winston Churchill, (1874–1965), cited in: Randal O'Toole, *The Best-laid Plans* (Cato Institute, 2007), Page 161.

miles[56], and the “high frequency of calls of New Zealand blue ducks cut through the bubbling and rushing sounds of the water”.[57]

Adaptation is a biological mechanism that allows all living species to adapt to their environments. Whether built or natural, wildlife such as the birds of the Savannah or human beings at UT Knoxville, all interpret their surroundings and form their lives around the environment. This ability to quickly adapt to ever-changing environments are ingrained in our DNA’s past on from our migrating ancestors. It is thus important for architects to thoroughly employ this understanding in all design. As newer technology is introduced, we often evolve our way of life around such helpful tools but often disregard many of the other elements that create such comprehensive architecture. It is important to understand how we come to depend on such technology and consider if said technology is truly the intent of design. Architects have most of the control over how humans move through and use the built environment. Such a focus should be a greater concern than designing an edifice of beauty.

1.6 Association

The ability for an individual to set up some spatial orientation and cognition relies not only on sensory input—such as auditory, olfactory, and visual cues—but also on the individuals own combination of experiences and needs.[58] A personal association to an area is what separates space from place. It is common for individuals to have a common interest in place, but most places are individualized areas that cater towards their personal desires. A family shares a home as a place, but a private room is associated with the individual. Individuals shape their rooms with furniture, paint color, wallpaper, framed prints, and favorite knick-knacks;-transforming the spaces to mirror themselves. The university or work place one attends is associated with all others who attend, but

[56] Gareth Huw Davis, “Birds Songs.” *PBS,* Accessed September 20, 2015, http://www.pbs.org/lifeofbirds/songs/.
[57] David Bryne, *How Music Works* (McSweeny’s, 2013).
[58] William H. Ittelson, *An Introduction to Environmental Psychology* (Holt, Rinehart and Winston, 1974).

the area in which the student or employee is assigned is where one associates one's self when thinking of place. It is a comfortable refuge as it is familiar and consistent. Human beings lend our emotions and associations to a space, and the space lends us its atmosphere, which entices and emancipates the individual's perceptions and thoughts.[59] This is what profound architecture does to us per Juhanni Palassmaa in the *Eyes of the Skin;* it makes us experience ourselves as complete embodied and spiritual beings within space.[60]

Place needs an association with the major aspects of our encounters with things in the world. Space as such is not something that can be known apart from things. As we associate ourselves to places, understanding associative behavior, process in which human being learns and association between two stimuli,[61] becomes important. When approached by things one does not quite understand, one quickly creates comfortable comparisons in an attempt to familiarize one's self with it. Humans associate and assign characteristics to everything from basic elements such lines as colors to the most complex components.

Typeface decisions offer everyone from the everyday emailers to advanced graphics designers an array of choices to define themselves. There are millions of typefaces, and people choose the one that embodies their design concept or personality. People even associate characteristics to the look of a typeface. Swiss philosopher, Alain de Botton, explains the behavioral associations he has found to have toward typefaces. "Helvetica", he writes, hints at a punctual, clean and optimistic attitude.[62] It comes as no surprise, then, that Apple has used the "Helvetica" typeface exclusively in all its user interfaces since 2007.[63]

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[59] Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses* (Wiley, 2012), Page 13.
[60] Ibid.
[61] Theresa Spanella, "Associative Learning: Definition, Theory, & Examples." *Study,* 2003-2017, http://study.com/academy/lesson/associative-learning-definition-theory-examples.html
[62] Alain de Botton, *The Architecture of Happiness* (Pantheon Books, 2006), 86.
[63] With the introduction of OS X 10.10 Yosmetie, Apple changed their user interfaces font to Helvetica Neue from Lucida Grande. *http://www.fastcodesign.com/3031354/apple-changes-os-xs-main-font-for-the-first-time-ever.*

While the typeface "Pholiphilus" has a droopy head, and soft features; it strikes a sleepier, more sheepish and more pensive note. [64] Texts written in "Poliphilus" remind one of fiction, magic, and wonder. De Botton writes, "[S]o refined is our skill at detecting parallels to human beings in forms, textures, and colors that we can interpret a character from the humblest shape. A line is eloquent enough."[65] A straight line will induce the appearance of stability or dullness, while a wavy line appears calming, soothing, yet foolish; a jagged line reminds one of anger or confusion. An example from Botton's book illustrates the character of lines and the associated emotions in Figure 1.

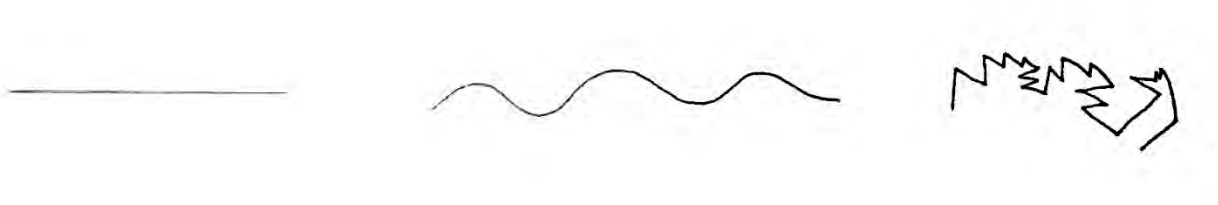
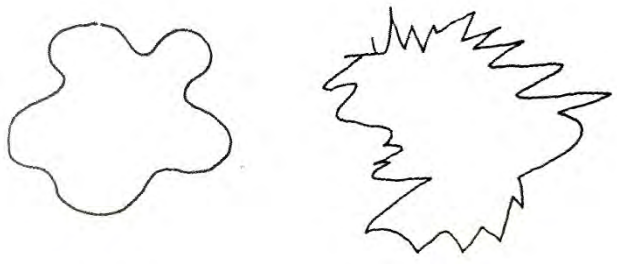


Figure 1. Behavioral Associations with Lines according to Alain de Botton[66]

Something as simple as the way a line is drawn can have most people perceive it in a particular way. Perceptual psychologist Rudolph Arnheim also published his findings of line and behavior association in *Visual Thinking*.[67] He had asked his students to quickly draw what a good marriage and a bad marriage looked like in line drawings. Smooth curves and mirror like symmetry reflect a union of love and peace, while rough, violently gyrating spikes serve as anger, disharmony, and strife.



[64] Botton, *The Architecture of Happiness,* 86.
[65] Ibid. 89.
[66] Figure cited from: Alain de Botton, *The Architecture of Happiness* (Pantheon Books, 2006), 89.
[67] Rudolf Arnheim, *Visual Thinking* (University of California Press, 1969).

Figure 2. Two line drawings depicting a good and bad marriage from Rudolph Arnheim, *Visual Thinking*, 1969[68]

The characteristics of ceiling height, size of the room, and finishes all factor into how we interpret and perceive space. Spaces are quickly internalized and adjusted towards, the associative behavioral characteristic that is often unconscious and goes unnoticed. Phenomenologists call this concept "the granted-ness of the world" or "natural attitude"[69] People rarely realize the conditions they are situated in until the perception of those conditions changes. For example, only when the room becomes too cold or hot do most people remember that there is a mechanical system controlling the temperature in our office space.

Psychologist Joan Meyers-Levy conducted research of the behavioral association of humans' experience with the ceiling heights of rooms.[70] Through her experiments, she found that ceilings with higher heights were associated with a freedom-like atmosphere, which allowed the users to be more imaginative than those exposed to lower ceiling heights. The response of people with high ceilings elected greater abstraction and higher-level thought processes. Those in rooms with low ceilings showed demonstrably quicker thought processes, revealing that people associate low ceilings with pressure, urgency, danger, restriction, and restraint. The higher ceilings association allowed the users to gain a zoomed-out perspective, mentally using the extra space in the room. In contrast, the lower ceilings created a more zoomed-in perspective, asking for more attention to details. Spatial boundaries impact peoples' psychological and emotional behaviors.[71]

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[68] Arnheim, *Visual Thinking*.

[69] David Seamon, "Phenomenology, Place, Environment, and Architecture" *College of Architecture Planning & Design: Kansas State University*, 2000, http://www.arch.ksu.edu/seamon/Seamon_reviewEAP.htm.

[70] Joan Meyers, Levy and Rui (Juliet) Zhu, "The Influence of Ceiling Height: The Effect of Priming on the Type of Processing That People Use," *Journal of Consumer Research* 34 (2007), http://assets.csom.umn.edu/assets/71190.pdf.

[71] Ibid.

"I know ___ like I know the back of my hand" is a common phrase to describe things people are completely sure they know. This may refer to the EU car nut who loves driving and repairing European car engines or the haute couture fashion buff who obsessive over wedding dresses and knows everything from taffeta to tulle. In addition to asserting one's knowledge, people associate emotions to objects, or to the factual understanding they possess about their culture. In 2009, Ravi Metah, a student at the University of British Columbia, Canada conducted a study on the effects of colored rooms and peoples' abilities to solve cognitive problems.[72] The results showed that a red room proved more beneficial for solving detail-oriented problems. Spelling, math, and memorization were all shown to be easier to do in a red room due to the association red has with danger. Red ostensibly had the power to speed up cognitive functions, at least temporarily. The blue room, on the other hand, showed psychological benefits for more methodical and creative problem solving. Blue has also been associated to aiding product evaluations, considering items of higher purchase value, and an overall stronger inclination to shop.[73] Scientists concluded that humans associate blue with the sea and sky[74] and a more relaxing atmosphere.[75]

Seeking comfort, we associate our most comfortable subject, ourselves, to those objects, spaces, or places to which we lend our emotions. A religious group associates to a chapel, church, or temple as a place. They seek refuge in their sanctuary to become more connected to their beliefs. Sports fans associate passionately to their favorite sports teams. They invest an enormous amount of money and emotion into watching them play; the stadium often becomes their

[72] Mehta, and Zhu, "Blue or Red? Exploring the Effect of Color on Cognitive Task Performances." *Advances in Consumer Research*.

[73] Barry J. Babin, David M. Hardesty, and Tracy A. Suter, "Color And Shopping Intentions: The Intervening Effect Of Price, Fairness And Perceived Affect," *Journal of Business Research* (2003), Page 56, 541– 551.

[74] Naz Kaya and Helen H. Epps, "Relationship Between Color And Emotion: A Study of College Students," *College Student Journal* 38 (2004), Page 396-405.

[75] Andrew J. Elliot, Markus A. Maier, Arlen C. Moller, Ron Friedman and Jorg Meinhardt, "Color and Psychological Functioning: The Effect of Red on Performance Attainment," *Journal of Experimental Psychology* 136, (2007), Page 154–168.

second home. Such places become areas for individuals to express their personal feelings alongside a like community, and, in return, their individual feelings are elevated. Places are areas of deep-fostered relationships of the spirit, the genius-loci. Understanding the things people prioritize, or give importance to, helps those who design the built environment for them. With a deeper understanding of peoples' passions, designers are better able to form space for the all the inhabitants' needs. Place associations come from understanding where we find our truest comforts. With the employment of colors, lines, forms, and materials, among other elements, architects come to understand the associative nature humans have toward places to design comprehensive architecture. Dutch architect Aldo van Eyck wrote in 1961 about his designed Amsterdam orphanage.

> I arrived at the conclusion that whatever space and time mean, place and occasion mean more, for space in the image of man is place, and time in the image of man is occasion. Split apart by the schizophrenic mechanism of determinist thinking, time and space remain frozen abstractions . . . . A house should therefore be a bunch of places—a city a bunch of places no less.[76]

Architecture is not an object (building); it is the subject setting (space), in which interactions take place—Individually or collectively. Architecture is not the knowledge of physical organization but the organization of spaces. The difference between the other design professions and architecture, and its greatest asset is its place making capabilities—the users' emotional investments, adaptations, and associations, as revealed to them by a vast range of scales, from the smallest space to an entire built environment. Currently, the best way humans understand how to shape space is through physically positioned boundaries that are primarily interpreted through our senses. The perception of space through our sensorium reveals qualitative boundaries in space that we interpret, internalize, adapt, associate, and understand. In architecture, it is for

[76] Aldo Van Eyck, *The Forum* (New Jersey: Wiley, 1961), 237.

designers—for single family residences to townships— to be aware of spatial perceptions influenced by human sensorium, the physical and non-physical. Understanding place making through its respective components of boundaries – physical or not – is the dissertations goal for architects.

CHAPTER 2. ARCHITECTURE OF THE SENSES

Architects add their collected experiences to the education they receive in order to design places. Our experiences with spaces and places are acknowledged with our sensorium. Colors, sounds, temperatures, pressures, spaces, times, and so forth, relate to one another in a manifold of ways to the adaptive and associative characteristics of our minds. French philosopher Gaston Bachelard, in *The Poetics of Reverie*, discusses our perceptions of places based on the homes in which we grow up.

> The house we were born in has engraved within us the hierarchy of the various functions of inhabiting. We are the diagram of the functions of the inhabiting that particular house, and all the other houses are variations on a fundamental theme. The word habit is too worn a word to express this passionate liaison of our bodies, which do not forget, with an unforgettable house[77]

Bachelard is describing our personal manipulation of space evolving into an emotional connection to space and the need of our body, our mind, and our senses to understand that space. Our body responds to not only our intellectual and social needs but also the basic traits and behaviors preserved by our genes, our senses, and instincts.[78]

The five traditional senses—sight, sound, smell, taste, and touch—aid our bodies in the perception of space, the built environment, and wider world. While all art forms need us to acknowledge our emotions to receive a reaction, architecture requires the addition of full bodily involvement and all of its senses. This inseparable aspect regarding the experience of architecture cannot be said of most other art forms, according to Finnish architect, Juhani Pallasmaa.[79] By surrounding the body, architecture reflects upon itself an action—the promise of function—and, through our senses, we can fulfill the designed purpose. [80] The

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[77] Gaston Bachelard, *The Poetics of Reverie: Childhood, Language, and the Cosmos* (Beacon Press, 1971).
[78] Juhani Pallasmaa, *The Eyes of the Skin: Architecture and the Senses* (Wiley, 2012), 68
[79] Pallasmaa, *The Eyes of the Skin,* 67.
[80] Henri Bergson and Nancy Margaret Paul, *Matter and Memory* (Digireads.com, 2010).

theories of individuals such as Juhani Pallasmaa, Edward Holl, Hans Jonas, and Martin Jay make clear how we use the full range of our sensorium to work through surrounding conditions,[81] when we place ourselves within physical space and built environments. Our global society has placed an emphasis on vision over all other senses; thus, it is important for architects to remember the effects our other senses have on our spatial associations and adaptations of the creation of place.

2.2 Audible Architecture

While our touch typically allows us to judge what's in front of us, our sense of hearing allows us to understand the proximity of space. The eyes reach and reach information, but the ears wait and receive, exceeding our peripheral vision and giving us an even greater awareness of our surroundings. Edward T. Hall, known for developing the concept of social cohesion,[82] wrote that the unaided ear can effectively cover up to twenty feet.[83] Within twenty feet, one's hearing has an efficient and solid grasp of its surroundings but is less and less efficient as the distance increases. He continues to explain that the ear at one hundred feet can perceive effectively in one direction but at a somewhat slower rate than at normal conversational distances. The reverberations of our footsteps, our voices, and all other audible cues we produce help us understand the dimensions of physical space. Sound makes the scale of space comprehensible; we "stroke the boundaries of the space" with our ears.[84]

The president of World Access for the Blind, Daniel Kish, shows the capability of navigating space through our ears. Kish has been blind since he was thirteen months old and has successfully navigated the world through "echolocation."[85] By clicking his tongue, Kish locates an object within his surrounding by listening for the reverberation, accurately identifying its location

[81] Pallasmaa, *The Eyes of the Skin,* 2.
[82] A description of how people behave and react in different types of culturally defined personal space.
[83] Edward T. Hall, *The Hidden Dimension* (Anchor Books, 1990).
[84] Pallasmaa, *The Eyes of the Skin,* 55.
[85] Richard L. Welsh, *Foundations of Orientation and Mobility* (Foundation for the Blind, 1980).

and size. Like the dolphin or bat, Kish reveals the power the ear has on our perceptions of space by navigating the environment using auditory rather than visual cues.

Our sense of hearing allows us to understand our surroundings as well as adapt to our built environment. As discussed in Chapter 1, Bach developed his musical sense with playing inside gothic cathedrals. The sound from a single pipe organ sounded greater, and it also had the pleasant effect of "softening any mistakes as he doodled up and down the scales, as was his wont" per musician David Bryne, author of *How Music Works*.[86] His creativity allowed him to innovatively modulate between different keys. Most musicians avoided such a space as the instruments would to make the room sound washy and unable to sense mistakes.

Similarly, Mozart's musical compositions were learned and tuned for each respective space and audience. Mozart would perform in very small rooms for very affluent and even royal subjects. The pieces he composed would dance around the throne room and the elaborate garments worn by his listeners thus dampening the reverberations. The elimination of reverberation combined with the décor and the rooms' modest size, as compared to Bach's cathedrals, meant that Bach's music in all its intricate details could be heard precisely.[87] Mozart composed music to be enjoyed in a much more intimate setting, unlike the way his pieces are enjoyed today, in large symphonic halls. To accommodate the larger halls, an orchestra is needed to fill the space with the intricacies of Bach's music.

Music became a social experience regardless of class. During the baroque period, vibrant and extravagant music had started to take form. Audiences would holler, cheer, gossip, drink, clap, and dance. The audience's behavior was essential for the music's content, string instruments would highlight the many parallels in melody, harmonic language, accompaniment, and form.[88]

[86] David Bryne, *How Music Works* (McSweeny's, 2013).
[87] Ibid.
[88] Kai Ying Chen, "Improvisation in Baroque and Jazz." The Musical Link, April 6, 2012, http://themusicallink.blogspot.com/.

Contrastingly, high social classes' distaste of the lower classes' inherent noisy behavior, splintered them from symphony halls and opera houses. According to American music critic Alex Ross, classical audiences were not allowed to shout, eat, and chat during a performance at the elite halls.[89] Ross writes that classical and opera music became exclusively for the elite. Without the crowds input, softer segments could be added to musical pieces to add dramatic effect because every detail could be heard. Bryne writes how many of the classical pieces of the twentieth-century could only be produced and be written for those socially and acoustically private spaces.[90]

More recently, music has shifted to the individual. With the invention of recorded music in 1877, the nature of the spaces in which music was digested changed.[91] For many people, music moved from the concert halls to any space with a phonograph such as a parlor or within the living room. Bryne explains the different approaches of musicians during this time. "The performing musician was now expected to write and create for two very difference spaces: the live venue, and the device that could play a recording or receive a transmission. Socially and acoustically, these spaces were worlds apart. But the compositions we expected to be the same."[92]

The invention of the Walkman, CD-Player, and iPod took private listening to a whole new level. Music in extreme detail could now be appreciated in all its subtlety in any space. Music effects known as reverberations were manipulated to make the private space feel like an enclosed space no matter where one went. The social nature of music completely changed, too. Private listening became the primary medium and discussing the content of the performance was conducted publicly after the fact. Music in space became much more confined and private, so our audience-based behaviors changed as well. The nature of one audience can be said to be in alignment with contemporary trends, similar to that of other

[89] Bryne, *How Music Works.*
[90] Ibid.
[91] Roger Beardsley and Daniel Leech-Wilkinson, "A Brief History of Recording." Charm, King's College London, 2009, http://www.charm.rhul.ac.uk/history/p20_4_1.html.
[92] Bryne, *How Music Works.*

modern technological advantages. Our adaptability to new technologies affects aspects of behavior, sociality, and spatiality even within architecture.

In a lecture given at TED Global 2009, sound and communication writer Julian Treasure presents the ways sound affects the human being. He plays a loud recording of an alarm clock and explains how the unpleasant sound gives one a shot of cortisol, which affects one's fight or flight hormone. He explains how the sounds not only affect one's hormone secretions but also breathing, heart rate, and brainwaves all the time. He then plays a clip of ocean waves and illustrates how most people find the sounds soothing. He explains that the tempo of waves is roughly the same frequency of a sleeping human's heartrate, associating the ocean sound with stress-free settings.

2.3 Architecture of the Eyes

The amount of information the eyes receive far exceeds those of any other sense organs; 18 times more nerve endings in the eye than in the cochlear nerve of the ear. Our eyes can see 500 levels of lightness and darkness and distinguish among more than one million combinations of colors.[93] The power and speed of our eyes have led to the prioritization on the sense of sight. Humans shape their environments to mediate their cultural desires and activities.[94] As architecture is inseparable from culture, architecture has become vision-centric as well. Our eyes reveal information about the world far quicker than our other senses. [95] Thus, the prioritization of sight, in ancient Greece, in the Western world, and in the subsequent global culture, have more quickly adopted a synthesized preference of information and speed.

In a seminal essay entitled "The Nobility of Sight," German philosopher, Hans Jonas outlines the visual bias of Greek thought and the consequent history

[93] Martin Jay, *Downcast Eyes the Denigration of Vision in Twentieth-century French Thought (*University of California Press, 1993).
[94] Richard Francis-Jones, "Place and Culture Are Inseparable." *Francis-Jones Morehen Thorp* (2009), http://www.fjmt.com.au/pdfs/rfj_place_culture.pdf.
[95] Ibid.

of Western philosophy.[96] He writes that the favoring of vision influenced Greek thinking as well as our own. Nowhere in Greek thought does vision appear more dominant than the invention of philosophy. Hans Blumenberg and Robert M. Wallace writes in *The Genesis of the Copernican World*,"Praised by the Greek philosopher Anaxagoras as the means to human fulfillment, contemplation of the visual heavens was extended to become philosophy, the understanding of knowing everything in a person's line-of-sight."[97] In Greek epistemology, "[k]nowledge (*eidenai*) is the state of having seen," and "*Nous* is the mind in its capacity as an absorber of images."[98] Visual preference is not exclusive to the Greeks, but its prioritization as a sense has influenced architecture to follow the ancient Greeks' preference for this sense.

Even the earliest written works of architecture highlights the aesthetic principles of architecture. "*De architectura"* was written by Marcus Vitruvius Pollio in the first century A.D. Pollio highlights the 3 principles of architecture: *firmitas*, *utilitas*, and *venustas* (durability, utility, and beauty). His writings have clearly influenced the profession of architecture including one of the prominent figures of modern architecture, Le Corbusier. Le Corbusier writes the following.

> My eyes see something that conveys an idea—an idea expressed, not in words or sounds, but solely through prismatic forms, shapes clearly defined by light, which are related to each other. These relationships have nothing to do with practical functions or descriptive effects. They are mathematical creation of the mind; they are the language of architecture.[99]

It would be unfair to contain Le Corbusier's beliefs based on his preference of vision as he still wrote about the importance of function in architecture.

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[96] Jonas Hans. "The Nobility of Sight*." International Phenomenological Society* 14, no. 4 (1990), 507-519.

[97] Hans Blumenberg and Robert M. Wallace, *The Genesis of the Copernican World* (MIT Press, 1987).

[98] Bruno Snell, *The Discovery of the Mind: The Greek Origins of European Thought* (Dover Publications, 1953).

[99] Jacques Guiton, *The Ideas of Le Corbusier on Architecture and Urban Planning* (George Braziller, 1981), 13.

Corbusier later writes, "[O]f course, if the roof leaks, if the heating system fails, if the walls crack, the delights of architecture are greatly impaired; it is as though a gentleman listening to a symphony were sitting on a pincushion or in a draft."[100] Ironically enough, Le Corbusier was sued for roof leakages for his commissioned work, Cinéma la Scala[101] and his magnum opus Villa Savoy.[102] While Le Corbusier explains his understanding of functional architecture, his prioritization of the visual "language of architecture" got him into legal trouble. Architects who have prioritized the visual art of building rather than the art of place making have often misunderstood a goal of architecture—placing individuals within space and time.

Culture and architecture have always been intertwined and synonymous to each other. Our visual society has integrated itself with architecture, from classicism to today's contemporary architecture. Vision being more temporal than the other senses lends to elevate static architecture and arts over dynamic ones.[103] In his 1993 publication of *Downcast Eyes,* Martin Jay, the Professor of History at the University of California Berkley, writes that the invention of the printing press, artificial illumination, photography, visual poetry, and other inventions of the 20th century have only increased our prioritization of vision. Since then, human beings have popularized the personal computer, laptop, on-screen information or entertainment, and smart cellphone. With access to large amount of visual enjoyment, our world has been dominated by technology. Martin Heidegger wrote that the fundamental event of the modern age is the conquest of the world as a picture.[104] The social world's outlook is one in which it views itself as a world of potential photographs.[105] Architects are no different when the profession measures itself through its portfolio—Images and photographs of work.

[100] Ibid.
[101] Deborah Gans, *The LeCorbusier Guide,* (Princeton Architectural Press, 2000), 151.
[102] Anthony Flint, *Modern Man: The Life of Le Corbusier, Architect of Tomorrow* (New Harvest, 2014).
[103] Blumenberg and Wallace, *The Genesis of the Copernican World,* 145.
[104] Martin Heidegger and William Lovitt, "The Age of the World in Picture." *The Question concerning Technology, and Other Essays* 134, HarperCollins Publishers, (2013), 134.
[105] Susan Sontag, *On Photography* (Picador USA, 2001), 7.

According to Palassma, the dominance of the eye and the suppression of the other senses tend to "push us into detachment, isolation, and exteriority".[106] The art of the eyes has certainly produced imposing and thought-provoking structures, but it has not facilitated human rootedness in the world.[107] The past centuries' architectural goals are of self-advertisement and personal ego. Through self-congratulatory sustainability badges, monumental scales, complex façades, and unusable forms[108], the goal of vision-centric-architect has been to instantly persuade the public through awe. Prioritizing vision has removed us from architectural environment, context, and content—the depth of architecture. Critiques of modern architecture disparage vision-centric designs and desire a spectacle of an exterior at the expense of the interior, as if a building were to be conceived for the pleasure for the eye rather than for the wellbeing of the inhabitants.[109] Great architecture may induce awe, but it should not appeal to just our vision but to all our senses. Vision allows one to quickly grasp and fixate on a given subject, to reify and totalize what the user is viewing,[110] while our other senses bolster, develop, and allow one to more fully comprehend space, the built environment, and the wider world. Vision separates us from the world while all the other senses brings us back into it.[111]

The invention of virtual modeling has helped vastly in terms of understanding architectural from a 3-dimensional perspective, but it has led designers to represent architecture primarily by photographs and renderings. Photograph's have become the primary medium to determine if a building is "good" or "bad" and a means of comparing buildings. Having full faith in these images is woefully dangerous, however, as a photograph is unable to capture architecture for its place. A photograph is divorced of its contexts and poorly represents space. It must be said, that there is no pure representation of

[106] Pallasmaa, *The Eyes of the Skin,* 22.
[107] Ibid.
[108] This is not to say that these elements create bad architecture, but that by themselves they do not make it great.
[109] Eileen Gray, *Maison en bord de mer*, *L'Architecture Vivante* (1929), 112.
[110] David Michael Levin, *The Philosopher's Gaze: Modernity in the Shadows of Enlightenment* (Duquesne University Press, 2003).
[111] Pallasmaa, *The Eyes of the Skin,* 28.

architectural works: elevations lack any real perspective, sections hardly evoke Kant's aesthetic of space, plans lack the depth of space, renderings have set focal lengths, and models are imperfectly scaled. Only through in situ experience can architectural works fully engage the human consciousness, in which our sensorium is fully utilized. Logistically, architects use drawing to convey the logic of their respective designs so that the thoughts can be made real, but too often the complete sensory experience is forgotten in design.

A poet, with just words, can clearly elicit the emotions associated with a setting more than modern architects can with their built work or even visually explicit renderings. However, it is the architectural experience that brings the world into the most intimate contact with the body through all the senses. Palassma writes, "An architectural work is not experienced as a collection of isolated visual pictures, but in its fully embodied material and spiritual presence. A work of architecture incorporates and infuses both physical and mental structures."[112] Our insight of architectural place should far exceed the limits of our vision and instead incorporate the factors outside of our physical information receptors; architecture should utilize the full human sensorium.

2.4 Lesser Architectural Considerations: Touch, Smell, and Taste

Audible and visible effects are more often considered of when designing spaces than the other three of the five senses—touch, smell, and taste. The evident issue is due to the fact that they can neither be visualized nor verbalized clearly. These senses are harder to address using the usual vision-based tools of design. In order for the sense of touch, smell, and taste to be considered, the invisible often has to invent other media, formulate new expressive languages, become clear and evident—In other words, make itself "visible."[113] Of the three, the sense of touch has more ease become visible with the invention of infrared technology.

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[112] Pallasmaa, *The Eyes of the Skin,* 48.

[113] Anna Barbara and Anthony Perliss, *Invisible Architecture: Experiencing Places through the Sense of Smell* (Skira Editore S.p.A, 2016), 13.

Touch allows one to gather information about the world, confirming information for the other senses. The sense of touch provides an extended sense of living and acting in space. Anglo-Irish philosopher, George Berkeley writes, “Sight detached from touch does not confirm ideas of distances, out-ness, or profundity, nor consequently of space or body.”[114] Our bodies develop our haptic senses first, and our visual development relies heavily on our initial haptic perceptions of the world. Places can be remembered in part because they are unique and because they have affected our bodies and have generated enough associations to hold them in our personal worlds.[115] With a lover’s first kiss or holding one’s child for the first time, one’s initial reception of a fond memories is often remembered sensually by touch. Place is no different. One’s fondest memories of place are remembered haptically. French author, Marcel Proust recalls the boundaries of place a warm fire creates. He writes, “It is like an immaterial alcove, a warm cave carved into the room itself, a zone of hot weather with floating boundaries.”[116] Our senses teach us about the surrounding environment.

In addition, Proust illustrates our understanding of layered boundaries not through a constructed plane but remembers place through our skin. The sensitivity of the skin can be said to be our first sensation in life. According to Jillyn Smith, fetus begins to sense the beat of its mother’s heart and detects the mechanical rhythm of the mothers breathing. This internal rhythm becomes a part of every aspect of our lives, such as the cadence of our speech, walking, dancing, music, poetry, and much more. It has been suggested that children begin to speak in double syllables (e.g. da-da and ma-ma) in imitation of the paired heartbeat sounds, and that a child instinctively clings to the left side, the heartbeat side, of the mother’s breasts from the familiar association developed

[114] Pallasmaa, *The Eyes of the Skin,* 46.
[115] Kent C, Bloomer and Charles W. Moore. *Body, Memory, and Architecture* (Yale University Press, 1977).
[116] Marcel Proust, *Remembrance of Things past, (*Random House, 1981).

from within the womb. We cling to our knowledge affirmed by our sense of touch.[117] We innately depend on touch to make sense of our world.

The technological invention of air conditioners in the last millennium has allowed heat and air quality to be managed and controlled for our comfort. Referenced earlier, Anna Barbara and Anthony Perliss wrote in “Invisible Architecture” that the reliance of visual-based tools of modern design typically control the way architects and designers approach design. Our consciousness of the environment and the effects of global warming have created a new field within the discipline of architecture—the green architecture movement. This field has given more value to haptic design and has benefited from the digital applications that allow the designer to visualize the sun’s direction and how it impacts a given space or place. Infrared technology, as well as simulation of heat, has provided the information to create more pleasant spaces. Audible and haptic applications have been created to inform the designer allowing him or her to make more educated decisions, utilized in designs such as concert halls and natural ventilation architecture respectively. However, the two remaining senses—taste and smell—have yet to significantly influence architectural design today.

While our senses of hearing and touching validate our physical spaces, we do identify, memorize, and recognize places, people, and emotional events through the sense of smell. Because the olfactory bulb is part of the brain’s limbic system, smell can call up memories and powerful responses almost instantaneously. Smell is responsible for associative learning, requiring one to rely heavily on the conditions of when the scent took place to recall the emotion or setting.[118] Studies have shown that most of our olfactory memories are produced during childhood.[119] Hellen Keller, the first deaf and blind person to earn a bachelor’s degree, associated the smell of fruits in her southern home to

[117] Jillyn Smith, *Senses and Sensibilities,* (New Jersey: Wiley, 1989), 2.
[118] P. Brennan, H. Kaba, and E. Keverne, "Olfactory Recognition: A Simple Memory System." *Science* 250, no. 4985 (1990).
[119] Johann P. Lehrner, Judith Glück, and Matthias Laska, "Odor Identification, Consistency of Label Use, Olfactory Threshold and Their Relationships to Odor Memory over the Human Lifespan." *Chemical Senses* (1999).

her childhood of frolicking in the peach orchard.[120] She could identify the lines of work with which people associated by the smell of their clothes. Her keen senses allowed her to recognize an old country house by the several levels of odors still being through a succession of families, of plants, of perfumes, and of draperies.[121] According to Barbara and Perliss, many of the problems with our ability to design for smell and taste is due to the fact that these senses are hard to talk about. There have been many attempts at systematizing the denomination and classification of perfumes and other odors but none have stood. There is no universally accepted vocabulary for odors. In fact, each perfumery creates its own definitions for scents.[122] In the opinion of Guy Robert, one of the experts in perfumes, with the development of our olfactory culture, we are stuck in the age equivalent to that of painters when their colors did not have names.[123] They described their reds as blood or their blues as shades of skies.

Our sense of smell has always been important in emotional connections. While the western culture has disregarded it in favor of vision, the eastern cultures have traditionally used smell as a factor in place design. Barbara and Perliss discusses evidence in Egyptian culture to give scents priority by in which their embalmment rituals carried out to “achieve synchrony with the eternal present, emptied the body of its earthly humors and stuffed with fragrances, divine balsams such as myrrh, and resins such as storax.”[124]

In product design, the senses of taste and smell are only considered when there is a public outcry and immediate action is necessary. A displeasing odor can significantly degrade the purchased product and hurt the brand of the company. Likewise, only when materials used for packaging of tableware degrades the natural taste of food will the designs be reconsidered. The sense of taste and the sense of smell—gustatory sense and the olfactory sense–are very

[120] Helen Keller, *The World I Live in and Optimism: A Collection of Essays* (Dover Publications, 2009), 66.
[121] Ibid., 72-73.
[122] Barbara and Perliss, *Invisible Architecture*, 115.
[123] Guy Robert, *Le Sens du Parfum* (Osman Eyrolles Myltimedia, 2000).
[124] Barbara and Perliss, *Invisible Architecture*, 19.

closely related.[125] The sense of taste is, just like the sense of touch, a sense of proximity. The sensory organs for tasting react only to objects with which they come into contact. However, writers such as Palasmaa have studied associated and behavioral relationships between taste, smell, and sight.

Cities' atmospheric conditions are often remembered by their smells. Pallasmaa, explains, "Fishing towns are especially memorable because of the fusion of the smells of the sea and land; the powerful smell of seaweed makes one sense the depth and weight of the sea."[126] Advertisers and branding specialists are beginning to recognize the power of smell and its association with memory. Verizon Wireless, the United States' largest cell phone carrier, secured a trademark for a "flowery musk" that perfumes its stores.[127] The scent associated with Verizon distinguishes the "unique retail stores from other communications and consumer electronics retailers in an increasingly crowded field," the company's lawyers told the trademark office in August of 2013.[128] Other companies are quickly following Verizon in trademarking smells. United Continental Holdings Inc., the second largest airline by traffic, Foltek, a U.S. ukulele company, and many more are taking advantage of the associative power smells have on memories and emotions—and our places.

In 1979, Jean-Paul Favre and Andre November published *Color and und et Communication* in which they noted the relationships between visual and other sensory registers. Through a variety of surveys, they had found concordances between chromatic and gustative sensations.

> Acid sensations are represented by yellow-green tones, till olive green;
>
> Sweet sensations by yellow-orange till red;
>
> Bitter sensations by brown-black and violet;

[125] Michael Haverkamp, *Synesthetic Design: Handbook for a Multisensory Approach* (Basel, 2013), 84.
[126] Pallasmaa, *The Eyes of the Skin,* 59.
[127] Jacob Gershman, "Eau De Fracking? Companies Try to Trademark Scents," *WSJ* (2015), http://www.wsj.com/articles/should-companies-trademark-scents-1428965455.
[128] Ibid.

Salad[sic] sensation by grey-light green till grey-blue sky.[129]

Dina Ricco, a Professor in 'Perception and Visual Communication' at Politecnico of Milan, decided to expand upon this research in 1999–2000 by pooling the students at the design course of Politencnico di Milano.[130] Their research published in 2002, they confirmed 75% of the findings of Favre and November, along with other observations. Throughout their experiments, they created large 20 x 20 cm graphics displaying artwork of various styles while supporting a unique chromatic dominance. Using different types of graphic elements (e.g., advertising, photography, and painting), they found that shapes and geometries in addition to color affect the gustative sensations:

"Sweet Sensations is most represented with round lines and circular shapes; Acid and salad[sic] sensations with fragmented lines and angular shapes; Bitter sensations with irregular lines and shapes."[131]

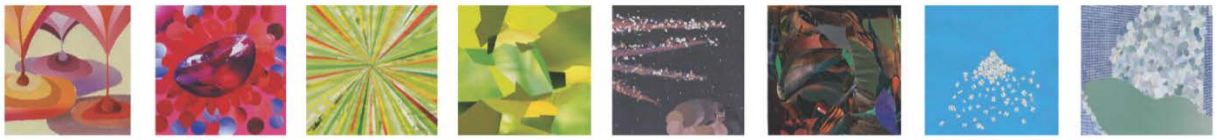

Figure 3. Examples of exercises on gustative and chromatic sensations.[132]

Taste, and in relation smell, are interrelated in the sense of place. When people think of cities, many times the culture and atmosphere of the places are described by the smells and palates of the city.[133]

"Architecture can only act as a recipient in which your desires, my desires can be reflected. Thus a piece of architecture is not architectural because it seduces, or because it fulfils some utilitarian function, but because it sets in motion the operations of seduction and the unconscious."[134] It is not the object

[129] J.P. Favre and Andre Novemeber, *Color and, und, et Communication* (Zurich: ABC Edition, 1979).
[130] Dina Ricco and Silvia Guerini, *Synesthetic Design,* (International Multisensory Research Forum, 2002), 2.
[131] Ricco and Guerini, *Synesthetic Design*, 2.
[132] Ibid.
[133] Barbara and Perliss, *Invisible Architecture*, 123.
[134] Bernard Tshumi, *Architecture and Disjunction* (The MIT Press, 1996).

but the subject in which, as architect Bernard Tshumi puts it, operations and seductions of the unconscious and subconscious take place. It is important for architects to remember that architecture is not creation of buildings but the places and the emotional experiences and responses associated with them. The emotions are based upon an interaction of the perception of external stimuli with the perception of body reactions. Therefore, interpretation of place involves phenomena with a fundamentally multisensory nature. Thus designers should take into consideration our sensorium and how spaces and places are perceived as this awareness is an important aspect to architecture.

It is paramount that designers understand the 5 senses as it is the way in which we receive our environment, however, it is not the sensation itself that matters most. The interpretations, memories, cultural influences, psychological, societal, and all other information that becomes interpreted are truly what the senses allow us to perceive. No other influence has been shaping our current cultural landscape than the digital renaissance.

CHAPTER 3. THE DIGITAL RENAISSANCE

Our senses aid us in perceiving information about space and object in space. The perception is then combined with our learnt experiences and influence or associations and adaptations to places. The aspiration of our digital society to access information at unprecedented speeds has led to many adaptations, but the speed at which we've become accustomed to receiving information has caused the access to instant information's influence in architecture to go unnoticed

The "digital renaissance" or "digital revolution" are popular phrases shared within social and professional circles today. Both words are used to describe the current overwhelming cultural shift by technology and new media, but as American media theorist Douglas Rushkoff would say, we are not in a revolution, more so a renaissance. Rushkoff believes the word revolution evokes "images of violent upheavals and guillotined heads."[135] The implications of a revolution do not assure or allow one's self to believe in the concept of true societal progress. Our digital culture may only be marginally considered revolutionary to compete with larger organizations using significantly cheaper processing powers. Commercial processing power is not meant to be used for revolutionary upheaval but an upscaling of perception, intention, and design, better known as a "renaissance."[136]

The term "renaissance," means the rebirth or rediscovery of old ideas in a new context. Rushkoff writes "It is a reconfiguring of the constructed ways we experience the world to reconnect with it, and the adaptation of our cultural lenses to conform to our changing vision."[137] The conventionally recognized Renaissance, from the 14th to the 17th century, was a period of intellectual discovery that transitioned the Middle Ages to the modern times across Europe. Architect Fillipo Brunelleschi is often credited for introducing one-point

[135] Neil Leach, *Designing for a Digital World* (Wiley Academy Press, 2002).
[136] Ibid.
[137] Ibid.

perspective drawings into the Renaissance.[138] Perspective drawings and paintings allowed artists to think and create not just within space as volume, but spatiality, the boundaries perceived of the mental construct. The discovery and circumnavigating of a round earth radically changed perceptions of space. Centuries later, the creation of the printing presses allowed the wide spread of ideas and political opinions, connecting people from around the globe resulting in the first signs of globalization and the emergence of cross-cultural ideas. People became enlightened, which caused them to challenge conventional models of reality through new perspectives.

The same or more can be said about today's digital renaissance. The late twentieth century brought with digital modeling and drawing. While perspective paintings allowed artists to think in three-dimensional spaces, the artistic approach was not a recreation of three-dimension that could be viewed at a multitude of angles—a construed representation. Many of the revolutionary artists of the Renaissance era used illusions of the eye to deliberately skew the viewer's representations of physical or visual reality. Current modeling software allows designers to imagine and create built environments as true three-dimension. Digital modeling, typically in a Cartesian coordinate system (X, Y, and Z axis), is used by digital-capable designers to visualize and create in measured space.

The Renaissance, as it followed the Middle Ages, changed the way people thought of the world with the discovery that the Earth is round. Exploring the Earth became a goal of every European continent during the Renaissance. In likeness, our technologies today allow countries to compete and discover not only our world but also the universe beyond our planet Earth. As space flight and space exploration became possible after the USSR launched a man into space in the Vostok program (1961), and humanity saw the center of the universe Earth as small and minute to the universe.[139]

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[138] Christopher Tyler and Michael Kubovy, "The Rise of Renaissance Perspective." *Science and Art of Perspective,* Accessed September 25, 2016, http://www.webexhibits.org/sciartperspective/raphaelperspective1.html.

[139] http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1961-012A

The Renaissance came with the popularization of the printing press. Invented by the German goldsmith Johannes Gutenberg in the 15th century,[140] it opened globalization proving wide dissemination of news and information to the public. Centuries later, the most significant and now indispensable phenomenon in the history of communication, the internet was born allowing the transmission of information instantaneously. Print media have evolved to a degree that surpasses the impact of the printing press and increasingly becoming a digital medium – a core feature of our digital renaissance.

According to Rushkoff, "Renaissance moments happen when we experience a shift in perspective so that stories, models, and languages that we have been using to understand our reality are suddenly up for grabs. But these renaissance moments are transitory, because as soon as our perspectives are shifted, we settle into new conventions."[141] The benefit of realizing that we are in a digital renaissance allows us to question and challenge our realities. By doing so, we understand what ought to be learned from said questions. Like the original Renaissance (14th-17th century), most innovations and improvements regarding human life were manufactured as an answer to the way of life of the Middle Ages. If we keep our renaissance-based sensibilities and awareness, we have the advantage towards enormous amounts of cultural progress.

A theme of this dissertation is to recognize the effects of invisible boundaries to human activity. During a renaissance, ideas and ideals are contemplated, expanded, and reinvented to allow human culture to further progress. Progress in technology however, are not necessarily invented, rather, innovated upon and advanced by designers. The layers of boundaries have increased exponentially with the innovations of technology, and have contributed to human being's perceptions of the world. With the added benefit of today's technology, humans can now realize the effects of these boundaries to their daily lives and apply this knowledge within the design disciplines. Renaissances are,

[140] http://www.biography.com/people/johannes-gutenberg-9323828

[141] Douglas Rushkoff, "Protest as Perspective: Do we Want a Revolution or a Renaissance?" *The Journal of Cognitive Liberties,* Accessed September 13, 2015, http://www.cognitiveliberty.org/9jcl/Rushkoff_protest.html.

in part, the moments when human beings examine a story for long enough to consider the way in which it is being told. This is important to do for the current digital renaissance. as it is one that defines the culture of today's modern world. Architects should try to understand how this renaissance affects the way people use architecture now and will going forward from a more broader scope.

3.2 Architecture and Technology

There is a clear disconnect between architectural thinking and the digital renaissance. Architects primarily view technology as an afterthought to space creation, as an addition to the design once imagined. The unique attributes each process would allow one to assume a sense of disconnect, but they are inseparable from each other. As designers, this is increasingly becoming important to understand to incorporate and understand the impact of technologies on space.

A building's primary quality is its permanence. The amount of solid materials, craft of construction, calculations of forces, time, and money it takes to construct a building is only believed worthy if not for its durability and integrity. Every fitting, switch, system, and element of technology within a building is not only meant for utility but is also meant for longevity. The engrained technology within a building is often hidden from plain sight within the cores, dropped ceilings, panels, cavities, and dedicated service spaces. Being able to solve issues and create livable spaces of permanence and hide replaceable infrastructure hidden from plain sight is considered good architecture.

In contrast to a buildings permanence, the success of technology is based on speed. Speed is essential to computing power, but there also exist the desire for the continual release of innovative technology. The most successful tech companies today are quick to invent products with faster processors and larger memory capacity. Splurging toward the most expensive and fastest computer is ill-advised when faster and stronger and less expensive computers with faster

processing speeds will be available shortly; at least an ongoing half a century of Moore's Law confirms such.[142] The rate of innovation is the imperative.

The unique relationship shared between architecture and technology is clear in all buildings today. Technology in regards to communication equipment, guidance signage, media, and computers are upgraded many times over the lifespan of a given building. Many corded telephones have been replaced with internet jacks, power outlets, and/or routers. Every new cycle of technological advances is retrofitted, becoming ad-hoc installations within architecture. While the technology may be industry standard, the fittings typically have no consideration of the design. Typically, these newer technologies are not designed for the space within architecture, and the architecture never imagined said technology within its spaces during the design phases. Technology is an irresponsible afterthought to design.

Yet the relationship between architecture and technology have become inseparable. Architecture is not the interface between two domains. It does not mediate between digital and physical boundaries. It is where technology and environment should work in conjunction with one another without seams. Technology produces space. People find as new technology arises a tether towards cyberspace and the access to it. The architecture informs the capabilities of access and humans learn to navigate physical space for digital access. As newer technologies populate a given city, the relationship between technology and architecture becomes increasingly temporary,[143] many of word's cities are already defined by technology. Architectural technologies are central to buildings as they are the systems that enhance the experience of the physical environment. These technologies have become imperative to our places and the collective human sensorium.

[142] Moore's Law predicts that the number of transistors per square inch on integrated circuits will double every 18 months. This observation was made by Intel co-founder Gordon Moore in 1965.

[143] Leach, *Designing for a Digital World.*

3.3 Non-Sensorial Influences

Technology's effects into space is an original study that few prominent architects have discussed or shared their thoughts in publications and forums. German philosopher Martin Heidegger and architectural theorist Rem Koolhaas have both written against the growing pace of people's dependency on technology and the concern it brings to architecture and humanity. In contrast, architects and theorists, William J. Mitchell, Neal Leach, and Theodor Adorno seem to embrace technology. These authors write of technologies clear effects within the field of architecture, but the argument within this dissertation stands as contrary to their thoughts in the sense of regarding the spatial qualities of technology and the place making factors it produces. Understanding differing opinions help understand the climate of technologies impact on culture and architecture and all existing information aids in the practice of design.

20th century German philosopher Martin Heidegger, writes on human 'essences' in relation with technology in a seminal text titled *The Question Concerning Technology*. 'Essence' is the reason or purpose of an object or person, derived from Aristotle's four causes; understanding the existence of things. Its mode of revealing, *enframing*, was where Heidegger believed the danger lay. It "banishes man into the kind of revealing that is an ordering,"[144] and thus, enframing holds us from the truth. And this form of revealing is an improvised one as it denies the possibility of deeper ontological engagement, metaphysics dealing with the nature of being.

One conceivable problem with modern technology is that it is taken as a complete solution, which Heidegger explains through the trend to see human beings as "standing-reserve,"—a condition in which humankind treats his surroundings as a form of resource. Standing-reserves are made quantifiable, as a form of resource, something to be exploited, stockpiled, and so on. "Everywhere something is ordered to stand by, to be at once on hand, indeed to stand there just so that it may be on call for a further

[144] Martin Heidegger, *The Question Concerning Technology, and Other Essays* (Harper Torchbooks, 1977), 332.

ordering."[145] Heidegger believes that technology, through its properties, has changed our collective views regarding nature and object. As technology exploits the environment for human use, people have become conditioned to view nature as commodity. The resources taken to produce industrial designs with little put back is a global problem.

Heidegger, foresaw the effects technology would have on the natural environment and Marx like consequences. However, to Heidegger, the human's essence was more endangering than the physical damages done to the natural environment by technologies production. Heidegger writes, "As soon as what is concealed no longer concerns man even as object, but exclusively as standing-reserve, and man in the midst of objectless-ness is nothing but the ordered of the standing-reserve, then he comes to the very brink of a precipitous fall; that is, he comes to the point where he himself will have to be taken as standing-reserve."[146] Technology, Heidegger fears, creates a means to view human beings as quantifiable, something to be exploited, less significant, and less respected. When humans are demarked to statistics, they are viewed as standing-reserves. Heidegger viewed technology as devices in contradiction of humankind from being in touch with a higher prospect of life.

The concept of revealing, to Heidegger, was not necessarily a negative thing. Revealing something previously hidden is an action to be sought after. But like modern physics, modern technology sometimes reveals itself as an answer yet conceals multitudes of other possibilities. By showing something as correct, one's frame of mind becomes completely focused on one track—the idea of something being undeniably correct—and everything verified from that thread is believed as truth. Heidegger believes that humankind is already traveling upon the thread of correctness in the terms of modern technology, and, because our collective technological focus is one-tracked, we lose the truth. When we see something as a standing-reserve, our human instincts are to be attracted to the standing-reserves because it becomes familiar and thought of

[145] Ibid.
[146] Ibid.

as qualitative assets. The threat of modern technology, per Heidegger, is its existential threat rendering humans as something less complete than human beings.[147]

Heidegger's approach to technologies impact on humankind reduces human beings to a singular, universal group, and collapses them into technology overlooking the potential of technology in the hands of the individual. Yet individuality is what many would agree, is the essence of being human. One individual interprets symbols and signals in different capacities from another individual. Human beings discuss objects in the world not just in regards to the object itself but also in regards to the experiences through which we know those objects.[148] The differentiation between individuals becomes important when striving to understand of the world at the subconscious level as every individual's experiences shape their views of the world.

British architect and theorist Neil Leach argues that phenomenological tradition does not consider technologies engagement with the wider world. In his essay, *Forget Heidegger*, Leach compares technology's adaptation within the modern world to that of our homes. Humans can transfer their cathected – emotionally invested – home from one dwelling to another. Technology too can become invested in and forged an attachment, overcoming any initial resistance to it. As such, individuals may re-appropriate it from the realm of standing-reserve.[149] Instead of worrying about technology's ability to alienate oneself from one's humanness as Heidegger suggests, we need to understand human beings' ability to "absorb the novel and the unusual within their symbolic framework".[150] Thus, we need to adopt a more flexible, dynamic framework that is alert to the chameleon-like capacity for adaptation that is fundamental to what it means to be human. A more open acceptance toward technology has permeated all aspects of contemporary human existence and has suffused itself within our "background horizon of consciousness".[151]

[147] Ibid.
[148] Leach, *Designing for a Digital World*, 23.
[149] Ibid.
[150] Ibid.
[151] Ibid., 24.

Theodor W. Ardorno in his written essay Functionalism Today writes, "According to [Austrian neurologist Sigmund] Freud, symbolic intension quickly allies itself to technical forms, like the aeroplane, and according to contemporary American Research in mass psychology, event to the car. Thus, powerful forms are the language of their own purposes. By means of the mimetic impulse, the living being equates himself with objects in his surroundings."[152] Adorno directs a discussion toward a phenomenon within the human psyche--human beings' ability to adapt and relate to their respective habitats, Mimesis. In such, Mimesis should not be used as Heidegger has used it, it should be as Adorno understands it and as borrowed from Freud – referring to a creative engagement with an object. "It is the non-conceptual affinity of a subjective creation with its objective and posited other."[153] The way in which humans progressively feel "at home," within a building, is done precisely through a process of symbolic identification with that building. And equally, this adaptation and integration comes to find with technological objects.[154]

Dutch architect, Harvard Design professor, and theorist Remmant Lucas "Rem" Koolhaas claims that the digital revolution—his use of "revolution" iterating the negative connotation mentioned—will leave architecture behind. In an April 2015 essay for *Artforum* magazine,[155] Koolhaas acknowledges that our networked technologies are transforming the way we experience space in architecture, separating the conditions "from bricks and mortar."[156] Koolhaas explains that "environmental sensors, adaptive thermostats, and security systems cloud-connected to massive computerized farms"[157] are catalyzing a nearly invisible shift in architecture that is far more profound and ubiquitous than the mere stylistic modifications that the digital technology revolution has had on the discipline thus far.

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[152] Theodor Adorno, *Rethinking Architecture: A Reader in Cultural Theory* (Routledge, 2005), 10.
[153] Theodor Adorno, *Aesthetic Theory* (University of Minnesota Press, 1998), 80.
[154] Leach, *Designing for a Digital World,* 25.
[155] Rem Koolhaas, "The Smart Landscape: Intelligent Architecture," *Artforum* (April 1, 2015), https://artforum.com/inprint/issue=201504&id=50735. https://artforum.com/inprint/issue=201504&id=50735
[156] Ibid.
[157] Ibid.

Although Koolhaas acknowledges the influential shift in architecture—claiming it to be the most radical change within the discipline since the confluence of modernism and industrial production—he labels its effects as "a stealthy infiltration of architecture via its constituent elements." Koolhaas continues to explain how technology in architecture has invaded our lives in a manner that results in intrusive, never-completely private spaces. "For thousands of years, the elements of architecture were deaf and mute—they could be trusted. Now, many of them are listening, thinking, and talking back, collecting information and performing accordingly."[158] Worriedly yet half-joking, Koolhaas foresees the future as follows. "[E]levators predict your intended destination by listening to your conversations and tracking your routines; toilets diagnose potential illness, building a catalogue of the user's most intimate medical data; windows tell you when they should be opened and closed for maximum environmental efficiency. Your house may soon insist on an early bedtime to stop irresponsible consumption of energy."[159] Per Koolhaas, our architecture has become invasive, infiltrating our most private and personal moments.

With the triumph of technology and those disciplines who've been enhanced by technologies emergence, Koolhaas proposes that the architect has been left out of the collaboration between technology and architecture. He is implying that those who are not trained in space-making are changing the way spaces are inhabited, never once suggesting that the architect may be the one to reject technology. The global pursuit of technology has created a universal, non-differentiating, popular set of ideals: "comfort, security, and sustainability".[160] In accordance to these global ideals, architectures' ideals of knowledge—accumulated over centuries—will not be able to merge with the narrow range of practices considered "smart" today. Koolhaas is concerned that the sensor culture human beings are moving toward will lead to a life of routine. Technology's programmed goal of offering the predictable and exact outputs will

[158] Ibid.
[159] Ibid.
[160] Ibid.

create “the world as an endless, tautological repetition of cause and effect.”[161] Koolhaas believes that technologies aim for perfection in repetition will cause a ripple effect into human individuality and cause a standard of humanness.

Koolhaas proposes that technology’s grasp in architecture is not limited to computation but a change to the discipline. Koolhaas claims that the integration of sensory data into architecture will undermine centuries of architectural principles without stating which principle conflicts with sensory information. Architectural principles revolve around human uses through elements such as form and function, and many sub-theories have been derived from this notion. From Vitruvius’s writings on human body proportions to Marc-Antoine Laugier’s primitive hut in architecture—expressing the exclusive essential of architecture being a beam and column—into today’s human ideals, architecture has always been in search of the consolidation of human livability with the built environment.[162] Koolhaas is misaligned in believing that sensory information is harmful to the design profession. Understanding sensory information will not only aid in the understanding of spatial conditions, but such an understanding might reveal aspects about our architecture that have previously gone unnoticed. Information has always and will continue to be incorporated into architectural design, not destroy it.

Post-biological architect theorist Karl S. Chu. In *Metaphysics of Genetic Architecture and Computation*, Chu’s dissertation is to advance the increasing dependency of architecture on genetic computation: “the generative construction and the mutual coexistence of worlds within the computable domain of modal space.”[163] Chu, unlike Koolhaas is enthusiastic about the opportunities possible within the post-biological world. “No instrumental concept or logic of implementation since the invention of the wheel has fostered so much enthusiasm and promise as computation.”[164] Chu feels the “origin of

[161] Ibid.
[162] Marc-Antoine Laugier, *An Essay on Architecture* (Hennessey and Ingalls, 1977).
[163] Krista Sykes, *Constructing a New Agenda: Architectural Theory 1993-2009* (Princeton Architectural Press, 2010), 429.
[164] Ibid.

computation" lies to embody "instrumental reason in an abstract machine with the attendant drive to encode the logic of life in the world around us in all its manifestations; a quest for a universal language."[165] Information being processed at the most fundamental level to be understood by all.

John Wheeler, the prominent American theoretical physicists in the 20th century, started an information-theoretic conception of the world by stipulating that every item in the universe, at its core, "has an immaterial source that is information-theoretic in origin."[166] Essentially, he is stating that all physical processes are, in fact and at the core, a form of computation. The same concept is iterated by British-American computer scientist Stephen Wolfram, who remarks, "All process, whether they are produced by human effort or occur spontaneously in nature, can be viewed as computation."[167]

Nature has proven time and time again to have a logic and reason behind its purpose. What Heidegger calls "essences," some like Wolfram, Wheeler, and Chu may call "computational equivalences." Because the human being is essential to architecture, Chu writes directly to the architects' new or removed role when talking about the future world he believes in. He states, "This is the beginning of the demise, if not the displacement, of the reign of anthropology which has always subsumed architecture. Architecture, especially from the standpoint of its mythical inception, has always been a subset of anthropology . . . The potential emancipation of architecture from anthropology is already enabling us to think for the first time of a new kind of *xenoarchitecture,* architecture without humans." Chu, with his evil-villain-esque spiel, suggests the development of two forms of evolution within the field of architecture.

Chu is astute in suggesting that architecture has still yet to incorporate the architecture of computation into the computation of architecture.[168] In addition, he believes that matter which underlies most theoretical and practical

[165] Ibid., 425.
[166] John Archibald Wheeler, *Information, Physics, Quantum: The Search for Links* (Physics Department, University of Texas, 1990), 5.
[167] Stephen Wolfram, *A New Kind of Science* (Wolfram Media, 2002), 41.
[168] Sykes, *Constructing a New Agenda,* 428.

discussions of architecture will be displaced by the information. The emerging conception is that architecture will become the art of putting two elements together rather than the Miesian manner of stacking bricks—elements that are programmed to self-replicate, self-organize, and self-synthesize into new relations and ensembles.

The death or rebirth—depending on who is asked—of the profession of architecture will not be caused solely by advancements in technology. Technology will only add to the advancement of the field; it will not take over the architect's role. Learning how sensory data can be incorporated in architecture will further the goal of architects and designers. Understanding how people respond to varieties of boundary conditions and use sensory data will empower architects to design with clearer intent. Not only will sensory data be incorporated into design but also into the lives of the inhabitants. Any added information will give the profession access to dynamic space making, not end the importance of architects. Koolhaas is reticent to accept technology as an architectural entity because he believes it will break the principles garnered through the sharing of generations of architectural knowledge. What Koolhaas does not understand is that design theories and strategies have always changed with time. The digital renaissance is just the next wave of change and the architect must stay in front of understanding its cultural shifts.

Austrian architect and educator, William J. Mitchell has written extensively on "network architecture" and "the network city." As the Dean of the School of Architecture and Planning at the Massachusetts Institute of Technology, he has pioneered a conversation for the inevitable collaboration between architecture and technology. Mitchell, in "City of Bits,"[169] compares the physical world with its digital world counterpart: street networks are compared to the worldwide web, galleries to virtual museums, department stores to electronic shopping malls, enclosures to encryptions public spaces to online public sites, and more.[170] If Netflix existed at the time of publishing (1995), it would have been compared to

[169] William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* (MIT Press, 1996).
[170] Ibid., 57-128.

Blockbuster or Redbox. Mitchell connects the human relationship with cities through a series of metaphors. Through the comparisons with the physical and the digital, Mitchell expresses the transformation of our approach in the physical world through the digital medium.

Continuing his thoughts seven years later from City of Bits, in *Me++: The Cyborg Self and the Networked City*, Mitchell illustrates the shift in society by comparing the physical and digital world to the human body—more specifically, the extension of the physical body into the digital realm.[171] Introducing our world as perceived through a series of boundaries and networks, the skin is the first boundary layer from the mind. By highlighting our core selves, Mitchell reveals the extension of our bodies into dematerialized information. Actions having previously taken place exclusively within physical space can now be facilitated within a computer. Aliases and avatars provide second bodies for us to interact within society. Mitchell writes of the evolution and spatial distinctions between the physical and digital through the miniaturized electronics of the world, our body has become a modular unit of subjective experience.[172] Mitchell imagines future humans '[shaking] the last few atoms from our souls, and simply [living] on server farms somewhere."—a "postbiological future" in which our memories are turned to text, sound, and compressed files. [173] Spaces would be measured in bytes rather than lengths, and life would depend on the servers.[174] Mitchell asserts that what began with our ancestors' first clothing themselves and recording on rock surfaces will end with our cyborg selves being transported into server farms of dematerialized data in the post human era.[175]

Mitchell does not discuss the spatial qualities networks create but, instead, sees the impact networks have on society. Mitchell, in his keynote address for MIT Author, discusses his interests in social movements aided by

[171] Ibid., 124–128.
[172] William J. Mitchell, *Me++ the Cyborg Self and the Networked City* (MIT Press, 2003), 41–47.
[173] Ibid., 167-168.
[174] Mitchell imagines a few probable solutions such as backups.
[175] Mitchell, *Me++ the Cyborg Self and the Networked City,* 168.

technology.[176] With the idea of communities formed through technology, Mitchell shows the power of organized democracy through the internet—ideas formed through social media and materialized in the form of group protest within public, physical spaces. However, in contrast to Mitchell's work concerning more with technologies non-sensorial, spatial qualities is understanding technologies underlying social implications rather than accepting it as fact, thus being able to incorporate the qualities into current design rather than concluding into post-human, computational future. While Mitchell's predictions may come to fruition, what is important is understanding our social desire for social connectivity and how our use of such creates places through architecture.

Human beings' experiences with the digital and physical worlds have merged and, as such, these entities become a part of our daily activities. When the digital renaissance began around the late 20th century, people were aware of its beginnings and used terms such as "cyberspace" to discuss the notion that human beings had started separating states of minds from the physical realm and going into a digital one. However, cyberspace has become more ingrained within our lives, and people no longer separate their digital lives with their physical. Aside from those who choose to fake a persona online. Today, the boundary between the two realms has receded and the realms have merged to become, collectively, a consistent part of our world. We are frustratingly reminded of the division between physical and digital only when we step away from a wireless hotspot or walk in the shadow of a building where our cell phone cannot get a signal.[177] Technology should help us assess our physical environments rather than trap us within them; its ability to inform and enhance our personal decisions should not be degrading or displacing. Technology allows us to experience our physical worlds in ways never imagined. Within our respective environments, the information one receives can show us nearby

[176] *ME++ The Cyborg Self and the Networked City,* (MIT Video, 2003), Online Film:http://video.mit.edu/watch/me-the-cyborg-self-and-the-networked-city-9050/.

[177] Jeffrey Inaba*, et al., Adaptation: Architecture, Technology and the City* (Content Development Publication, 2012), 14.

highly rated dining establishments, popular entertainment spaces within the city, and hiking paths that, before the digital renaissance, we might not have been able to find.

The digital renaissance provides designers with new layers of thought into their design. An architect's greatest asset in place designing is the abundance of information that he interprets, filters, and uses within design. The fail-safe way of designing for the 5 senses is not enough. While inspiring and essential, it's should be the baseline of design thought. A thorough architect delves into history, site conditions, and an abundance of other non-sensorial factors and incorporates them into design thought.

Many architects today shy away from quick paced innovation the digital renaissance gives resulting in relatively dated designs and retrofit accommodations. The adaptations of these technologies and architecture are unresolved and disconnect us from the qualities of space, deteriorating place potential. The Singaporean Changi International Airport offers a great case study of how architecture adapts to the trends and after the fact and is constantly catching up with its demands. Designed with the 5 senses in mind, Changi is consistently renovating and reinventing themselves. In truth, Changi is updating itself to accommodate the current times and have never been ahead by thoroughly considering its design for future trends and innovations. If they did, the potential for place reveals itself.

CHAPTER 4. CHANGI AIRPORT CASE STUDY: CURRENT

Airports are not studied for its place making qualities. The infrequent visits of airports by an individual and its current programmatic nature as a tool for transportation over an architectural experience makes it an odd case study for place. However, given the diverse user groups, heavy commuter traffic, public spatial use, physical and non-physical spaces involved with airports, an airport begins to become an architectural encyclopedia. The architecture of an airport offers spatial use with varying degrees of emotional behaviors that few other designed spaces account for. Situations of high stress such as late flight arrivals, delayed flights, foreign environments, and language barriers arise often within airports; while other passengers are feeling high levels of emotions in regards to situations such as farewells to loved ones, meeting a friend for the first time in years, or starting fresh in a new environment. In between these emotional highs and lows, airports visitations have often become physically draining, yet its position to induce excitement, wonder, and potential for adventure makes observation of designed space and use a valuable one.

When architects understand the impact, they have when designing spaces, it becomes an interesting study in behavior, memory, sociology, psychology – the non-sensorial impacts – and the traditional five senses. In addition, airports are great case studies in regard to evolution in architectural design in relation to technology introductions and quick turnarounds. Designers of airports are constantly looking to renovate and improve their structures to adapt to technological trends and innovation. For the public to see terminals built only to be outdated and “out-technologied” by a future terminal within ten years’ time or renovated to adapt to better technologies leaves social and psychological footprints that can be studied. No better airport perhaps to study is one consistently rated as the best airport since its opening in 1979.[178] Constantly looking to improve, Singapore’s Changi airport provides snapshots in time as well

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as the resiliency to keep up with technological and architectural change in order to maintain its high marks.

4.2 History of Singapore's Changi International Airport

Singapore's first purpose-built civil airport, Kallang, was a testament of the stock placed on the future of air travel and of Singapore as a gateway between England and Australia—a role that Changi still possesses to this day.[179] The region's first airline, Wearnes Air Services, began operating between Singapore, Kuala Lumpur, and Penang within the first weeks of the airport's opening. Other airlines such as the Malaysia-Singapore Airlines that preceded the current Singapore Airlines had started operations during Kallang's existence; however, World War II stunted the growth of aviation globally. After the war, industrialism and the demand for air travel cause of many of the world's most notable airports such as Heathrow (London, 1946) and John F. Kennedy (New York, 1958), to be designed and commissioned. In the mid-twentieth century, the airport as a singular edifice emerged, no longer adaptations of military prototypes and services. The influence of traffic and innovation had spurred the industry to develop larger scale aircrafts for the public.

Abandoned just 10 years after the end of World War II, heavier and noisier aircrafts symbolized the end of Kallang's airport, replaced by then Paya Lebar Airport, which opened in 1955. It was optimistically created to be the airport of Singapore but quickly faded as its design could not cope with the pressures and demands of newer aircrafts and traffic. It was clear that Singapore's Paya Lebar Air Base could not sustain the quick events of aviation development. Only 15 years after Paya Lebar's commissioning, the move to Changi was announced in the Singapore press.[180] These changes followed several highlights in global air travel and were in response to those developments in order for Singapore to not lose ground in aviation capital to Hong Kong, Thailand, and South Korea.[181]

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[179] Nirmal Kishnani, *Changi by Design* (Page One Publishing, 2002), 17.

[180] Ibid. 19.

[181] Nancy Loh, *T2ansfomation: The New Changi Airport Terminal 2 (Civil Aviation Authority of Singapore, 2006),* 8.

Changi's site was optimal for a new airport as its flight paths would not disrupt the already built infrastructure of Singapore, and the noise would not bother any residences as it had in Paya Lebar. A site large enough for future technological innovations, advancements in air travel, and land expansions were needed for the future airport, and Changi was decided as the logical site to support such endeavors. Singapore Airlines, once a joint company with Malaysian airlines, could call Changi home as the separation from Malaysia in 1965 opened doors for the two to separate into two independent companies in 1972.[182] Thus opportunities were created for Singapore Airlines to compete with other international airlines for routes, access to airports, attracting new customers and so on, and establish its high reputation in today's world of air transport as the prime measure of its outstanding success. As such, it would give Changi unique recognition in its advantage in world commerce and trade.[183] However, while the location itself was highly desirable, site conditions required a great deal of work to prepare the site for the ambitious airport.

Substantial land reclamation had begun along the coast between the Casuarinas and Bedok since the mid-1960s, preparing for extensive developments including the creation of a modern expressway. Half of the fully completed airport would have to be reclaimed from the sea—the landfill being obtained partly from the hills outside the airport area and the rest from 44 million cubic meters of sand recovered from the sea bed.[184] The other half of the work that needed to be done before pile driving was site clearing, which entailed 558 military buildings, unearthing 2096 graces, clearing swamp areas, and diverting three streams on the western side of the former RAF runway.[185] The foundation stone for Terminal 1 was laid in August 1979.

[182] Henry Probert, *History of Changi* (Changi University Press, 2006), 114.
[183] Ibid.
[184] Ibid., 115.
[185] Ibid.

4.3 Terminal 1: 1981

Terminal 1 was completed in 1981, and operations began on July 1 of that year. In the years after T1's opening, a management philosophy emerged that set the tone for Changi's operations. The inherent problem is that an airport is home to many, often conflicting, interests of government agencies (i.e., immigration, customs, quarantine, and police) airlines, and retailers. Changi would operate under a common ethos; a user-centric strategy was devised by the Civil Aviation Association of Singapore.

Figure 4. Terminal 1, 1981 Configuration.

In Creating Paradise T3: Singapore Changi Airport, the Changi Airport Group discusses the standards they had set out for Terminal 1. "The team had decided to combine efficiency with friendliness that shaped the Changi Experience for the foreseeable future." The large rectangular plan with 4 small piers resembling an "H" set the foundation and flow experience that Terminal 2 and 3 would later adopt and extend upon. The simple plan gave clear orientation and direction for passengers, many would-be first time flyers.

In terms of design decisions, Terminal 1 took to a multi-story building plan that set the departure and arrival halls on different levels. Common in most airports today, the organization while not innovated in Changi, was not as

common an organization as it is now.[186] Passengers at Changi would not need to change levels as departure passengers would stay on one level and arrival passengers the same, rarely intersecting with each other. The separation of levels increases circulation efficiency and clarity. Those with luggage in tow would not have to heave their belongings upstairs or change levels. Terminal 1's original schemes were very successful in its goals to be efficient for origin and destination passengers. Changi however did not believe that it would become the hub airport it was today, thus the designers thought scantly of transit passengers in the original schemes.

The Changi Airport Group writes about Terminal 1's standard setting goals. Terminal 1 delivered generous hall sizes, indoor planting, and impressive water features, giving the terminal an attractive and friendly face that was not seen in most airports at the time."[187] The high ceilings were carried out through each pier as to give a breath of fresh air to the spaces. The immigration hall checkpoints, where most airports at the time had low ceilings, were given high ceiling space. The designers felt that the stresses of queues would lighten with the feeling of space above their heads.[188] Installing glass dividers at baggage claim allowed arrivers to view their family waiting in the arrival hall, this was another conscious decision that broke norms. Where most airports have an opaque wall, the designers felt the excitement of seeing their family members provided joy and anticipation.[189] Similarly, this was done at the departure immigration counters to maximize visual contact families had with their loved ones.

4.4 Terminal 2: 1985 - 1990

Terminal 1's efficiency based design for departure and arrival passengers had many positive reviews and introduced Singapore to the world. Just four years later (1985) after its opening, construction began on the second terminal.

[186] Lim, *Creating Paradise T3, 21.*
[187] Ibid.
[188] Ibid.
[189] Ibid.

In 1989, the first of many “Best Airport of the World” was awarded to Terminal 1 by the UK-based magazine, *Business Traveler*. Mr. Goh Chok Tong, the Prime Minister of Singapore, seized the opportunity of the terminals quick success and operations as a statement to the rest of the world of what the city-state of Singapore could achieve.

In preparation for the future of Changi airports and Singapore’s Aviation, a study was commissioned in 1989 revealed that Terminal 1 would have the potential to handle an annual capacity off 22 million passenger movements, 23 million passenger movements for Terminal 2, and 20 million for Terminal 3. The study uncovered the imperative upgrading Terminals 1 and 2 would need to undergo before the inevitable Terminal 3.[190] And In November of 1990, the bigger Terminal 2 opened its doors.

Figure 5. Terminal 2 built upon the southeast pier of Terminal 1.

Terminal 2 was designed with Terminal 1’s groundwork in mind. Fitting in like a puzzle piece of the, Terminal 2 created its halls from off the southeast pier of Terminal 1. A long linear terminal design with two sprawling piers off to the east of the large rectangular departure/arrival hall, much like Terminal 1. Terminal 2’s plan so closely resembled Terminal 1’s design as if it had always

[190] Ibid., *48.*

been intended as a singular design. To increase efficiency and connectivity, the first driverless and automated skytrain in Asia was added. The inter-terminal journey between the two terminals would take only around 90 seconds.

4.5 Terminal 1 Refurbishment: 1994

Based off the studies taken right before Terminal 2's opening, Terminal 1 began its plans to refurbish its Terminal 1. Completed in 1994, the 170 million Singaporean dollar refurbishment introduced a rooftop swimming pool, hotel-style dayrooms, transfer lounges, and shops for the increasing amount of transit passengers.[191] Although Terminal 1 and 2 were initially designed for the origin-destination traveler, Changi soon began to realize the flux in transit passengers and felt it important to accommodate them.

To increase the passenger experience and decrease the stress, designs in the refurbishments were catered towards the perceptual senses. Many of the wall tiles were replaced with aluminum cladding and cheerful colors in the arrival and departure halls presenting more pleasant atmospheres.[192] Custom-designed carpets, which were not very common at the time, were introduced to add warm hospitable touches. Small touches that aid in relieving stress and creating friendlier associations with air flight experiences. Adding concierge-style information counters, custom check rooms, and attendants at the restrooms gave traveling an exclusive and accommodating feel.[193]

4.6 Terminal 2 Expansion: 1995-1996

As evidence in Terminal 1 Refurbishment, accommodating transit passengers became a priority and shaped the design of airports thereafter. Another study was commissioned in 1995, the Changi Airport Group commissioned the International Civil Aviation Organization to develop an aviation

[191] http://www.changiairport.com/content/dam/cacorp/documents/changiairportgroup/CAG%20Major%20Milestones%20Jul%202014.pdf

[192] Vincent Lim, *Creating Paradise T3: Singapore Changi Airport* (SNP International Publishing, 2008), 51.

[193] Lim, *Creating Paradise T3,* 23.

activity forecast for a period up to 2015. The masterplan study had projected that 20-35 percent of Changi's annual passengers would become transfer or connecting flight passengers.[194] Transit areas however were sparse. These spaces didn't make sense to an origin-destination airport's such as Changi who would dedicate 12-15 percent of the total area of an airport. However, many airports who were gaining hub status were giving 30-50 percent of their total airport space to transit spaces, due to the very profitable hubbing business.[195]

Major changes to Terminal 2 were undergo just 6 years after its door openings. Known as Terminal 2 Expansion, the Changi Airport Group hired RSP Architects Planners and Engineers, who won the tender bid against 20 finalists collaborated with Gensler San Francisco.[196] The design intents behind the expansion of Terminal 2 were to handle the ever-growing capacity needs and areas to expand upon the traffic. By building two angled pier extensions, off the existing couple of fingers, twenty-two fixed boarding gates were added to allow for greater passenger capacity. The original procedure to board planes was to enter a bus that would take you to the plane and passengers would board from the ground level onto the plane by stairs, which by the times of expansion was viewed as very unattractive.[197] To remedy this, passenger loading bridge technology were introduced in the Terminal 2 Expansion.

Airports adapt to existing technology that designers believe will affect the passenger experience. No technology than the aircraft itself change and shape airports are operated. Airflight, becoming a common commercialized business over exclusive, demanded larger planes to hold many more people than previously possible. Market research by Airbus showed the demand for efficient and capacitive aircrafts and thus started the wheels on the Airbus A380. Neither Terminal 1 nor Terminal 2 would be capable to house the larger Airbus at gates. Prudently, the plans for both terminal's extension provided antiquate parking

[194] Ibid., 45.
[195] Ibid., 30.
[196] Loh, *T2ansfomation*, 43.
[197] Lim, *Creating Paradise T3,* 51.

spaces, boarding gates, and passenger traverse distances for the A380, even though the aircraft wouldn't take its first flight nearly 10 years later in 2005.[198]

Completed in 1996, the passenger experience concepts driving Terminal 2 Expansion's design was to introduce the feeling of a park within the airport. Tropical greenery was fit into built space providing visual and haptic contrasts with the physical elements of Terminal 2. The designers understood that in any terminal, no matter how extraordinarily beautiful, individuals would nevertheless experience an underlying aspect of personal tension by an airport's prescribed function—air traveling being taxing to the body as well as the emotional seas of farewells that occur when departing. The terminal, as per the architects, should not add to the inevitable pressures and stresses of air travel.[199]

Figure 6. Terminal 2 Extension constructed from two piers of Terminal 2.

The enhancement experience would begin from the arrival at curbside and all throughout till flight departure. All considerations were made with the intent of giving passengers the impression of Changi becoming a place *where time flies*. Changi accomplished this by providing passengers with an array of tempting options pre-flight in terms of dining, shopping, and leisure activities.

[198] http://www.airbus.com/newsevents/news-events-single/detail/a380-the-21st-century-flagship-successfully-completes-its-first-flight/

[199] Loh, *T2ansfomation*, 43.

Perhaps the most significant addition to the terminal was the change of the vertical facade extending from the second level up to introduce massive daylight into the space that was once nearly completely enclosed. The Terminal 2 design team researched and mocked up different planning schemes and planters that would work with the interior features of space. Plants were firstly chosen for their relatively low light requirements and for not needing overly great or costly maintenance. Ficus Benjamina, or weeping fig, was chosen for the entrance as its height of up to 20 meters was the most significant plant that would help to create an impressive verticality from the first level voids upwards, as well as being an attractive yet functional sunscreen for the all glass façade. The trees planted on the first level would rise above the punched floor areas of the second level and receive the natural daylighting the facade now provided. Offering the park like atmosphere to both arrival and departure passengers.

The design of the construction accommodated ongoing airport operations and completed in incremental phases. Areas being worked on would be blocked off while the construction crew worked on specific sections subtracting hall space during construction. The construction process however was designed cleverly enough that many air travelers did not even know that the terminal was being worked on.[200]

The lighting fixtures were designed beyond to function beyond the fundamentals of brightness levels for the indoor plants. Each lighting fixture was designed to enhance the building materials and reveal the volumes and proportions of the interior. Warm glows and cool whiter hues were used to differentiate spaces that would form and give dimension to the vast area. The designers also integrated a dynamic change in the interior lights for the traveler's body clock to easily adjust. Constant exposure to bright lights could throw the body clock out of sync. Thus, an electronically controlled and programmable auto-dimming feature was added to give importance to time. These sensors worked with the time and lighting levels of the exterior as well as the day lighting penetrating through the space to give the desirable levels of light throughout all

[200] Lim, *Creating Paradise T3,* 44.

times of the year as well as improving energy costs. Morning, afternoon, evening, and night all are acknowledged and discussed within the interior of Changi Terminal 2.

The architects even gave deliberate positioning of tile patterns in the baggage claim area. In addition, the architects claim that the tiles are detailed with human scale in mind and organized in a way to psychologically have people queue-up in an orderly fashion when waiting for their bags.[201] Using black and white tiles, the architect demarcated spaces where they would prefer passengers stand, hoping that the associations of colors would help do so.

4.7 Terminal 1 Expansion

Set in motion during the construction of Terminal 2 Expansion, the Terminal 1 Expansion planning and building was underway. Completed in January 1998, a two-pier extension with 14 new aerobridges, nine remote aircraft parking stands, and two link tunnels were built. Both pier extensions resembled each other making it appear as if its original form intent was such.

To accommodate the influx or transit passengers on top of the rising flyers, Terminal 1 offered many of the similar concepts learned from Terminal 2 Expansion. The world's first cactus garden was added to give passengers another unique experience and provide stress resilient environments. An evaluation of popular areas was taken and was decided that air-conditioning the taxi queue area would be extremely beneficial to customer satisfaction. A slight redesign was done to limit the weight time to 5 minutes' maximum when waiting for a taxi. Creating extra space and lines proved to make this successful. Adding more color into areas of higher stress, such as the cab queue area, was applied throughout Terminal 1. The generous ceiling heights and large daylight openings reinforced the sense of openness and spacious outlooks, which here and at Terminal 2 Upgrading, became the prototype for Terminal 3.

[201] Ibid.

Figure 7. Terminal 1 Extension, added onto two piers of Terminal 1, just like Terminal 2 Expansion/Terminal 2.

4.8 Terminal 2 Upgrading: 2001-2006

Terminal 2 to improve the physical appearances, layout, facilities, and commercial avenues. Referred to as the Terminal 2 Upgrading, the continuing concept of transparency followed suit to the, now signature, leaf canopy glass and steel structure that was designed and constructed over the departure curbside. The leaf structure continued into the check-in departure hall bringing with it extended hall space and daylight.

To enhance the variety of shopping and dining experiences, space for retail, landscape, and seating facilities were expanded. Way finding and reorganizing interior spaces enhanced navigation within the terminal space. Along with improving accessibilities with escalators and better accessibility for disabled individuals, technology facilities were introduced and built into the airport terminal allowing passengers to connect to the internet.[202]

It has always been an important aspect of air travel to be able to contact loved ones from inside an airport. From hand, written signs at arrivals, telephone calls, or todays texts messages, people find ways to communicate and coordinate plans to be picked or dropped off.

[202] Ibid., 54.

Payphones and communication services installed in the Changi terminals show an interesting phenomenon that appears often when technology is introduced to architecture. Like most of the technology installed within airports, it is first retrofitted and forced into open space designed without program. Then, they're integrated with the space and improved slightly giving program to space. In the case of telephones, the idea was improved by putting them in spaces that would be the most necessary and desired. From there, designs become incorporated and thus integrated within space. The final steps in the technological lifecycle would be to make it more efficient, space conserving, and more visually appealing. When new technology arises, the process repeats itself.

The need for payphones have mostly been replaced with personal smartphones. More importantly than the availability of payphone booths is internet and cellular service.

In Terminal 2's arrival hall, the terminal reveals the after though of outlet integration for personal electronic devices. The space was not deliberately decided or planned for yet retrofitted for the current needs for such sources. Retrofitting charge outlets around the terminals. For the terminal 2 arrival halls, the designer cleverly integrated universal electrical outlets and universal serial bus ports for users to charge any of their electrical devices. While there was public seating available nearby, people preferred the designated area of space attached to the column. Even if it meant that they'd be standing, kneeling, or sitting on the floor the entire time, people preferred personal discomfort over the ability for their electrical devices to be charged and connected to the internet. The lack of power sources is clear in the amount of uncomfortable positions many put themselves in for a simple charge.

It is an incredible sight to see how designed space use is completely different than its first purpose. The traffic centered around the electrical charging column as well as the information desk where you obtain access to the Wi-Fi is vastly overused compared to the available services. In addition, the vast amounts of unused, bolted down seating reveals to us the public desire of space. Even when there are people sitting on the provided seating, they are typically on their

phones. Changi has abided to the passenger's desires by creating over 550 internet access stations and has created kiosks in which people may enjoy internet access on offered computers.

The broadband boom forced T2's new extension to incorporate fiber optics which lets through much more traffic faster, a technology that is indispensable for any global air hub. Laptop areas, Internet stations, and hot-spots were created in order to satisfy the travelers. The designed cabling infrastructure could be adaptable for future usage. Unlike the previous stand-alone systems, each of which had its own cabling organization, new infrastructure.

For Changi Terminal 3, this trend was becoming a reality and thus they've moved their phone booths to locations away from typical circulation areas and added them near the exits of the arrival hall. The other pop-up phone booths have been removed from the other 2 terminals yet are still provided at 7-11's and departure transit halls, providing users with free local calls 24/7. Because of cellphones, passengers are more inclined to look for electrical outlets over phone booths.

Figure 8. The evolution of telephone integration within Terminals 1-3.

The two terminals worked well, partly because there was little difference between them in terms of layout and operations. The decision to upgrade Terminal 2 was cause by the studies and designs of Terminal 3. The Civil Authority of Singapore Deputy Director-General Ho Beng Huat, who was intimately involved in the project from conception to completion, explained as follows. “[Terminal 2] would look dated in comparison and the contrast would be quite stark.”[203]

Safety and security within an airport is the most important concern of any travailing passenger. The security procedures were lax. In the book, *The Skies Belong to Us*, Brendan I. Koerner chronicles the early transitions of airport security. Initially, most airlines opposed the idea of individual passenger screenings. Airlines would hire security contractors who were often underpaid and often incompetent to operate their gate security machines. Many of these security companies would not need Identification, and would only really look for

[203] Ibid., 10.

hijacker traits in passengers. If the passenger would show a lack of eye contact or inadequate concern for their luggage, then they might be scanned with an electric magnetometer before boarding. Just 0.5% of all boarding passengers were screened and frisked.[204] When X-Ray machines and metal detectors were mandated by the institution of universal passenger screenings in 1973, some airlines only implemented them during international flights as the technology was very expensive. In most cases passengers, could arrive 30 minutes before takeoff due to the ease of security clearance, unheard of today in comparison for international flights.

The nightmare of a wakeup call to global flight security was the hijacking and attack upon New York City, on September 11, 2001. Many added regulations and rules have been added to enforce strict security. Since the terrorist attacks of September 11, security has significantly heightened but prior to the events, the security was not nearly as strict as it is today.

After September 11, airline design had transitioned to a more centralized configuration plan and drastically heightened security measures. In the United States, the Transportation Security Administration runs security in all US airports and are constantly revising and tightening airport screening measures. Currently, many airports have a traveler issued a boarding pass and is met at a check point where the guard checks all identification and pass to make sure it belongs specifically to the person and no fraud is taken place. Then the passenger is asked to remove shoes and jackets to be scanned in an x-ray machine. Then the passenger is scanned through a millimeter-wave scanning device and metal detector. Since the 8th of May 2007, liquids were restricted to 100ml following the 2006 transatlantic aircraft plot in which a few terrorists tried to blow up an aircraft by carrying explosive liquids disguised as soft drinks.[205]

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[204] Brendan I. Koerner, *The Skies Belong to Us: Love and Terror in the Golden Age of Hijacking* (Broadway Books, 2014).

[205] Bob Sherwood and Stephen Fidler, “MI5 Tracked Group for a Year.” *Financial Times.* August 11, 2006, http://www.ft.com/cms/s/0/041a9e68-28da-11db-a2c1-0000779e2340.html?ft_site=falcon&desktop=true#axzz4WAesJUQL.

In Singapore, the security measures fall under the Airport Police Division of the Singapore Police Force. In addition to the new security measures, solders armed with assault rifles from the Singapore Armed Forces and specialists with canine teams patrol the terminal buildings. Layers of checks are also applied in the backroom, where advanced screenings are conducted on check-in baggage, including bags from transit flights. Image processing closed-circuit televisions detect any unusual crowd situations were installed during the Terminal 2 Upgrade and in Terminal 3 which was being raised at the same time.

Singapore terminals 1 and 2 were designed as a decentralized concept which was initially believed to offer a higher level of security. [206] Meaning, Terminal 1 and 2's decentralized plan's security checks were done at the gate rather than the entrance of the boarding gates. Most airports designed pre-September 11 were designed as such. This is visible through the many x-ray machines and metal detectors fixed at every gate. The problem with this configuration meant more security guards had to be hired to take control of the systems and checks. The benefit of an olden decentralized plan meant that most people would be able to enjoy a much larger landside (parts of the airport that are accessible to people not boarding) with their loved ones and nearly see them off at the gate. Another benefit of a decentralized conceptual plan is dispersing traffic during peak seasons. Passengers flow to their gate and very rarely must wait long to enter their boarding gate. Because a centralized configured plan inspects all their departing passengers at a singular point, during peak times, many passengers accessing different areas of the airport must funnel in the center causing a very time consuming affair, causing many to miss their flights. The centralized plan is why frequent international flyers recommend you pass through security 2 hours earlier than the expected flight.

[206] Antonin Kazda and Robert Caves, *Airport Design and Operation* (Emerald Group Publishing Limites, 2000), 318.

Figure 9 (Left). Security Bag Check at the Gate of Terminal 2.[207]

Figure 10 (Right): Passport Check Security prior to Airside at Terminal 3.[208]

Terminal 3 would be designed as a centralized plan, and to follow along with the change of the times, Changi Airport Group started to join the gate rooms of Terminal 2. Instead of operating 92 gates as independent and autonomous units, holding rooms were paired or grouped into common waiting lounges. Changing the system from individual x-ray and metal detector for each gate, 2-3 gates would share a security check point, a hybrid of decentralized and centralized plans. Large holding rooms are then shared with departing passengers of differing flights. This reduced the capital outlay, labor requirements, and maintenance costs typically given to decentralized plans. To order the large common rooms, carpet patterns would demarcate the different gates seating areas so that people would subconsciously recognize that they're in a different dedicated space without the use of walls and barriers.

[207] httpssgbluesky.files.wordpress.com201405dsc03440.jpg

[208] http://www.blogcdn.com/slideshows/images/slides/338/865/9/S3388659/slug/l/departures-area-at-new-terminal-3-at-changi-international-ai-1.jpg

4.9 Terminal 3: 2006-2007

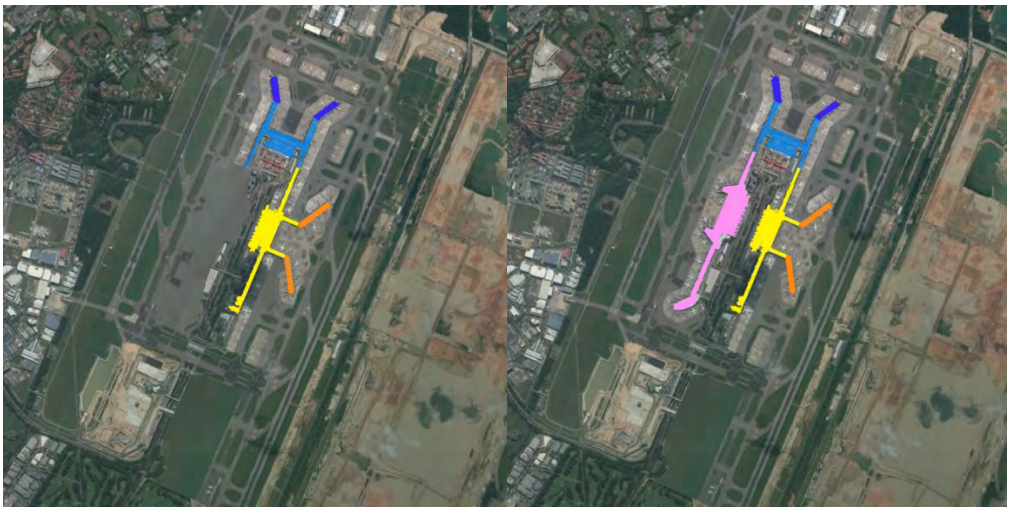


Figure 11. Terminal 3 built upon the southwest pier of Terminal 1, similarly to Terminal 2.

Changi Airport turned towards a more centralized plan of operations for Terminal 3 after the attacks on September 11, 2001. Terminal 3 became the first terminal at Changi to construct itself around a centralized plan. A disadvantage of this configuration compared with Terminal 1 and Terminal 2, cause passengers to walk longer distances for passengers to reach. The problem with longer walking distances were remedied with the introduction of travellators within the Terminal 3 halls. The largest walking distance any passenger would have to traverse between travellators was decided to be 450 meters, by the designers.[209] They concluded that the distance would not overtax passengers physically. Circulation plans were developed to decrease the occurrence of bottlenecks in addition to limiting level changes at all costs. Not only are the universal design features, design considerations for those who are less able bodied as well as people without disability, but disruptive level changes proved to be annoying and very confusing to the passenger navigating the airport.

On the 30th of May 2006, the $1.74 billion Terminal 3 was unveiled by CPG Consultants in association with the design principally by Skidmore, Owings,

[209] Ibid., 55.

& Merrill LLP (SOM). Adding 380,000 square meters of gross floor area, the architectural plan was designed to fit within Terminals 1 and 2 by creating a horseshoe configuration around the sky tower.

The existing sky train was upgraded to unite all three terminals.[210] The design team drew up many options for the skytrain to connect between all three terminals such as putting them underground, running above the roof of the terminal buildings, and deciding on making it a continuous loop or independent segments of loops linked at selected points.[211] In the end, the design team decided on a point-to-point system, "comprising two track for trains to shuttle back and for the in opposite directions."[212] The decision was made in part when the designers understood that a peoples mover system was not a mass rapid transit system where passengers develop a reflex for getting on or off a train at the right point through constant and repeated use. A continuous loop may disorient a passenger. The 142 million Singapore dollar skytrain contract was drawn up to connect the existing skytrain to Terminal 3. The skytrain can hold a maximum load of 97 passengers per train; each cabin being fitted with LCD screens to display airport information and fitting more vertical stanchions and handholds.

Terminal 3's aim was to become an up-to-date, leading air hub, adapting to paradigm shifts affecting air travel and airport design—a new air terminal experience incorporating technology for sophisticated modern travelers. Changi could not ignore the "experience culture" that had taken root. Savvy travelers have come to expect an iconic and memorable experience when visiting international hub airports, Changi Airport being no different. Airports have become destinations themselves. Many passengers view the iconic architecture of airports as the front door and entrance to the country its built upon. A positive initial impression of the architecture opens the mind of the passenger towards the cultural offerings while a negative impression may do just the opposite.

[210] Ibid., 59.
[211] Ibid., 60.
[212] Ibid., 62.

Airlines are constantly trying to shorten the turnaround times by automating baggage handling systems. At large airports, it is important to offer automated sorting of baggage. It's invention and use has given a significant increase to the capacity of a terminal building and has improved the service standard.

When terminal 1 and 2 were originally built, baggage systems were operated manually. Terminal 1 had 8 baggage belts with a joint length of about 600 meters and Terminal 2 had 8 baggage belts as well but with a joint length of about 820 meters. It took until Terminal 3 infrastructure planning to obtain an automated baggage handling system.

Civil Aviation Authority of Singapore appointed a consortium making up Denmark's FKI Logitex and Singapore's Inter-Roller Engineering Ltd baggage handling system. The system comprises of two S-3000E tilt tray sorters (each approximately 1,000 meters long). First implemented in Changi Terminal 2 Extension due to Terminal 3's complete plan. This allowed for universal check, meaning that any passenger could check in from any of the six departure check in islands and be sure their bags would be routed to the right plane. Each of the islands is served with two belts and all 12 belts are linked to the two tilt tray sorters.

Figure 12. Automated Bin and Bag connection moving through Terminal 2.[213]

In addition to the baggage handling system, Terminal 3 introduced a high-speed luggage processing system for high speed transfer of baggage between terminals. The first system in not only Changi, but any airport in the region. Plastic trays equipped with RIFD tags merge with each IATA barcode marked bag to help complete in-line baggage screening, complete sort-track-and-trace capability, full baggage sorting and transportation, and stores early bags. The 10,000-meter inter-terminal system moves at speeds of between 1.8 meters per second for curves and 15 meters per second for straight elements, the system can channel up to 2,700 bags per hour/per line. Travel efficiency is increased as bags can be sorted from aircraft to aircraft within 35 minutes.

The system introduced in Terminal 3 facilitates the high-speed transfer of baggage from T3 to the other terminals and vice versa. Sorted baggage is convoyed through two high speed conveyor belts between Terminal 1 and Terminal 2, and four high speed belts between Terminal 2 and Terminal 3. Served by a network of underground tunnels, means that each bag moved from one terminal to another takes only about 3 minutes. All bags are dispatched automatically when the flights are ready. The system is designed to receive

[213] https://www.beumergroup.com/fileadmin/_processed_/csm_changi_2_cf772414b3.jpg

changes in flight itinerary so that the bags can be automatically processed and convoyed to the right connecting flights.

4.10 Terminals and Architecture in the future.

The consistent theme of transparency persisted within the Terminal 3 design that owes a great deal to the projects from the 1990s, especially from the expansions of Terminal 1 Extension and Terminal 2 Extension. Glass facades blending seamlessly into skylights were created innovated, and tested through the expansions, giving confidence to Civil Aviation Authority of Singapore so as to attempt even more ambitious curtain walls that approached the tarmac, facade, and sky in one swoop. Technological advances in construction also changed the approach of Terminal 3 from the first two. Lighter, more capable architectural expressive steel was used to create larger spans as well as enhance the feeling of openness.

Changi Airports with its 3 terminals experienced prolong success as the best airport in the world constantly, while more and more traffic began to enter the doors of the terminals, Changi Airport Group when about to prepare for Changi's 4th terminal. So they opened up the design to architectural groups around the world. In 2013, Changi Airport Group (CAG) announced that it had appointed an architect and design consortium to pilot the overall architecture, design concept and construction of Changi Airport's Terminal 4. Partners for the T4 project include AECOM Singapore and Beca Carter Hollings & Ferner which are renowned civil and structural engineering and mechanical and electrical engineering consultants respectively. Mr. Yeo Siew Haip, Managing Director of SAA Architects has said that the goal of T4 is to be built within 3 years and deliver a travelers' experience to new heights, contributing to Singapore's goal of being a leading aviation hub.

Due to site constraints, T4 will be smaller than the other Terminals on Site. While the other terminals can handle more than 20 million passengers a year, the facility will be expected to handle around 16 million people annually. Residents of Singapore as well as local architects have welcomed the appointment of a

Singaporean company to lead the project. There was a stir of commotion when the airport group had initially announced that in March of 2012, several local architects were led to believe that local design groups would be excluded from the competition and was pleasantly surprised when SAA Architects had won the competition. It is currently under construction.

Changi is booming to become more than just an airport but a complete transition hub. The team's goal is to create places for people and commerce. This can be seen with the new ongoing addition of the Jewel Changi Airport. This new addition will bring together outdoors and indoors in a fusion of nature and marketplace. Designed by Moshe Safdie, the architect of the Burj Khalifa, is designing the Jewel Changi Airport. Its main feature is the 40-meter-high waterfall in the center of the steel dome, expected to be the tallest of its kind in the world. In addition, another expansion is being done on Terminal 1 to expand the parking capacity, update the departure halls baggage system to a fully automated system, and create pedestrian bridges that link to the Jewel of Changi.

Another development from the Changi Airport Group is Terminal 5. The land is secured and the development will be larger than all the current terminals, 1-2-3-and 4, combined. With all these developments and goals of place making, it is important to understand what is important to understand the users of airports.

Understanding how people use the architecture as well as how people adapt to societal shifts in relation to architecture is an important element within the design process. One of the key observations of this study was seeing how important our digital culture has invaded our architecture. Not just as amenities but near-necessities.

Using Changi as a case study becomes valuable because it shows snapshots of design thoughts in time as well as constant retrofits/renovations in order to keep pace with modern societies demands. Its history is rooted in its foundation and its architecture, while always renovating or trying to improve its user experience by understanding its modern client base. Retrofits and installations always serve as a purpose to bring dated terminals to modern

demands. This allows architects to understand how people value space while serving the basis function since its start, flight transportation.

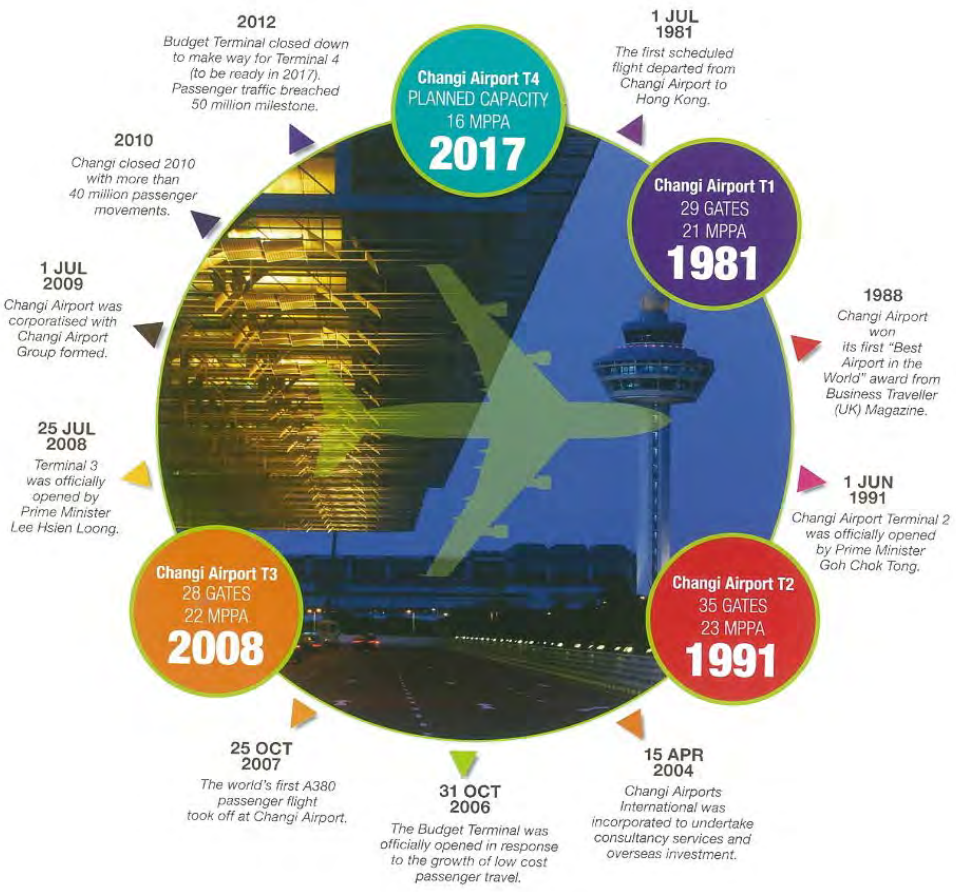


Figure 13: Changi's Airport Through the Years.

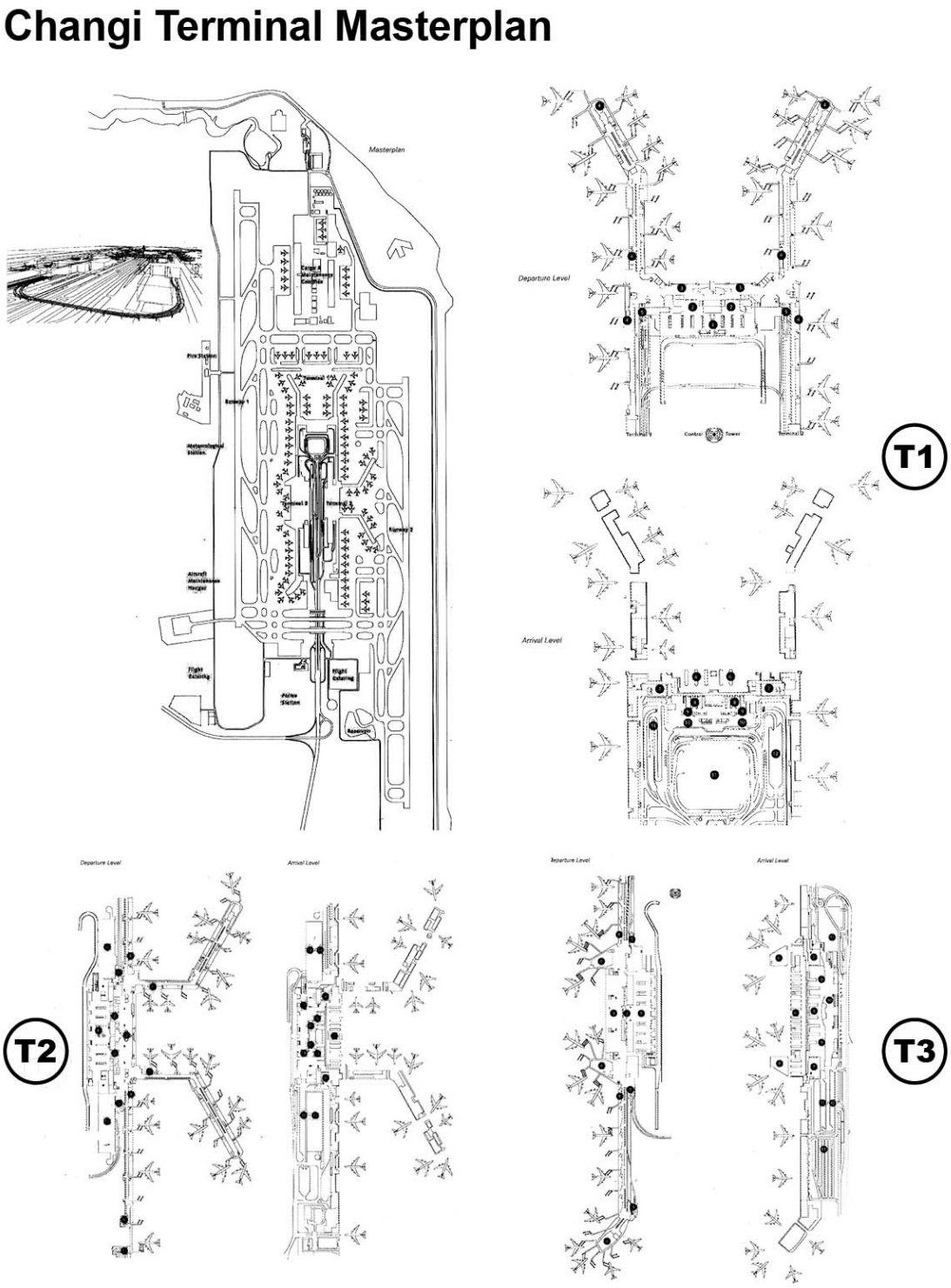


Figure 14. Plan View of: Site, Terminal 1, Terminal 2, and Terminal 3.[214]

[214] CPG Consultants, Changi by Design. 17-18.

4.11 Interviews with the Designers

To further understand the thought processes behind the terminal designs, two interviews are presented. The first interview was conducted in 2002, two years after construction had started on Terminal 3. Conducted for the book, Creating Paradise T3: Singapore Changi Airport, Teng Wai Man (TWM) who headed the PWD Consultants' Airport Development Division was interviewed. Over 20 years of experience, Teng actively designed or managed the design of each of Changi's terminal related projects. In the candid interview, Teng reflects on the evolution of airports and all the terminals design thoughts:

CPG: Let's start with the airport. What are your thoughts on the architecture of airports?

TWM: The same as for architecture in general: that it seems to have become removed from the reality of its users. Architects- or maybe I should say the way architecture is presented by the architectural media – has divorced the building from its occupants. They have become its garnish, when they should be the primary ingredient. As a profession, we sometimes subscribe to an inbred logic and a private audience.

CPG: Are you suggesting that architects don't pay enough attention to the way people see their buildings nor do you think there is a fundamental problem?

TWM: It's a fundamental problem. The way we define ''good' is askew. It shouldn't simply be a case of asking, "What do people want?" It should be designing with their eyes.

CPG: Is there a danger here of becoming overly pragmatic? Worse still, of ending up with the kitsch one sees in the Singapore suburbs. Is that not a reflection of what people want?

TWM: First, you have to distinguish between the public and private realms. The balance between public good and private entitlement shifts across the spectrum of buildings. For residential projects, yes, the owner is king. Even if you and I

disagree with his preference we have to respect his rights. As designers we have the ultimate prerogative of turning down his commission. With an airport designer must consider the needs of a community of users where there can be conflicting needs and preferences. Here, the architect becomes arbitrator.

Second, ‘pragmatic’ does not imply the absence of vision.

CPG: If the architect is merely arbitrator, wherein lies your authority?

TWM: I’m not suggesting that we should design by consensus. I am arguing that the designers are too often swayed by arguments of style and space or what we perceive, as a professional community, to be the forces of history. We should start by asking what, at the heart of this project brief, is the human condition? This is not an argument for functionalism. There is more to the human condition that activity alone. We need to understand perceptions and realities. The history of humanity is the history of competing realities.

CPG: We need to start asking what do the users of this building feel? What do they fear? Is there experience constant throughout the time they spend in the building? Does it depend on their gender, age, or nationality?

TWM: My job is to bring together these needs, requirements and aspirations and integrate them into a cohesive entity, one that is more than the sum of its parts. The problem is that many of these user0needs are unspoken. You will not find them in the project brief. Often clients are incapable of articulating them, so the primary task of an architect is that of seeking out and finding insights into the human condition. He must then bring to bear technical and administrative skills that can help translate vision to reality.

CPG: Can questions about the human condition be answered during the design process?

TWM: Yes. Sometimes thought through observation and sometimes by extrapolation. Quite often by simply asking people what they think. It doesn’t have to be a scientific process of data collection... nothing elaborate or expensive. The inclination to understand the human condition is in us: it is the

ability to empathize to extract from our own experiences a close approximation of another's. But we don't use this faculty much. When an architect receives a project brief, the first impulse is to look for similar buildings in magazines or books. The priorities of space, structural expressiveness and stylistic innovation live on as do the mistakes with regard to climate, clarity, and scale.

CPG: Is this approximation harder with some buildings such as airports?

TWM: With airports there is more to reckon with – a greater number of people, more user groups, complex information systems. The overlap and conflict between realities can be bewildering at first. But it takes a little longer to sort out, that's all.

CPG: Coming back to the question of airport architecture, what is your criticism?

TWM: It's not so much a criticism of the airport itself as it is of the way it is discussed. A building cannot exist in a bubble. Its place in time goes beyond the rhetoric of architectural discourse. It upsets me when airports are talked about as it they were a private discourse on geometry and form. I contend that you cannot talk about Changi without also talking about aviation history. You cannot discuss Singapore's airport without understanding a little bit about Singapore. A building merely reflects its larger reality. And the better it is at reflecting this reality – of connecting people, place, and time – the more interesting it becomes. Look at the architectural icons we know: The Opera House in Sydney or the Eiffel Tower. They became symbols of nationhood and technology not because the architectural community or the politicians dictated it so. They became important because they mirrored a reality that was already out there.

CPG: What about the making of the modern architectural icon, buildings designed to become symbols of regeneration and growth?

TWM: I think the jury is still out on those types of projects. They may have received considerable press, but I would argue that the true test is time. In an era of media hype, we are too quick to attribute greatness. This is not a critique of

the buildings themselves nor the forces that created them. But something other than the architect or politician will decide their place in history.

When we set out to create Changi we had no idea how big it would become. This has not been – in all honesty – a result of an architectural discourse. It's been a process of election, a truly democratic decision. People have decided this airport has a place in their hearts.

CPG: But this decision has been artificial in one sense. Hasn't Changi been voted to its place through pool carried out by travel magazines of its readers?

TWM: In the beginning, yes – and we took it all with a pinch of salt. But the momentum of Changi's success has been tremendous. If you look at the list of accolades there is little doubt that not one but many groups think that Changi does what it does extremely well.

But really, what I am talking about is its bond with Singaporeans – which is a separate audience altogether. Change has entered a place in the hearts, and not just the frequent travelers. In my opinion that will be its true legacy that it is a symbol of a nation.

CPG: It's been said that Changi Airport is functional. What is your response to that?

TWM: And so it is. It functions extremely well.

CPG: So what do you think makes it architecturally significant?

TWM: That is does its job well and does it in a creative way; that it sets standards with which others are forced to reckon. That it has grown organically and eloquently and managed to hold on – after 210 years in existence – to its design coherence. I think that our truest achievement is that we have given Singaporeans a building that they can be proud of. It gives us a sense of national pride and optimism. The airport has transcended function and become an icon. How many buildings in Asia can you name that have done that?

CPG: Surely Changi's success is due to its service standards?

TWM: Yes. And the Civil Aviation Authority of Singapore does an amazing job of keeping those standards high. But that's not all. Changi's design is part of those standards. It reflects them. It amplifies them. Whether we are designing directional signs or planning a new terminal, we ask ourselves again and again: "How will this be used? How will the passenger see this? Will this be a memorable experience?" The building is like a glove that fits the hand that welcomes the visitor. Try giving a handshake with an oven mitt (laughs).

CPG: What were your first thoughts when Terminal 2 opened?

TWM: To be honest – and few architects will admit this about their work – it left me with a sense of awe, bordering on terror. You rarely see in your mind's eye the full effect of what you have created. All I could think at the time: 'My God. This is huge!' The scale was bewildering.

CPG: Were there criticisms of the building?

TWM: Let me first say that I dislike trends. When the interior designers for T2 proposed stylized traveler palms, I said 'no!' I look for a timeless quality in architecture, the coming together of space and light. The building is a stage set for people, not an exercise in High Art or Pastiche, screaming for attention. The books I read as a student were *Pattern Language* and *Places for People*, which were about the integration of elements that make up the environment – landscaping, seating, handrails – for a setting in which the needs of the individual are paramount.

CPG: I recall students of architecture in the 1980s rushing out to buy the Charles Jencks' book on Postmodernism...

TWM: (laughs). Yes. There were pressures to be resisted. Postmodernism is like the Disco of architecture. We are a little embarrassed now to admit that we enjoyed *Saturday Night Fever.*

CPG: Did you give in to Postmodernism? Just a little, perhaps?

TWM: No... not really. It was never my things. I admired Kenzo Tange and Arthur Erickson. I was excited by the spatial gymnastics of John Portman – inspired by the restraint of Leandro Locsin.

CPG: Coming back to the Airport, what do you think of the new airports in the region – in particular the ones in Kuala Lumpur and Hong Kong? What can we learn from them?

TWM: They are excellent buildings. And they teach us much about the integration of technology and architecture, and the drive to humanize the airport. They also demonstrate that as designers, we need to take onboard a whole new set of issues. Airport design has become more complex.

CPG: For instance?

TWM: Green issues, energy simulations, intelligent facades that work with the climate. Complex roof systems that filter daylight collect water and act as solar collectors. These are part of the bigger agenda of the 21st century. At ADD we have acquired these skills or are working with people who are experts in their fields.

CPG: What about the dramatic roofs of these buildings?

TWM: That's not new and certainly over-hyped. Airports have always been metaphors. The media makes much of fancy roofs because they make for great photographs and captions. I think the real innovations are harder to photograph. It's harder to photograph simplicity and clarity.

Airports today are trying to be simpler in layout. Designers went the wrong way in the 1960s and 1970s with complex movement routes and opaque planning. The real challenge think is to keep it simple. Not so simple that it is boring, of course.

CPG: If none of this is new, why haven't we seen it in Changi?

TWM: If you are talking about technology, much of it is invisible. Information technology for instance has made our buildings smarter. T2 had an advantage over T1, as will T3 over T1 and T2. If you refer to questions of clarity I think you

will find that Changi made that a part of its agenda in the 1970s with T1, long before it became fashionably to say so.

But if you are referring to metaphors of form, this goes beyond the simple question of how an airport looks. It is also a question of how it works, how easy it is to maintain, how expensive the technology is that goes into making these elaborate roofs. An airport is as much a reflection of its users as it is of the designers, and even more a reflection of its owners and operators. In the past, there was skepticism (amongst our clients) of doing things for architectural effect – which was I think justified after problems with recent designer terminals elsewhere in the world.

We've taken Changi – its many extensions and renovations since it opened in 1981 – one step at a time. Look at some of the concept proposals for Terminal 2 Extension in 1991: they were more cutting-edge than Terminal 1 Expansion (completed in 2000). We can only go as far as we are permitted. Sometimes far too much credit is given to designers.

CPG: So what changed with Terminal 1 Expansion?

TWM: Our clients agreed to push the frontier that little bit further. We are all more confident of the way in which building form and service delivery converge so there is greater room for exploration. The project has been about creating an experience of engineered quality.

CPG: Does it signify a shift in design approach?

TWM: Not in the sense that the experience should be people-centre. And that means having a building that can deliver a high standard of comfort in a manner that is easy to manage and maintain. If you are looking for the radical in Changi, you will not find it. It's been a process of evolution more than revolution.

But yes, we are trying to bring in more daylight, which is the key to creating an experience that is much more humane. It adds depth and variety. Daylight enlivens, animates, and clarifies. The humanization of the airport beings with creating a sense of clarity. As a passenger, you want views of parked aircraft –

which is reassuring – and you need a sense of where you are in the larger airport complex.

Clarity is the first and hardest rule of airport design. There are so many demands on a passenger's attention that making the experience lucid and coherent is an enormous challenge. It begins with keeping circulation and movement options simple. You try to give the traveler a sense of where he is, all the time. Signs can only go so far because so much of what we know comes from our understanding of the whole. We deduce our location outside as often as possible. These principles are already in place with T1 and T2. What you are seeing with T1E is the opening up of the building to the outside and a simultaneous refinement of the inside.

With the interiors there is now a smoother design statement in which everything is integrated, a deliberate attempt to break free from the 'air-con-and-light-fittings-in-the-ceiling' approach. These elements are now on the walls, on the floors tucked into columns. You experience the building as something that is larger than the sum of its parts.

CPG: It's been 20 years since Changi opened. What have been the biggest changes since then?

TWM: Building technology, primarily. For instance, the choice of glass in the days of T1 was limited. Having too many windows or large areas of glazing then meant a phenomenal heat load on the building with higher energy bills or localized discomfort. Also you could never get a particular type of glass to do everything. In an airport you need the envelope to deliver sound attenuation, sun shading, low thermal transmission, high transparency. One of our biggest problems in T2 was finding a glass that could give a view out at night (laughs).

CPG: Let's look at T3. What is in the project brief today that wasn't there when you set out to create T1 and T2.

TWM: Expectations have shifted. With T1 in 1981, we were moving out of Paya Lebar. That was the point of reference. Today we are striving to keep our

rankings in the worlds: Number One, no less. With every addition through the 1990s, we have had to deliver on the expectations of what's already there and then improve on it. If we fail, it's big news. If we succeed, everyone shrugs: of course!

It sounds tough but we really have several things to our advantage. First the cumulative wisdom of our clients – who know precisely what it takes to run a world-class airport 0 and second, the ADD team which knows how to produce a building that can deliver on these promises.

I think that with T3 the biggest challenge will be refining the Changi experience. CIVIL AVIATION AUTHORITY OF SINGAPORE knows what the customer wants in terms of service standards – speed of customs clearance, courteous staff, clean toilets, etc. What's harder to pin down is what the customer expects in terms of architecture. How do you give him that little bit extra, a sense that he has been somewhere unforgettable? How does clockwork efficiency coexist with a sense of the spiritual? This is the Holy Grail of airport design everywhere. At Changi we have a coupled of advantages: we know our strengths and we know our limits. We will combine what we know with what others know – pulling in expertise in certain strategic areas from around the world – and create something breathtaking.

CPG: Does that include achieving architectural prominence?

TWM: As defined by who?

CPG: Whoever matters most.

TWM: That would be the building's users. And yes, we will deliver whatever is needed to keep Changi on top. But design is subjective at best. One man's mansion is another's kitsch palace.

CPG: You would deliver kitsch if you had to?

TWM: (laughs) That's not what I mean. Anyhow our client is far too sophisticated to settle for that. I was talking about the subjectivity in design. We keep a finger

on the pulse of the building's users. How the passenger measures his experience and how he compares Changi with other airports. It's his expectations we must met. Not those of the editor or some glossy design magazine.

In 2013, Changi Airport Group (CAG) announced that it has appointed an architect and design consortium to pilot the overall architecture, design concept and construction of Changi Airport's Terminal 4. Partners for the T4 project include AECOM Singapore and Beca Carter Hollings & Ferner which are renowned civil and structural engineering, and mechanical and electrical engineering consultants respectively. Mr. Yeo Siew Haip, Managing Director of SAA Architects has said that the goal of T4 is to be built within 3 years and deliver a travelers' experience to new heights, contributing to Singapore's goal of being a leading aviation hub.

Due to site constraints, T4 will be relatively smaller than the other Terminals on Site. While the other terminals can handle more than 20 million passengers a year, the facility will be expected to handle around 16 million people annually. Residents of Singapore as well as local architects have welcomed the appointment of a Singaporean company to lead the project. There was a stir of commotion when the airport group had initially announced that in March of 2012, several local architects were led to believe that local design groups would be excluded from the competition. In this 2nd interview, the author interviews Mr. Kok Kin Toh, Executive Director of SAA and leads the Changi Terminal 4 Project Team offered to gain insight on the design considerations that go into airport design. Specifically, the goals and challenges of Changi Terminal 4:

Q: What is the goal of Changi Terminal 4?

KKT: When we consider Terminal 4, it is more than goal setting at play as there are multiple reasons why Terminal 4 came to be conceived. A lot of it has to do with passenger capacity needed to keep Changi Airport relevant as the premium/preferred aviation hub in the region.

Other reasons revolve around the changing face of the aviation business. In its original “state” the budget airport that T4 is sited on was conceived to cater for the growth in the burgeoning “budget airline” business. However with time, it appears that the even “premium” passengers gravitated toward budget or regional carriers not only because they are more affordable but because a mature passenger demographic appreciated the fast pace and lesser emphasis on passenger perks as both business travelers and tourists would rather spend their dollars more “wisely”. So for regional travel “budget no frills providers” were experiencing fastest growth.

Takes into account the thousands of airline service and ground service staff who have to be at their best, in order to deliver the ultimate Changi Experience.

So in a nutshell Terminal 4’s goal is to deliver that “Changi Experience”, building upon years of being one of the best in the world.

Q: Have you learned or observed anything from the Terminal 1, 2, and 3 designs for Terminal 4 from CPG Consultants? Are there significant similarities, differences, criticism in architectural design or approach? Have you looked at other airport designs around the world as guidance?

KKT: Changi Airports through the years have seen Terminals 1, 2 and 3 developed, always adopting world standards and incorporating what’s best practice in both space planning and technology. Terminal 1 since its upgrade to its interiors is currently undergoing its “expansion” phase to again increase its passenger handling capacity by 50%! The terminals are constantly being upgraded and improved, they are on a constant evolutionary path to becoming more relevant and indeed to anticipate trends that will keep Changi ahead of the pack. CAG does extensive studies of airport developments around the world, not just on new airports, but more to sense what is new and exciting in any aspect of the aviation industry, be it technology or service standards to architecture that has made some airports more memorable than others. No aspect is ignored.

T4 will screen passengers at the immigration gates. The passengers, once they have cleared customs and security screening can then wander freely, stress-free before they board. There are no gate-hold rooms in T4. There is also a lot more transparency in this terminal. This will be the first time that there is unimpeded visual connection between land side and air side. One can view planes taking off even from the check-in hall.

This transparency shifts the passenger experience from being land side/air side bound, to feeling they are in a single space, seamlessly traversing from one zone to the next. The visual access to the air side transit lounges where all the air side retail and F&B also beckons the traveler to check in early and spend more time AND dollars on air side offerings. This is a game changer in airports, as air side retail keeps airports financially sustainable. The essence of the design is to offer this naturally and allow the more “mature travelers” the opportunity to enjoy their savings with lower airfares. It is not that “budget” travelers do not have the dollars to spend, they just choose to spend it more wisely.

Q: With an expected 16 million people passing through Terminal 4 annually, have you considered the different user experiences within Terminal 4? If so, how? I.e. the stressful traveler, the person bidding farewell to his/her family, the late traveler, the curious explorer.

KKT: The technology side of airports has moved toward self-service, primarily because there is a need to make airports less labour intensive and also because the traveler is becoming more savvy and sophisticated. But in T4 this will happen in phases, with some self-check-in and self-bag-drops while other counters will remain manned conventional counters.

The approach to managing pax expectations is to test it in the field. So there are also future provisions for the systems to be upgraded in the future…always taking the cue from the passenger.

Way finding is crucial, with clear and intuitive signage. Lighting levels, in lux terms and down to the color temperature of the lighting is meticulously considered, and

are well over industry norms. Washrooms are always within eye-shot and are well ventilated and clean and attended to. These appear insignificant, but they are extremely important. Access to Internet and charging points, even at seats, these are the “little” things considered to ensure maximum convenience.

Pax studies show that peak-stress occurs at 2 points in air travel. First, at check-in where bags could be overweight or visa issues, and secondly, at security screening. The stress builds where crowds are not processed efficiently. So the number of counters, screening stations has to be carefully considered to ensure fast and stress free clearance.

The maximum capacity of any airport is only as good as its weakest link, or process. It is crucial that all aspects of pax movement to-and-fro aircraft need to be perfectly synchronized be it bag drop or luggage claim or the wait for that taxi. Any bottleneck mars the experience.

There are also many offerings of kinetic and static artwork, giant digital screens, feature gardens, children’s playground, to take the edge off the stress of travel, making it instead, an unforgettable experience.

The hardware of airport must also be matched by its heart ware, and this is where the service standards of Changi have worn it years of accolades. The combination of the two, that’s the Changi experience, delivered seamlessly.

Q: In my research on Terminal 2/3 I’ve found that the architects designed the baggage claim floor tile arrangement in such a way to psychologically queue users in an organized fashion or researching how the body clocks work and arranging the lighting fixtures/technology to have it follow the normal ebb and flows of the body. What design considerations, as small as they might be, have the Terminal 4 team considered and incorporated into design?

KKT: There are many visual cues embedded in T4. The petals of the west canopy mark the entrance vestibules. The angled check-in rows as do the fused stone floor patterns, intuitively guide pax to immigration. Lighting levels at various parts of the check-in hall increases as you are closer to the service counters, giving more

comfort level without glare in the terminal. Super-clear low-iron glazing for glass walls separating land and air side, thereby allowing direct view access. This enables a much better intuitive way finding making the T4 friendly and legible to the users.

Q: What are your thoughts on societal/technological advancements and its affect on spatial use? How can these advancements be considered, incorporated, and/or examined in architecture? Were they ever considered in Terminal 4?

KKT: In T4, charging points are available at least 10% of all the seats. All Changi Airport terminals have free WiFi access, this is now a given in most buildings. In the transit lounge areas, there are Internet kiosks and work desks. They are also at boarding gates, for passengers to do their last minute emails or chats. We no longer ask “if” we provide such, but in how we provide it to best serve the user. A part of this service will be just access, the rest will probably be about content. This level of connectivity has opened new avenues.

Q: On a similar note, Terminal 2 - 3 claim to have considered “future” considerations such as data infrastructure. Apparently the wiring management was done in such a way to be easily fixed, replaced, or adapted too. How is Changi Terminal 4 suited to adapt to future advancements and or technologies?

KKT: A lot of airport work is ongoing, be it upgrading of services or an increase in handling capacity. In the past, it has been challenging when new infrastructure is needed. In T4, there are FGS, “FIXED GROUND SERVICES” planned in both land and air side for future upgrading of services, be it electrical or fibre-optics or data. These are ground infrastructure which will allow easy access in the future. There is also a level of “redundancy” planned into the system to cater for downtime or should upgrading affect existing services.

Q: What is it about working in Terminal 4 that excites you the most as an architect?

KKT: I think there are 2 aspects I find very exciting about T4.

One is seeing how CAG is constantly reviewing the design, the infrastructure or the systems that will become T4. It is not “normal” that a building gets conceived with such a degree of fluidity. I do not mean to imply that there are constant changes but I believe it is certainly not cast in stone even after Award. I think the developments in airports and systems are always considered before major decisions are made, regarding layouts and equipment, and systems. The currency of the ideas are kept so fresh because a mistake in adopting the wrong solutions are actually very costly to unravel in infrastructure projects like airports. I find this fluidity very exciting.

Second is really how a large scale and complex project comes together. We see a lot of the work as Architects on drawings, but the fruition of all projects requires collaboration, with many disciplines, and requires a lot of skill in negotiating from Authority to Contract/Construction to Client expectations to even Public opinion…. it’s also down to the last brick or tile, or façade element which will be installed…it’s really about man over matter really. The ball is certainly not always in your court as the Architects, but it takes skill to navigate the journey to bring the whole team to reach the goals and aspirations we started to envision. Inspiring the entire team to match towards reality, I find that very exciting.

Q: On the other hand, with such a big project, I suspect there are many limitations, what are some of the challenges and how do you go about seeing the architectural vision through?

KKT: On large scale projects, the main challenge is really control…or the lack of it. The limitations are multifold…ranging from budgets to authority requirements to managing the Client’s expectations.

To start with the Client is not a singular entity, as with large projects, the client is a conglomerate of USER GROUPS. They do have an ultimate “boss” but at such a scale it is normal to work by “consensus” as there are so many stake-holders, all with very pressing needs. Is it an airport with a retail component or a mall where you can board a plane? If we look at the financial figures, the lines can get blurred sufficiently.

We have approached T4 also with a sense of collaboration with the authorities and have brought them along this journey. For projects this scale, we best treat them as our partners, as we explore the limits of building codes against the design and vision for T4…and at times even challenge the prevailing codes, to test its validity against this project.

I believe an Architect is trained to identifying what is critical and what may be secondary, and have the people skill to navigate the process. We stay idealistic, but grounded and rational in our approach to find solutions…

Above all, we need to have enough passion to will the vision into reality.

With the thoughts of the architects to better understand their design goals and philosophies, we can better understand where their priorities and thoughts have gone. In Chapter 5, Terminal 4's design thoughts as it is currently being constructed in 2016. Then, the dissertation will look at, evaluate the design goals of Terminal 5 and compare it with the release conceptual proposal. After investigating, suggestion and a new set of proposals will be made in attempt to better the design towards the dissertation and of CPG's statements.

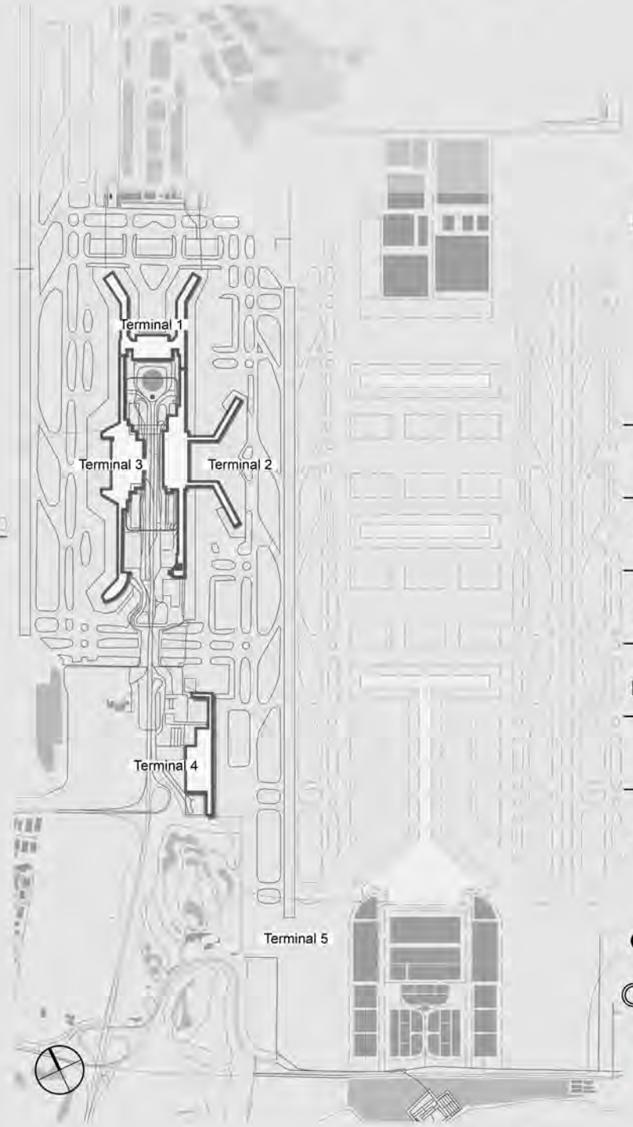
CHAPTER 5. CHANGI AIRPORT CASE STUDY II: EXPECTED PROJECTS WITHIN CHANGI

Singapore's Changi Airport went through extensive changes to keep up with the demands of operation and the advancement of technology. Major events and innovations affected Changi's design intentions and approach. Seen in Figure (#), Changi initially believed itself to be an "Origin and Destination" airport. Immediately after the completion of Terminal 1, Terminal 2 had begun to take form in the exact mold of Terminal 1 to accommodate the increase of air travel. Very quickly, the Singaporean airport realized the influx of transit passengers. In fact, up to 30% of all flights were transit passengers and the competition to be the South-East Transit Hub began. In order to adjust this demand, the designers added two finger piers to both Terminal 1 and 2 that provided larger fixed gates. Technological innovation in showed that larger aircrafts capable of handling many more passengers were on the horizon. Airside amenities squeezed into Terminal 1 and 2 for the passengers with long layovers to enjoy stress reducing environments. Keeping a positive customer rating proved to aid in securing hub status.

Then, September 11, 2001 changed the global airport security model. Terminal 1 and 2 went through changes once again improve their security organization. While not the centralized security organizations of other airports built after September 11, Terminal 1 and 2 made the best of their ability with their already decentralized system and joined many of their individual holding rooms. This gave the airport with higher standards of quality control in lieu of its fused infrastructure. Terminal 3 was built off this idea of consolidated gate holding rooms with a clearer emphasis on transit amenities and commercial availability. Terminal 3 became what Terminal 1 and 2 wished itself to be through all its renovations based off demands and expectations of modern airports.

CURRENT TERMINAL 1-5 ORGANIZATION & HISTORY:

Changi Terminals Information



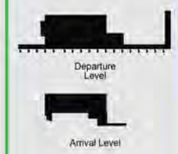
	Terminal 1	Terminal 2	Terminal 2 Extension	Terminal 1 Extension	Terminal 3	Terminal 4	Terminal 5
	Passenger Capacity Priority		Hub Status Priority		Post September 11, 2001	Commercial Priority	Passenger Capacity Priority
Gate Typology + Extensions							
Year Opened	1981	1990	1996	1998	2008	~Q4 2017	~late 2020's
Terminal Passenger Capacity	10 million / annually	10 million / annually	21 million (+11m) / annually	23 million (+13m) / annually	22 million / annually	16 million / annually	50 million / annually
Terminal Floor Area	220,000 m^2	285,500 m^2	358,000 m^2	308,000 m^2	380,000 m^2	195,000 m^2	1,600,000 m^2
Aircraft Fixed Gates	15	13	35 (+22)	29 (+14)	28	25	~63
Aircraft Remote Parking	7	2	11 (+9)	16 (+9)	15	6	~30
Security Approach Scheme	Decentralized Scheme	Decentralized Scheme	Consolidated Scheme (Post 9/11)	Consolidated Scheme (Post 9/11)	Consolidated Scheme	Centralized Scheme	Centralized Scheme
Gate Organization							

Table 1. Changi Terminal Design Analysis Through the Years

Terminal 3's masterplan included an addition of automated baggage service which proved to be highly efficient and effective. Innovative technology enhanced the efficiency of airport operations while buildings technologies improved and enhanced the interior spaces with the introduction of controlled daylighting in all three terminals.

The theme of transparency persisted within the Terminal 3 design that owes a great deal to the projects from the 1990s, especially from the expansions of Terminal 1 Extension and Terminal 2 Extension. Glass facades blending seamlessly into skylights and tested through each of the expansions. The success of the steel structures gave confidence to the Civil Aviation Authority of Singapore to try even more ambitious curtain walls that approached the tarmac, facade, and sky in one swoop. Lighter, more capable architectural expressive steel allowed Terminal 3 to create larger spans as well as enhance the feeling of openness than the earlier two terminals.

Changi Airports with its 3 terminals experienced prolong success as the best airport in the world. As more and more traffic began to enter the doors of the terminals, the Changi Airport Group set out to create the fourth terminal. Thus, they opened the design competition to architectural groups around the world. In 2013, Changi Airport Group (CAG) announced that it had appointed an architect and design consortium to pilot the overall architecture, design concept and construction of Changi Airport's Terminal 4. Partners for the Terminal 4 project include AECOM Singapore and Beca Carter Hollings & Ferner which are renowned civil and structural engineering and mechanical and electrical engineering consultants respectively. Mr. Yeo Siew Haip, Managing Director of SAA Architects has said that the goal of T4 is to be built within 3 years and deliver a travelers' experience to new heights, contributing to Singapore's goal of being a leading aviation hub.

Due to site constraints, T4 will be smaller than the other Terminals on Site. Replacing the old budget terminal which closed in 2012, Terminal 4 will serve as a smaller air terminal that will serve a more affluent clientele. While the other terminals can handle more than 20 million passengers a year, the facility is expected to handle a little less at around 16 million people annually. Residents of

Singapore as well as local architects have welcomed the appointment of a Singaporean company to lead the project. Prior to the competition end, there was a stir of commotion when the airport group had initially announced that in March of 2012, several local architects believed that local design groups were excluded from the competition and was pleasantly surprised when SAA Architects had won the competition. As of 2016, it is still under construction and expected to be so until Q4 of 2017.

Figure 15. Rendering of Terminal 4 Departure Hall Dropoff.[215]

Changi is booming to become more than just an airport but a desirable area of commerce. As the revenue reports show, retail has made up the majority of the profits at Changi airports as well as airports globally. Aside from Terminal 4, the airport group has commissioned a massive retail center branded the "Jewel of Changi." This new addition will bring together outdoors and indoors in a fusion of nature and marketplace. Designed by Moshe Safdie, the architect of the Burj Khalifa, the Jewel of Changi will feature a 40-meter-high waterfall in the center of the steel dome, expected to be the tallest of its kind in the world. The

[215] https://i.ytimg.com/vi/KSmE0TY36uk/maxresdefault.jpg

cumulative gross floor area 134,000 m2 commercial center is centrally placed to Terminal 1 through 3 replacing the current Terminal 1 outdoor parking lot.

Figure 16. Interior Render of Jewel of Changi Indoor Waterfall.[216]

The final project in the pipeline, and the project this dissertation is mainly focused on is Terminal 5. The land, east of the four-current terminals will be capable of handling more passengers than the latter combined. With the influx of development and designs on site, it is paramount to take a step back first and reassess how the architecture will complement each other. Currently, Terminal 1 through 3 acts as its own small airport each with no cohesive relationship with each other than the fact that they're physically attached to each other. Transit amenities in another Terminal is difficult to access without a real effort and desire to visit. The Jewel of Changi aims to remedy this, but Terminal 4 and 5 seems to lose any of the cohesive bond that the Jewel promotes.

[216] http://www.jewelchangiairport.com/

Terminal 5 which is projected to be opened late 2020's will be thoroughly evaluated and provided suggestions to change the current trajectory that it is on in favor of one that suggest place. Investigating the potential, the architecture gives as well as how people adapt to societal shifts in relation to architecture is an important element within the design process. The digital renaissance gives opportunities for an enhanced passenger experience. Not just as amenities but near-necessities.

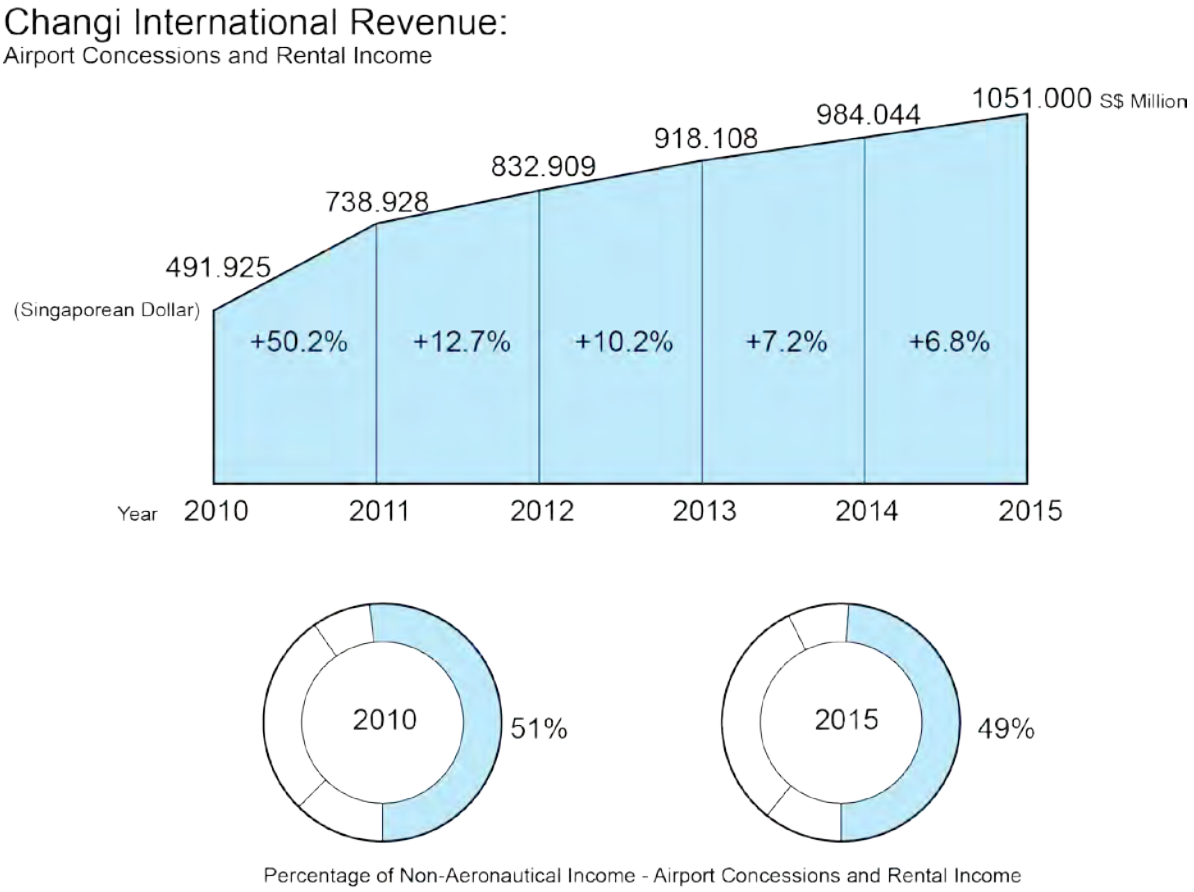


Table 2. Revenue off Airport Concessions and Rental Income

Using Changi as a case study becomes valuable because it shows snapshots of design thoughts in time as well as constant retrofits/renovations in order to keep pace with modern societies demands. Its history is rooted in its foundation and its architecture, while trying to escape its bars by renovating or trying to improve its user experience by understanding its modern client base.

Retrofits and installations always serve as a purpose to bring dated terminals to modern demands. A great understanding of space as an evolving material as its first function is just important as its inception, but not its sole purpose anymore.

5.2 Terminal 4 Analysis: Passenger Experience.

The 195,000m2 Terminal 4 is a simple rectangular building with a tail like linear concourse hall. An expected capacity of 16 million people annually, the 25 fixed gates will now be the first airport in Changi to support Category C aircrafts, smaller aircrafts than Terminal 1-3 can hold. The smallest aircraft Terminals 1-3 house are Category D (The minimum wingspan of Category D is 36 meters while Category C is 24m). Planned to catered towards the affluent, the more exclusive – Terminal 4 located far off the other three terminals confirms this sentiment – terminal exemplifies the shift towards a commercial emphasized design.

Guiding passengers across the commercial areas prior to the boarding gives incentives for the passengers to become customers as the revenue from commercial means is a key component at Changi; making enough profit of revenue to subside aircraft parking and landing, as well as other aeronautical charges.[217] By changing from a decentralized or consolidated security organization to a centralized organization, passengers are funneled into the airside and led through the commercial center prior to reaching their gates. The shift in design to give retail space more hierarchy stems from the rise in commercial revenue, growing 8% in 2015 from its previous commercial revenue record in 2014, earning a net operating revenue of S(ingaporean)$2.2 billion ($1.54 billion USD) in 2015. [218] In terms of non-aeronutical revenue, retail is Changi's biggest stream of profit.[219]

[217] http://www.straitstimes.com/singapore/changi-ranks-3rd-in-traveller-spending
[218] http://www.dfnionline.com/latest-news/retail/changi-airport-concession-revenue-grows-8-s2-2bn-2015-27-01-2016/
[219] T2 Transformation

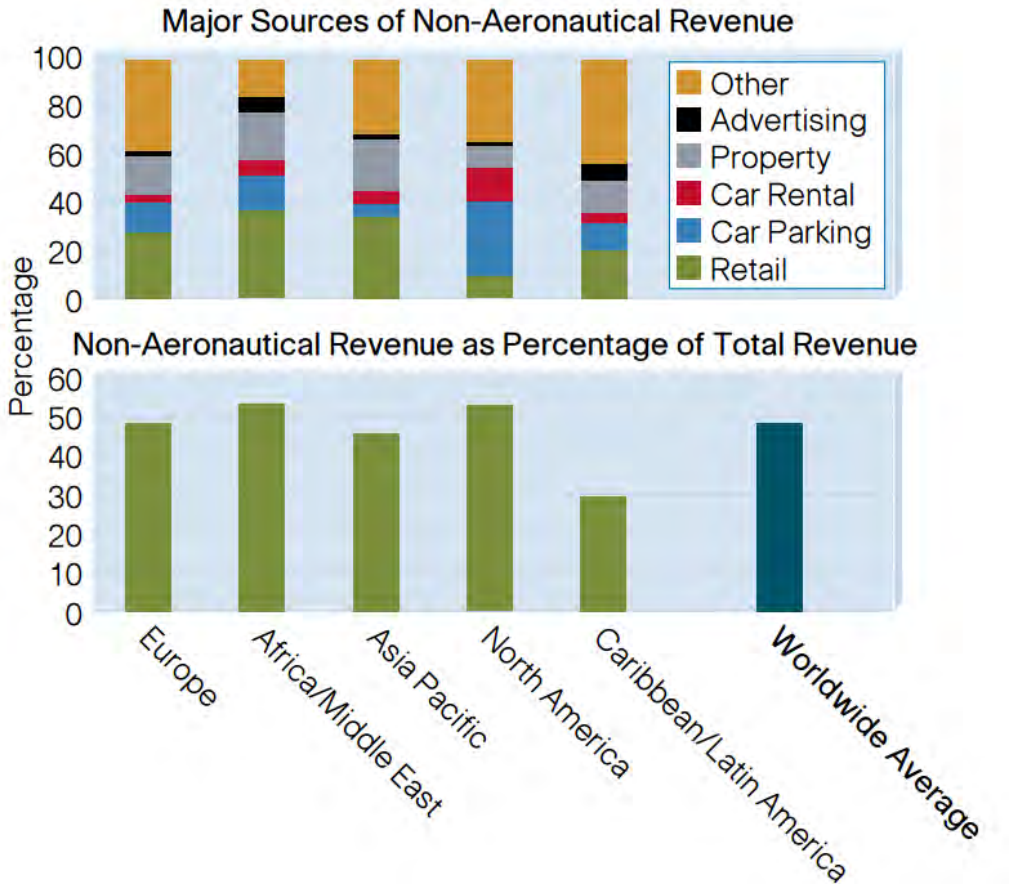


Table 3. Non-aeronautical revenues in global air travel.[220]

The change from a decentralized organization to a centralized one in regards to architectural design allows the passengers preparing for travel through Changi to direct passengers through the commercial areas. Departing and transit-based passengers may experience a unique experience within the airport given all the pleasantries on the airside. However, a large potential of the customer base is lost due to the separation caused by the security gate. The commercial mall situated on airside prevents loved ones on landside to accompany passengers while they shop, eat, and enjoy the vast amenities airports have to offer, a conceptual potential that is unrealized in today's strict mindset. The potential experience has not adapted to the technological advances in security. Stuck in the ways of old, while masking the technological progress through slow and gradual improvements rather than brave innovation. Even Changi Terminal 5—an

220 http://www.cisco.com/c/dam/en_us/about/ac79/docs/pov/Passenger_Exp_POV_0720aFINAL.pdf

airport extension expected to be finished more than a decade later—is laying the foundation of its organization with past design approaches, losing the potential the new generation of innovation in other sectors have to offer in order to enhance the passengers experience and approach today.

Terminal 4, and the proposed conceptual design of Terminal 5, have a very similar flow-through as compared to Terminals 1 through 3. The differences lie in the switch to a central plan over a decentralized plan, as discussed in Chapter 5. The main difference is the fact that the security checks are conducted prior to reaching the airside of the airport. Aside from that variation, the main ebb and flow throughout the terminals are similar. When considering Terminal 4's design, one can see an emphasis on customer commercial services during the passenger's way toward the boarding gates.

Figure 17. Rendering of Divide between Airside and Landside in Terminal 4.[221]

[221] http://www.greenaconsultants.com/our-work/changi-airport/

Circulation Diagram

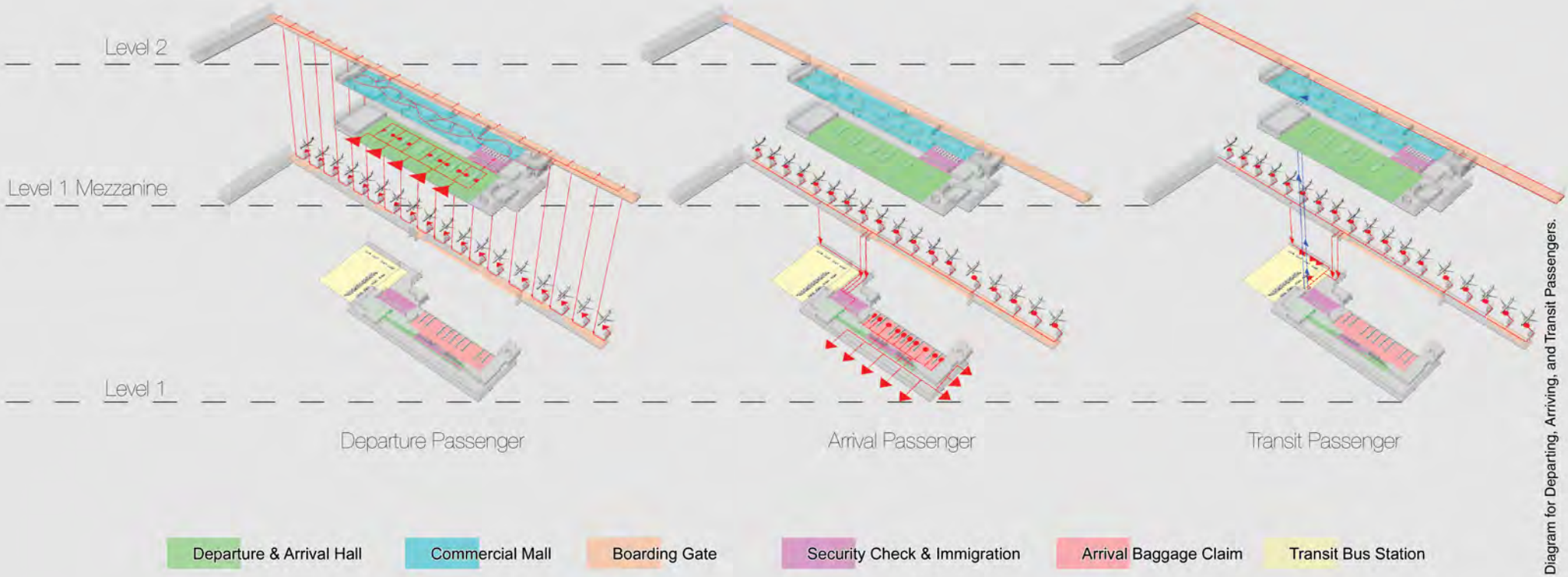


Figure 18. Terminal 4 Circulation Diagram for Departing, Arriving, and Transit Passengers.

5.3.1. The Departing Passenger

The architects emphasized the experience around the departing passenger once within the terminal. The circulation of the departing passenger is architecturally strategic, which offers the user a defined experience. By changing to a centralized security scheme, the terminal may hire less yet highly trained security staff to monitor the centralized full body scanners. This scheme controls exactly where all passengers enter the airside area, and while most airports these days lead you into a large boarding concourse filled with kiosks, Terminal 4 designed the store fronts journey and circulation routes to almost force the passenger to sensually engage with the commercial environment. The sights and sounds of the active area, in addition to the traffic of people flooding into the mall area gives passengers a sense of belonging.

Once through the commercial mall, the passengers then find their way towards their boarding gates. As a singular concourse hall, it is very easy to find their specific gate in comparison to other larger terminals such as Changi's other three. Typically, in other terminals that don't force you through a commercial center, the passenger will collide into many kiosks and stands that aim to entice the user. Airports emphasis designs to accommodate peak passenger capacity, not enhance the experience of the individual. This is further seen in Terminal 5's current proposal.

The departing passenger then waits at the gate, occasionally getting up to use the restroom or grab something small to snack on, time allowing. Once the gate opens, Terminal 5 uses a split access floor to flow passengers in. The boarding passengers on level 2 travel down a ramp or stairs to the mezzanine level where their fixed gates have attached to the aircraft. Once through the gates, the passengers find their assigned seats on the plane and prepare for lift off.

5.3.2 The Arrival Passenger

An arrival passengers main goal is to exit the airport as smooth and quick as possible. After being on an aircraft for a prolonged period of time, most often uncomfortably seated, people want as best to escape the airport atmosphere. In Terminal 4, passengers exit the fixed gates on the split level. To avoid any confusion, passengers move towards the center of the concourse where they will take an elevator or an escalator down a level to the arrival level.

The split organization provides a barrier between departing passengers and arriving passengers. In airports without split level arrangements, awaiting departing passengers stare at each arriving passengers as the exit towards the arrival hall. In at

the same time, to make room for the unloaded arrival passengers, airline crew often instruct the starring departure passengers to stand clear and move their occupied space to make room for all the unloaded passengers. A confusing and tense atmosphere that Terminal 4 designers felt avoidable.

Once on the arrival level, all arriving passengers queue up to obtain their visas and get their passports and boarding tickets rechecked. Residents and already obtained visa recipients may go through automated passport and thumb scanners to bypass the long queues of the manned process. After the passenger meets all criteria, the arriver passes through a small strip of duty free stores that surround him, keeping with the theme of Terminal 4. When introduced to the hall, those with baggage to retrieve move left towards the dedicated carousel, if not, then the arriver moves right past the security declaration area, and into the arrival hall.

5.3.3 The Transit Passenger

To be a transit passenger must feel very daunting in Terminal 4. It appears as if the designers gave little consideration towards the transit passengers. Transit passengers must follow the arrival passengers down a level into the area where immigration checks are being done. From this space, the passenger must know if their connecting flight is within Terminal 4 or one of the other three. If they are connecting within Terminal 4, the transit passenger must go through a security check point verifying the fact, then take a lift of long escalator up 2 levels to the departure mall. The elevator or double long escalator releases the transit passengers in the back end of the mall where they have a very limited experience of the mall compared to those the departure passengers receive.

For those who must transit to one of the other terminals, they will find the dedicated bus transfer stop found prior to the immigration checks. Once found and boarded, the bus will drop off the passenger to the destined terminal where they will need to go through another security check at the gate holding room as Terminals 1, 2, and 3 are decentralized security systems.

From all the analysis and research, there is a possibility that Terminal 4 is not expecting many transit passengers. Terminal 4's targeted demographic is those who are more affluent than the average flyer providing a more exclusive experience. 17 narrow-body aircraft stands are being introduced to Terminal 4, capable of docking smaller aircraft that the other three terminals are incapable of housing, as well as its own

dedicated traffic control tower.[222] There is also an assumption that those spending more on exclusive flight have little desire to fly with connecting flights.

Yet assumptions aside, it would not make sense to offer more 20% of floor area on the arrival hall's level to bus parking stands, stops, and access lanes if very little passengers are expected to transfer out of Terminal 4. In addition to space allocation, the parti form of terminal 4 is a rectangular box with a negative square splitting the box; this negative space all given to the bus transit area.

5.4 Evaluation of Terminal 5's Proposal design.

Expected to open its doors late 2017, Terminal 4 is nearing completion. The Changi Airport Group are being proactive and have started the design process for Terminal 5. Planned to open at the dawn of 2030, Terminal 5 is expected to become one of the world's largest airport terminals. The 1,080 hectare reclaimed site airport expansion, immediately east of the main airport, is likely to double Changi Airport's current passenger capacity—up from today's 66 million annually to 135 million—and boost the handling capacity to 700,000 flights a year by the end of the decade (300,000 currently).[223]

[222]http://www.caas.gov.sg/caasWeb2010/export/sites/caas/en/BridgingSkies/TopReads/Changi_Airport_Terminal_4.html

[223] http://www.straitstimes.com/singapore/transport/no-public-private-partnership-for-t5

Figure 19. The current site of Changi, map retrieved September 2016.[224]

Figure 20. The future site of Changi (Year 2030), Map retrieved September 2016.[225]

[224] Retrived from Google Maps. “https://www.google.com/maps/@1.3527398,103.9887735,13z”
[225] Retrived from Google Maps. “https://www.google.com/maps/@1.3527398,103.9887735,13z”

As of 2016, the East West Line for the Mass Rapid Transit (MRT) is the only connecting railway line to the three terminals. The last train from Changi Airport Station leaves at 11:18 p.m. and restarts the services at 5:45 a.m. the following day. Other means of transportation to and from the airport includes public buses, taxis, and, of course, personal vehicles. Bus stops are found at the basement bus bays of all three terminals with many connecting routes to the areas of Singapore. Shuttles offer drop-offs to most downtown hotels for a small fee and takes 25 minutes to arrive at these hotels under normal traffic conditions.[226]

The current plan for Singapore's Changi area is to expand the airport and add many new MRT lines, all the while extending the current MRT East West Line to accommodate passengers boarding through terminals 4 and 5.[227] The Downtown Line is the only existing line of the other two proposed lines, but it is 18 miles away from the nearest stop in relation to Changi. Approximately 20 more stops need to be created before the line is connected to Changi. The Cross Island MRT Line and the Thomson-East Coast MRT Line have not begun construction. Currently, the new Changi Coast Road—a motor vehicle road boarding the reclaimed land—is being constructed. Moving the road from the current Terminal 5 site towards the perimeter of the coast. In addition to the New Changi Coast Road, contracts have been awarded to build the third runway for Changi Terminal 5, and construction is expected to complete by the early 2020s. Used by the military, the runway will be extended from 2.75km to 4km to handle larger passenger aircrafts. Almost 40 km of new taxiways will also be built to connect the runway with the current airport to allow for efficient aircraft movement.

The Singapore government has decided against inviting private corporations to help fund and, thus, eventually own segments of the future Changi Terminal 5. The decision puts to rest many years of speculation that the Changi Airport could become a privatized airport like London's Heathrow and Germany's Frankfurt airports. The decision has the Singaporean government wholly run operations and ensures that Changi Airport will not focus on profits, rather the service standards and efficiency.[228] The current plan, as of 2016, is for Changi to be an "expanded airport" that will be "operated as a single, integrated facility for ease of transfer between different terminals, passenger

[226] http://www.changiairport.com/en/transport/shuttle-services.html
[227] https://www.lta.gov.sg/content/ltaweb/en/public-transport/mrt-and-lrt-trains/train-system-map.html
[228] http://www.straitstimes.com/singapore/transport/no-public-private-partnership-for-t5

convenience and airfield operational efficiency," according to the Transport Ministry.[229] Terminal 5 is to be built in two phases, with the pace of construction dependent on global air traffic growth. Land preparation works on the site, undertaken by the Ministry of Transport, have been conducted as follows: site surveys, soil investigations, services detection, and site clearance works. The project is currently moving to its next phase of ground improvement works, involving the consolidation and compaction of soil layers, which is necessary before further development works can proceed.[230]

The Changi Airport Group's mission is as follows: "To be the world leading airport company growing a vibrant air-hub in Singapore and enhancing the communities they serve worldwide."[231] CAG prides themselves for their outstanding customer service through establishing a culture of excellence. On the company's website, they define their user experiences as personalized, stress-free, and positively surprising.[232] The goals of the airport are to deliver what they named the "Changi Experience." It is their hope that everyone who enters and moves about within the terminal partakes in this holistic experience on a personalized level.

Lee Kim Choon, the former Director General and Chief Executive Officer of the Republic of Singapore Airforce (1998–2006) explains that the Changi Experience proposes to remove all elements of anxiety the traveler may feel while offering an overall pleasant travel-based atmosphere. A certain intuitiveness must weave itself into the overall design, strengthening the emotional bonds customers have toward airports and playing up the quality experiences they provide. Choon's predecessor, Lim Hock San spoke of Changi's Experience as "an oasis," wanting passengers to think that Changi is the "best connection" because the airport is an experiential delight. If the passenger considers the transfer at Changi memorable, then the architects and designers have achieved their overall goal.[233] The late chairman of Changi Airport Sim Kee Boon stated, "As time changes, design will change. With newer demands and competition from airports, passengers want something different."[234] However, the proposed terminal does none of these things. The Terminal 5 plan reads as an efficient airport model with little

[229] https://www.ainonline.com/aviation-news/air-transport/2016-02-11/changi-airport-outlines-expansion-plans
[230] http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2015/Changi_Airport_Group_Annual_Report_2015_Full-Report.pdf
[231] http://www.changiairport.com/corporate/about-us/our-belief.html?anchor=definingthechangiexperience
[232] http://www.changiairport.com/corporate/about-us/our-belief.html
[233] Creating Paradise T3. Page 40.
[234] Page 38 T3

regard for the human experience behind the design, especially given the Changi Experience for which the airport group prides themselves.[235]

To expound, terminal 5's current conceptual plan displays that the Changi Airport Group have not considered an "exceptional passenger experience that is cutting-edge and at the forefront of technology" aside from retrofitting and improving upon existing ideas that have existed since Changi first opened in 1981. The way a passenger moves through the airport has gone unchanged since its start in the eighties. Aside from retrofitting contemporary technology in the form of automating baggage systems, self-check-in kiosks, and improved security equipment, among other areas, the traveler from 1981 essentially travels exactly like the traveler in 2016.

[235]http://www.changiairport.com/content/dam/cacorp/publications/Changi%20Connections/2010/Changi_Connection_xOctx10x_-_FINAL.pdf

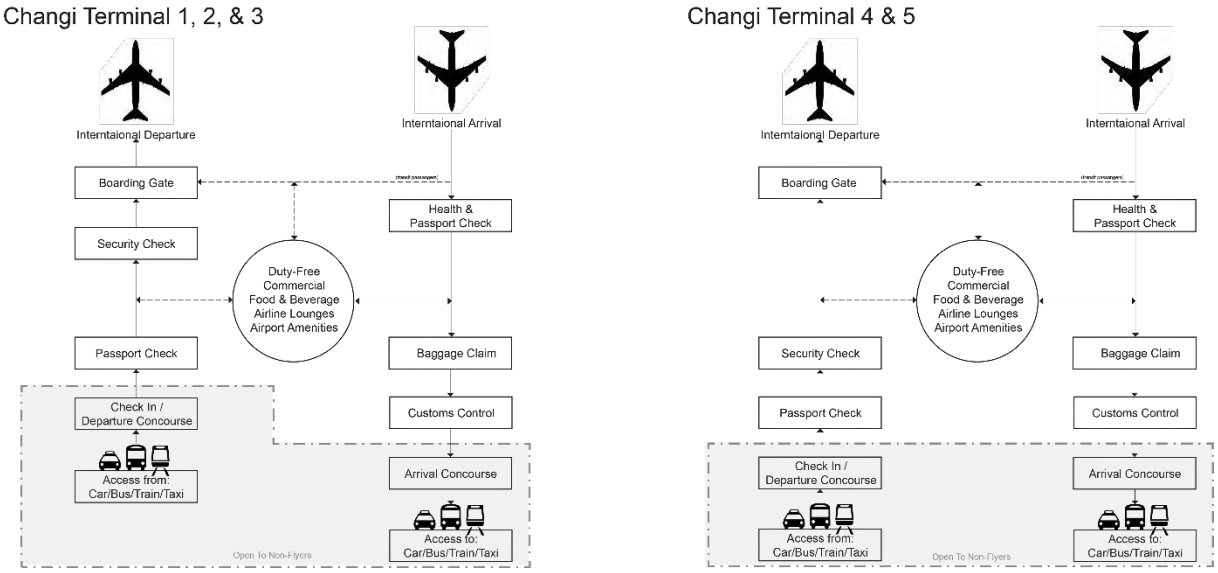


Figure 21. Designed progression diagrams of Terminal 1-5's architectural organization.

The design of Terminals 1, 2, and 3 depicts the decentralized system under which Changi has operated for as long as it has been in operation. Aside from automated machines in Terminal 3 to check for passport access to the airside of the terminal, the passenger operations process has gone unchanged. Users of the terminals 1, 2, and 3 arrive at the terminal by car, bus, train, and/or taxi, and converge into the 2nd floor Ticketing/Check-in hall. After checking in through "island" configured counters run by airlines, the passenger is then headed toward the security gate. If the traveler was accompanied by any loved ones, then those loved ones are to say their farewells and separate as the passenger enters the airside partition of the airport. The passenger can then decide to head straight to their designated gate and wait for departure or to explore the airside area of the airport. In Terminal 1, 2, and 3, the airside amenities include eating, shopping, visiting indoor gardens or movie theatres, and more. If and when the passenger decides to enter the departure hold rooms, the passenger in Terminal 1 through 3 pass through the security check at the entrance of the room to enter. Once on board the plane, the passenger leaves the country of Singapore.

Transit passengers' experiences, as they arrive at Changi, may need to transfer terminals. Shuttle busses are provided before proceeding to immigration clearance for passengers to connect to corresponding terminal boarding gate halls. The airside of Changi Terminals 1 through 3 has many activities and entertainment venues such as gardens, business lounges, theatres, and resting spaces. If the passenger wants to view something in particular or partake in tours on the landside of the airport, the passenger then passes through immigration first and, then, repeats the cycle to reenter the airport at a later time.

An arrival passenger steps off the plane and heads toward immigration. Once verification is established for the international visa, corresponding documents, and returning ticket, the passenger walks toward baggage claim and stands in queue to wait for his or her bags. Most passengers who are set on arrival possess goals that stand as, simply, to get out of the airport as soon as possible, but some linger and shop at duty-free stores placed prior to baggage claims. With bags in hand, and through the customs control, the passenger enters the arrival hall to meet any who have come to celebrate the arrival of family or friend. If he or she is traveling alone, there are signs placed around the arrival hall to help travelers locate the proper means of transport out of the airport (e.g., train, bus, car, or taxi).

5.5 Changi Terminal 5 Conceptual Proposal Analysis

The airport typology that the Terminal 5 CAG team proposes is a centralized linear concourse plan. In their conceptual plan, each of the remote concourses relates to the main terminal building through underground tunnels in which passengers walk to their designated concourses. Traditionally, linear concourse plans create a very chaotic transit phase when changing from international to domestic flights. However, as there are no domestic flights at Changi, the boarding rooms and planes can be organized less rigidly. The closest conceptual relationship Changi's Terminal 5 has with any other airport is Atlanta's Hartsfield-Jackson Atlanta International Airport. The satellites, connected by underground passageways, are linear in shape, which allows for maximum amounts of aircrafts to be docked.[236]

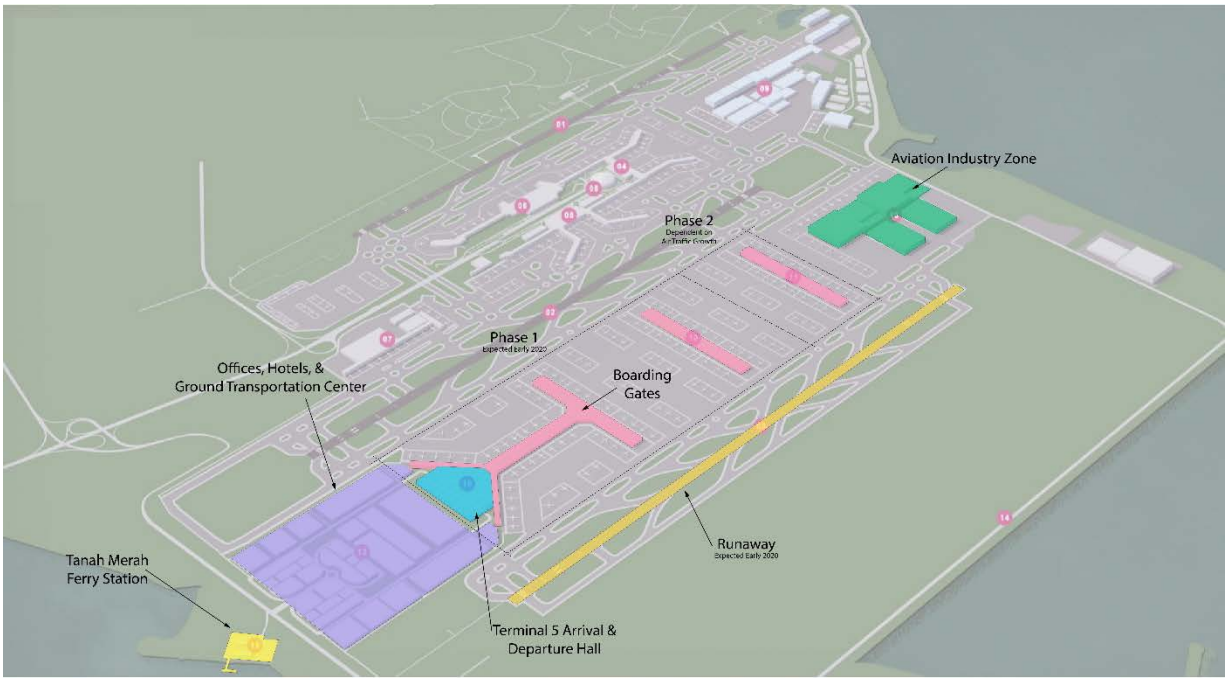


Figure 22. CAG Current Terminal 5 Concept Plan. Diagrammed to show space allocation.[237]

[236] Airport Design and Operation. Page 132-133.

[237] http://www.ainonline.com/sites/default/files/uploads/2016/01/204-fact_sheet-t5_concept-plan_annexweb.jpg

Although linear concourse plans are the most efficient for terminal space, they are often criticized for their lack of passenger pleasantries. Aaron Betsky, the current dean of the Flank Lloyd Wright School of Architecture, explains that Atlanta's Hartsfield Jackson Airport is the "single ugliest, most unpleasant semi-public space" he has ever forced to use on occasion.[238] He continues to say that the most significant problem in the terms of linear concourse plans, such as with Changi's Terminal 5 proposal, is that the planning and organization "tends to feels like a maze"[239]. As a hub airport, Changi receives many passengers in transit, but Betsky notes that it becomes very difficult to find connecting flights in the heavily congested, tight concourses. Weaving through the packed halls gives one little sense of respective whereabouts as each of the concourses are very similar in organization, and the efficiency lends to crowded and packed spaces with little area for queueing. When designing Terminal 5, a significant element to consider is the idea that efficiency with compromise cannot be successful within the worlds of planning and architecture.

[238] http://www.architectmagazine.com/design/flying-into-design-flaws-at-atlantas-hartsfield-jackson-airport_o

[239] Ibid.

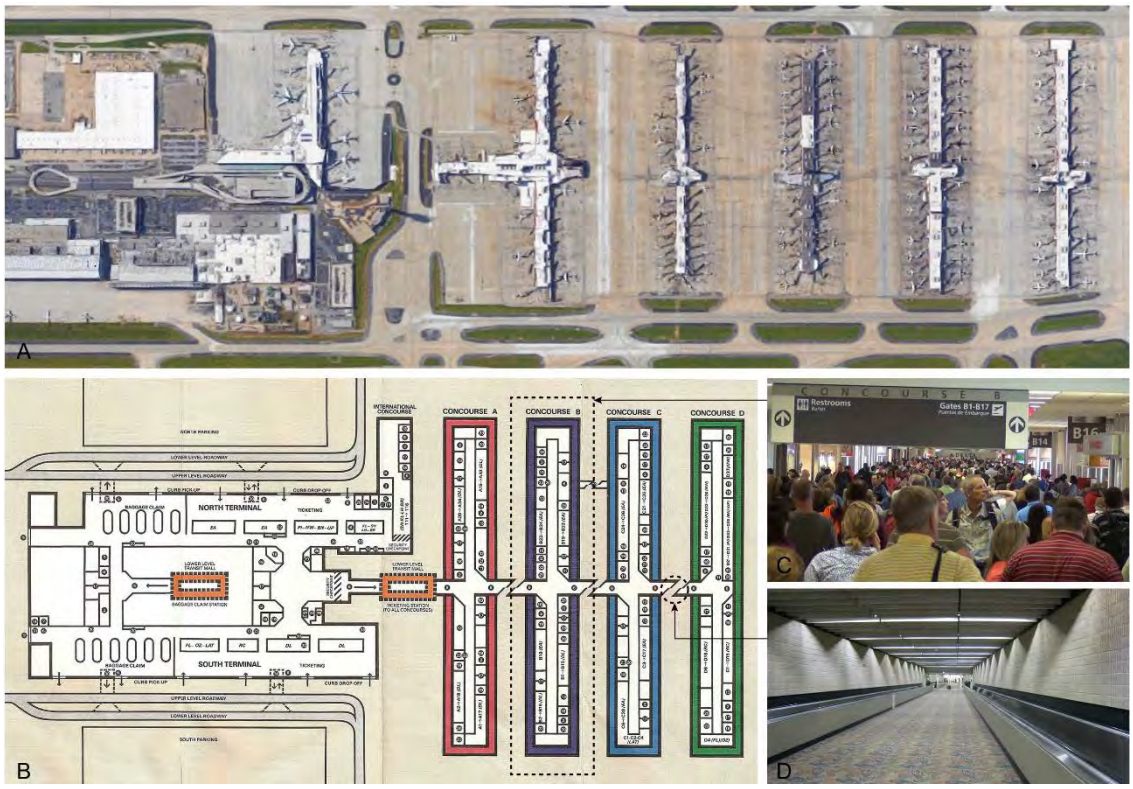


Figure 23. Atlanta's Hartsfield Airport. A: Birds-Eye View. B: Plan View. C: Gate Concourse View. D: Ground Tunnels between Concourses. [240, 241, 242, 243]

[240] https://dilemmaxdotnet.files.wordpress.com/2015/08/hartsfielde28093jackson-atlanta-international-airport.jpg
[241] http://www.sunshineskies.com/uploads/4/3/7/6/43764233/atl80midbig.jpg
[242] https://i.ytimg.com/vi/xVp2DCitKdw/maxresdefault.jpg
[243] https://c2.staticflickr.com/4/3286/2876930993_9e2d0e06fd_b.jpg

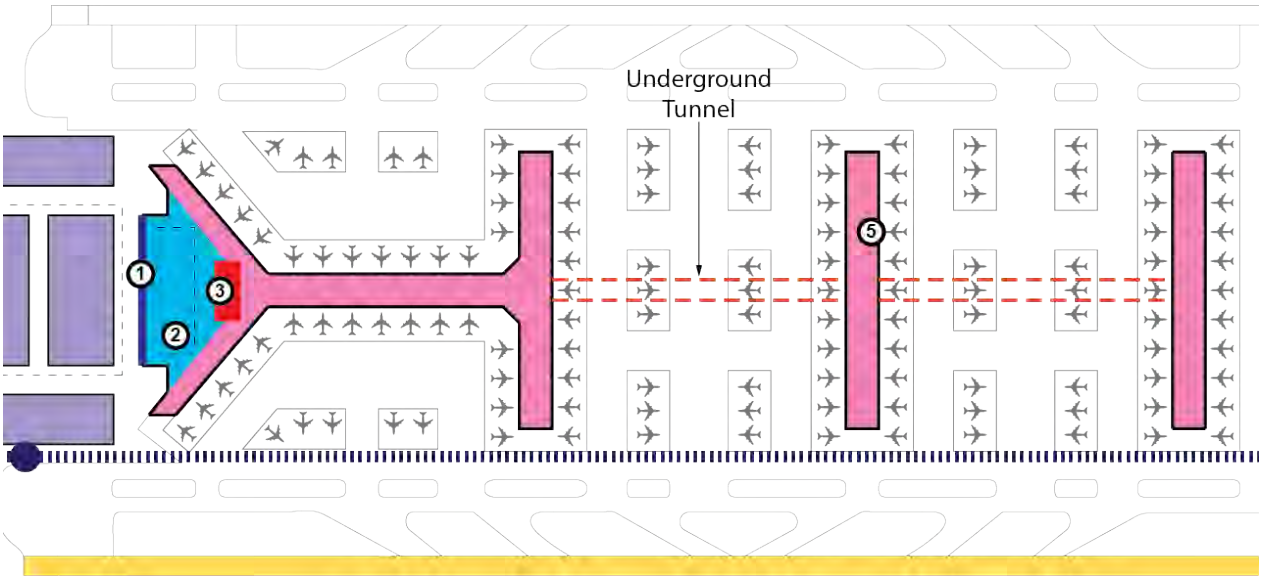


Figure 24. Terminal 5 Current Concept Proposal (transportation, offices, hotel, and parking in purple) departure/arrival halls in Blue, security check point in red, and gates in pink.

Changi Terminal 5 architecturally only communicates the efficiency model of the Changi Experience. The current proposal efficiently transports passengers well with use of linear concourse typology in combination with linear satellites. Creating an underground tunnel allows people to move from concourse to concourse without taking up the apron space for planes to dock, while its circulation centrality means the largest travel distance within the concourse is half the length of concourse.

This scheme works well for the passenger who expects the bare minimum at an airport. The one-way passenger departing Singapore to visit another country. Optimized for a fairly quick transition into the boarding gate and off they'd go. While the current proposal remains the best option for gate rooms per floor area, the delight elements of the airport that Lee Kim Choon strived for been forgotten; losing the Changi Experience.

Doubling the passenger capacity as the primary goal appears unnecessary when looking at current passenger growth at Changi Airports. During the global recession of 2007-2009, the rate of annual passenger increase slowed down but quickly regained steam and has risen quite high in the last 5 years. In 2011, we say a 10.7% increase in annual passengers, to a 10% increase the year after, and slowing down more recently in 2013 to 4.9% increase, in 2014 a 0.7% increase, and in 2015 a 2.6% increase. It is only last year in 2016 where the annual passenger growth percentage exceeded 5% at 5.8%, the most since 2012. While the upwards trend is in no means a failure, it is an oversight to blindly double the max capacity of the airport when the current model has not been maxed out. Once Terminal 4 is completed in quarter four of 2017, the largest capacity of Changi Terminals will be 82 million people; 23.3 million more people than its last recorded annual year. Even if given the generous average of the past 5 years, it would take 27 years to fill the capacity of the almost finished terminal.

This dissertation for one is not against anticipating for the future, specifically one in such an optimistic way; in fact, it's encouraging the ambition. However, it should not be the terminals primary goal to double in size, when its lessening the airport experience and place making possibilities to do so.

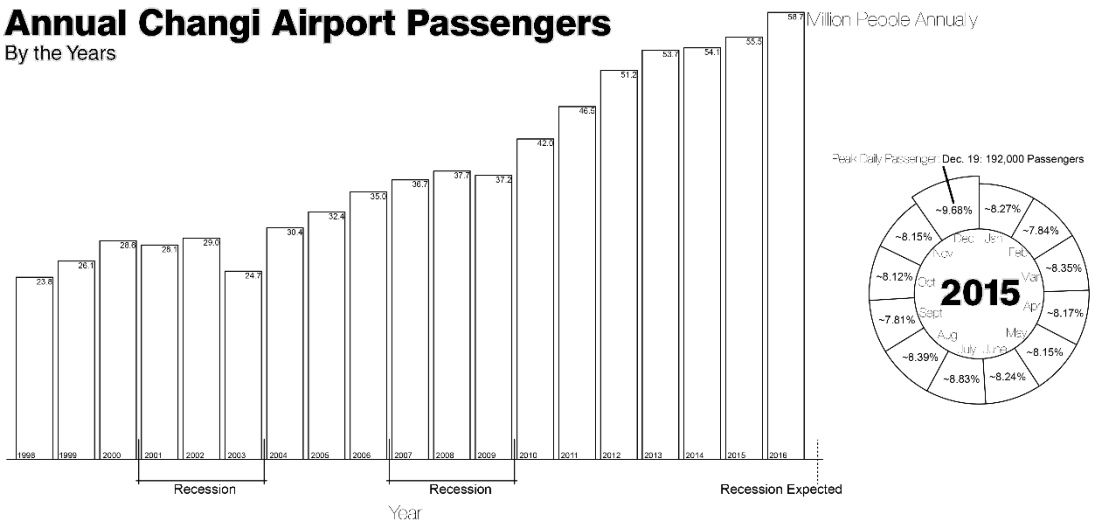


Table 4. Changi Airport Passengers (Annual) & 2015 Monthly Breakdown of Passengers

The linear concourses scheme is an unfavorable configuration for passengers catching connecting flights. In 2015, Changi Airports had 151,900 passengers fly daily. In 2016, we're seeing an increase of about 6.5% passengers per month.[244] With 30% of those passengers accounting for transit passengers, the linear piers scheme, in its current iteration, goes against the Changi Experience goal of catering a lasting experience to their customers.

In a survey prepared by Unison Consulting Inc., the researchers found that in 2011, Over 52% of layover times at the LAX were over 3 hours in peak season and 48% in the non-peak seasons. Of all the people surveyed, 95% of all transit passengers stayed at the airport. Only 35% of people who have a layover of over 8 hours choose to leave the airport.[245]

[244] http://www.changiairport.com/corporate/about-us/traffic-statistics.html

[245] https://www.lawa.org/uploadedFiles/OurLAX/pdf/LAX_Survey_Final_Draft_REPORT_2012_08_19.pdf P64-65

Layover Statistics at LAX

Connecting Passengers Layover Time	Peak n=4,284	Non-Peak n=3,878	Total Sample n=8,162
Less than 2 hours	22%	22%	22%
2 < 3 hours	27%	31%	29%
3 < 4 hours	19%	17%	18%
4 < 6 hours	17%	16%	17%
6 < 8 hours	8%	7%	7%
8 hours or more	8%	8%	7%

Table 5. Los Angeles International Airport survey produced by Unison Consulting Inc. shows the transit passengers layover time by hour.

The linear pier concourse configuration in the current Changi Terminal 5 leaves transit passengers with very few areas to enjoy their respective layovers due to spatial limitations of the scheme. If the airport offers transit passengers at point 1 on the figure above, the route for a passenger who would land at the gate point 2 would have to walk the full length of the airport to enjoy the point of interest offered in point 1. Spatially speaking, point 3 would be the place best suited for enjoying services. However, the location, 3, is the primary access route to all the other concourses and thus would be unviable because it would add unnecessary congestion.

Passengers whom already found and settled at the boarding gates are limited in their options to occupy the extra times between flights with the scheme proposed. The transit passenger specifically is limited in options to explore and intake the design. As each linear hall is organized in similar fashions so that there is little mystery and intrigue to move around the space. In addition, due to its max-efficient design, there is little for passengers to enjoy place, completely focusing on giving space for passengers to board.

Take, for example, Atlanta Hartsfield Airport's concourse plan. Within the construct of the linear concourse, there are little places to shop, eat, or enjoy the different services that airports potentially provide to departing guests. The enjoyment of place is removed for maximum efficiency. In addition, commercial vendors are limited in their approach to marketing their respective stands as the area allocation is confining, and equivalent to the other concourses. A passenger from another linear satellite will not wander and visit the retail stands in another satellite as they will experience similar frames of space. The passenger's options are then restricted to the randomness of his

or her gate. Because of the stagnant organization, retailers have adjusted and offer no unique attraction to the airside concourses. Convenient stores, newspaper stands, coffee shops, and fast food restaurants repeatedly be the concourse of each linear satellite. Thus, is the same for Changi Terminal 5 as designed now. Blatantly ignoring its own motto and formal and public airport-based statements, the airport is striving toward maximum plane to area efficiency, limiting the experiential possibilities that honor Changi's name and removing the customer's ability to associate place within the airport.

Atlanta Hartsfield Airport

Amenities Figure Ground

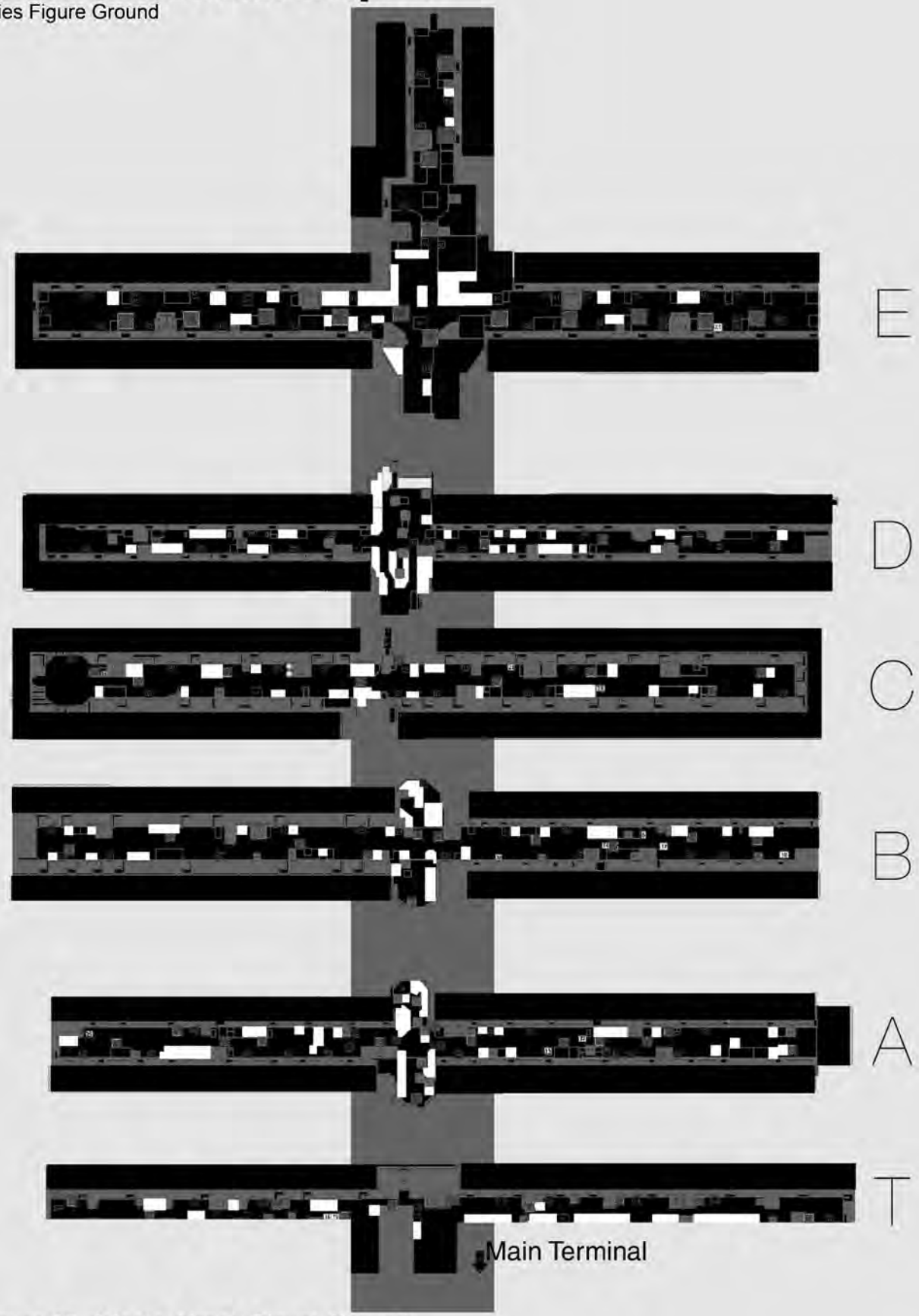


Figure 25. Atlanta Airport Figure Ground:
White = Amenities, Food, and Beverage. Black = Concourse.[346]

[346] http://ontheworldmap.com/usa/city/atlanta/atlanta-airport-terminal-t-map.jpg

Architects use figure ground drawings to quickly understand the relationship between spaces. In the figure ground of Hartsfield-Jackson Atlanta International Airport, we can visually recognize the inconvenience that amenities become to passengers. Most of the amenities are organized around the main axis (typically traversed by rail). Once you find the designated boarding gate printed on your ticket, it is left up to chance which amenities are in the concourse your boarding gate exists within. If a friend recommends a restaurant within the Atlanta airport to enjoy, potentially, you must traverse long (and ought to be needless) distances just to take part due to the linear satellite organization.

The proposed Changi terminal 5 design limits the possibilities of design intervention due to its reliance on ancient concepts and familiar plans. Referencing the design through the Changi Airports Group's goals,

> CAG prides itself in delivering an exceptional passenger experience that is cutting-edge and at the forefront of technology. In its efforts to enhance the Changi Experience, CAG harnesses new technologies and implements touches of innovation to propel Changi's facilities, efficiency and service—creating an airport of the future.[247]

The airport group's dedication to pure aircraft efficiency has taken away from the passenger's potential experience. There is no evidence in the current design proposal that exemplifies "cutting-edge" experience, and it's claim on "creating an airport of the future". Even though the plan is now in its infancy in programming and planning, laying its foundation with the same principles used in previous terminals and efficient-dominant typology limits the ability for the eventual designers to enrich space and deliver the Changi Experience. Killing any potential for the airport to become place.

5.6 Introduction to Terminal Hub Conceptual Potential.

The passengers adapted airport experience is a result of the program design and organization of airports. The emphasis of point a to b circulation has given airports its associated behavior acted upon and enforced by the passengers. Airport design teaches us that its purpose and function serves us only one purpose. The airports beginnings

[247]http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

would lend itself to the function of flight transportation, but as with most designs, purpose and influence begin shaping the actual use once the design becomes tested.

As discussed previously in the chapter, serving origin and destination passengers was the sole goal of Terminal 1 and 2. The then influx of passengers shifted the goals from origin and destination passengers to then serve transit passengers, resulting in transit amenities. Advancements in both consumer and architectural technologies allowed the designed spaces to bend and flex to accommodate the added programs and functions. Tragedy then struck in the form of terrorism on September 11th, drastically emphasizing the global safety of air travel. In Changi's case, the airport decided to join many of its individual gate holding rooms and security scanners to shared room to process people in a more thorough way, highlighted in the design of Terminal 3 and adapted to Terminals 1 and 2. Once the dust settled and global air travel stabilized, its use continues to rise to this day. A direct impact of more air flight passengers' results in more consumers.

In evaluating Terminal 4, we finally see a rift from the old program organization and architecture. With an emphasis on commercial opportunities, the airport design gave an importance to retail, food, and beverage by directing all passengers through a mall to reach their gate. This change in program drastically changes the architecture and experience one processes when going through Terminal 4. Although the commercial considerations changed Terminal 4's architectural organization significantly, the emphasis on commercial is the only program that was mixed into the *canon* of airport programmatic design.

Even sadder is Terminal 5's reversion in design sophistication. Although it's in its early stages, the foundational elements are the most vital components to place. The beginnings jumpstart the inevitable restrictions that come into being once the architectural design takes form. By starting from a maximum passenger capacity mentality, and not the passengers' experiences within the airport, the designers become restricted and little chance to design place.

All airport designs from this point forward must consider what an airport offers today, how its uses and influences should shape the current organization, and what it can be in the future. This begins with a deep understanding of an airports current purpose and history, as well as foreseeable influences upon airports. Currently, this means understanding the potential technology has on airport experience.

It is time to rethink the programmatic organization of airports. With the current research and expectations of future innovations, place designing becomes increasingly possible. As with all architecture and extended information such as client and thorough analysis of site. In Changi's case, three concepts are formed within the mold of how an airport can operate today, with the benefit of planning for future innovations; primarily in security and logistics. These concepts will be viewed and experienced through three different passenger types and the typical experiences and airport offers them currently and what it could offer if designed for intently.

An airports main function will always be offering a service to travel through the air from point a to point b. As it has always been a priority, in no way has this program been changed. In Changi's current designs, with all the additions, renovations, and security measurements, the founding concept has been lost and muddled. No longer is it easy for one to get to one's gate quickly and effortlessly, ideally mindlessly, when the technology suggests it should be easier. In the next chapter, the direct-oriented traveler will illustrate the potential to reintroduce an efficient, safe, and quick boarding through the terminal.

The misplaced transit passenger will also be a conceptual priority in the re-proposal design of Terminal 5 detailed in the next chapter. In every Terminal built in Changi thus far, little attention has been payed to the transit passenger, though over 30% of all visitors to Changi are transit passengers. In Terminal 5, which demands a capacity that equals all other terminals combined, it will be important to offer the proper amenities and recourses needed for the transit passenger's in the much larger organization. Viewed and detailed through the experience of a transit passenger in the next chapter. Designing place that caters towards all transit passengers, even shaping the overall coordination for all terminals to mingle and share their amenities; with the bonus of making interterminal transfers simpler.

The last experiential

To supply the individualistic and experiential concepts introduced here for Terminal 5, a change in airport philosophy must change, and the architecture must reflect these changes. Importantly, the design proposes to change the operational philosophies of the current terminals. For terminals 1 through 4, the Terminal 5 design will address uniting all Changi terminals instead of the current set up of acting as individual airports independent of the others (in terms of passenger use). Instead of designing Terminal 5, the dissertation proposes a Terminal Hub that connects all

terminals together, linking amenities, circulation, and back of house logistics such as security and baggage. This central Hub will offer foreigners a central area to enter and be guided towards their designated gate, simplifying the maze and reintroducing an a to b system.

Today and for the foreseeable, airports are much more than just a connecting point from point a to b – although it is its primary function, and what this author believes will return to once capable – it's become architectures significance to aid in facilitating and managing our emotions throughout the travel experience, in the form of all the different travelers an airport supports.

CHAPTER 6. AIRPORT DESIGN

The following statement can be found in a publication released by the Changi Airport Group (CAG).

> Changi Airport finds itself at the threshold of a new era as it undertakes planning to secure Changi Airport's future. The considerations today are multi-faceted and the challenges, dynamic. An airport is no longer just an incidental aircraft interchange, but is expected to be a destination on its own. This is something that many air hubs around the world recognize . . . . It is imperative that CAG does nonstop innovating and reinventing Changi Airport. [248]

The modern-day airport has the need to provide an additional service aside from flying. Revealing the influence and meaning to the passengers as well as providing a comfortable and worriless environment. With further thoughts on Terminal 5, the CAG makes the following statement.

> As the operator of the world's most awarded airport, CAG prides itself in delivering an exceptional passenger experience that is cutting-edge and at the forefront of technology. In its efforts to enhance the Changi Experience, CAG harnesses new technologies and implements touches of innovation to propel Changi's facilities, efficiency and service—creating an airport of the future.[249]

Acknowledging the continual trend of the digital renaissance is important in preparing for the use of space as well as setting forth architecture to stay current with innovation over catching up and retrofitting as was seen and done in the previous terminals. set forth by the airline group is imperative to designing an airport that attaches itself with the Changi brand, all designs and decisions should reflect these goals.

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[248] http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

[249] http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

The way people experience the world has changed through technology. Technology makes past methods and approaches regarding an array of things fall short, but brings with it the potential of creating a desired experience that design can deliver. One such example can be found in the redesign and creation of Changi Terminal 5 as it reimagined the airport experience. The architecture is the starting point for these adaptations and experiential changes, while the amenities and services further enhance the possibilities presented for visitors. Throughout the decades, airports have consistently retrofitted newer technology into previous perspectives. Evidence of this is explored in Chapter 5 as snapshots of design thoughts have not thoroughly been contemplated or optimized regarding the airport experience. Rather, the innovative technology has just added to and retrofitted newer means of efficiency upon the existing built structures instead of designing with a renewed sense of efficiency and experience.

First, the current plan for Changi Terminal 5 will be discussed in order to critique its current design and architectural thought processes that went into that design. Understanding the reasons behind the current decisions allows for the presentation of an argument for a more dynamic terminal design. The goal of this dissertation is to propose a redesign of the airport toward the user's experience. One approach will be to consider the airport visitation experience through the lens of different travelers: a traveler using the airport as a means to travel from point to point, a traveler who experiences the airport as its final pages in the current chapter of life as well as the start on the next (i.e., a one-way traveler), and a transit passenger who has had a layover spent within the terminal. Through the viewpoints of these passengers, the airport design will be studied regarding the elements of initial concept, visitor access, general circulation, baggage handling, retail experience, assorted amenities, and foreseeable future additions and how they enhance the passenger's experience through design.

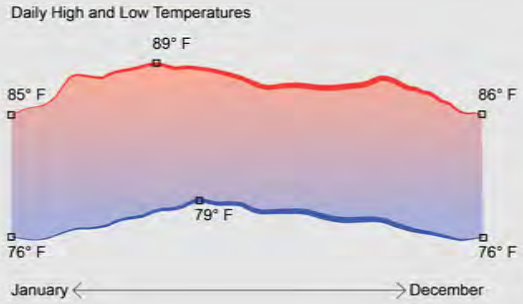
6.2 Site Analysis of Terminal 5

Site analysis is the basis of architectural design as it provides a base of information to improve and enhance design though. It allows architects to examine information and imagine through our senses, a higher level of design occurs when proper analysis is take and considered. As emphasized continually in the dissertation, information has become the architect's greatest material in place making. These studies reveal design opportunities that may have been unconsidered and along those lines or often reveal design ambitions that were compromising the users' wellbeing.

SITE ANALYSIS

CLIMATE SITE ANALYSIS
POINT OF INTERESTS
LAND RECLAMATION
MASS RAPID TRANSIT SYSTEM
TERMINAL ACCESS ROADS
PARKING STRUCTURE
ACCESSIBILITY IN AIRPORTS
(CURRENT) TERMINAL 5 ZONING
HUB CONSTRUCTIBLE SPACE
HUB LOCATION: CONCEPTUAL SCHEME 1
HUB LOCATION: CONCEPTUAL SCHEME 2
HUB LOCATION: CONCEPTUAL SCHEME 3

Climatic Site Analysis



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Median Cloud Cover
(Does Not Vary Substantially)

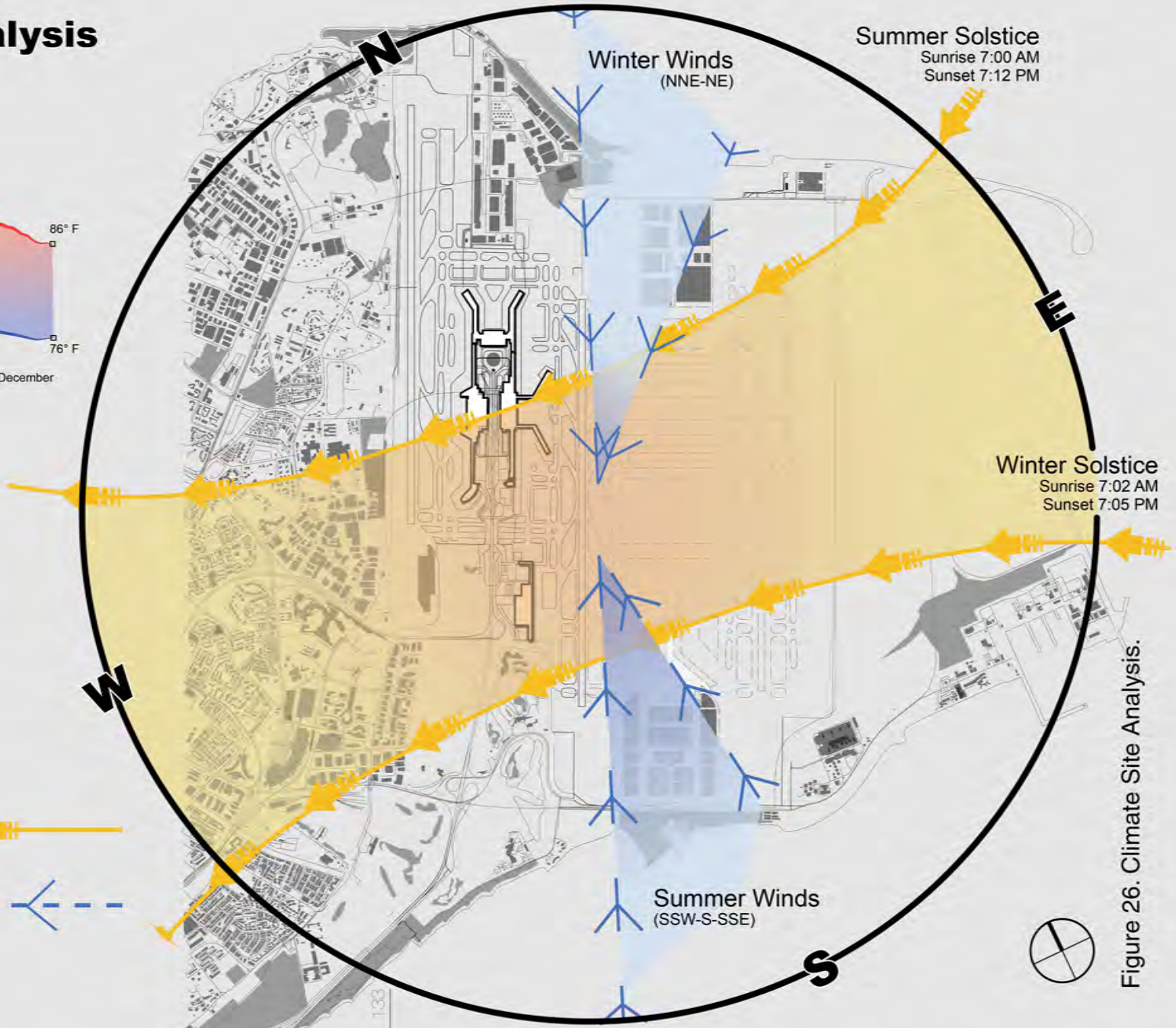


Figure 26. Climate Site Analysis.

Point of Interests

Site Features & Proceeding Developments

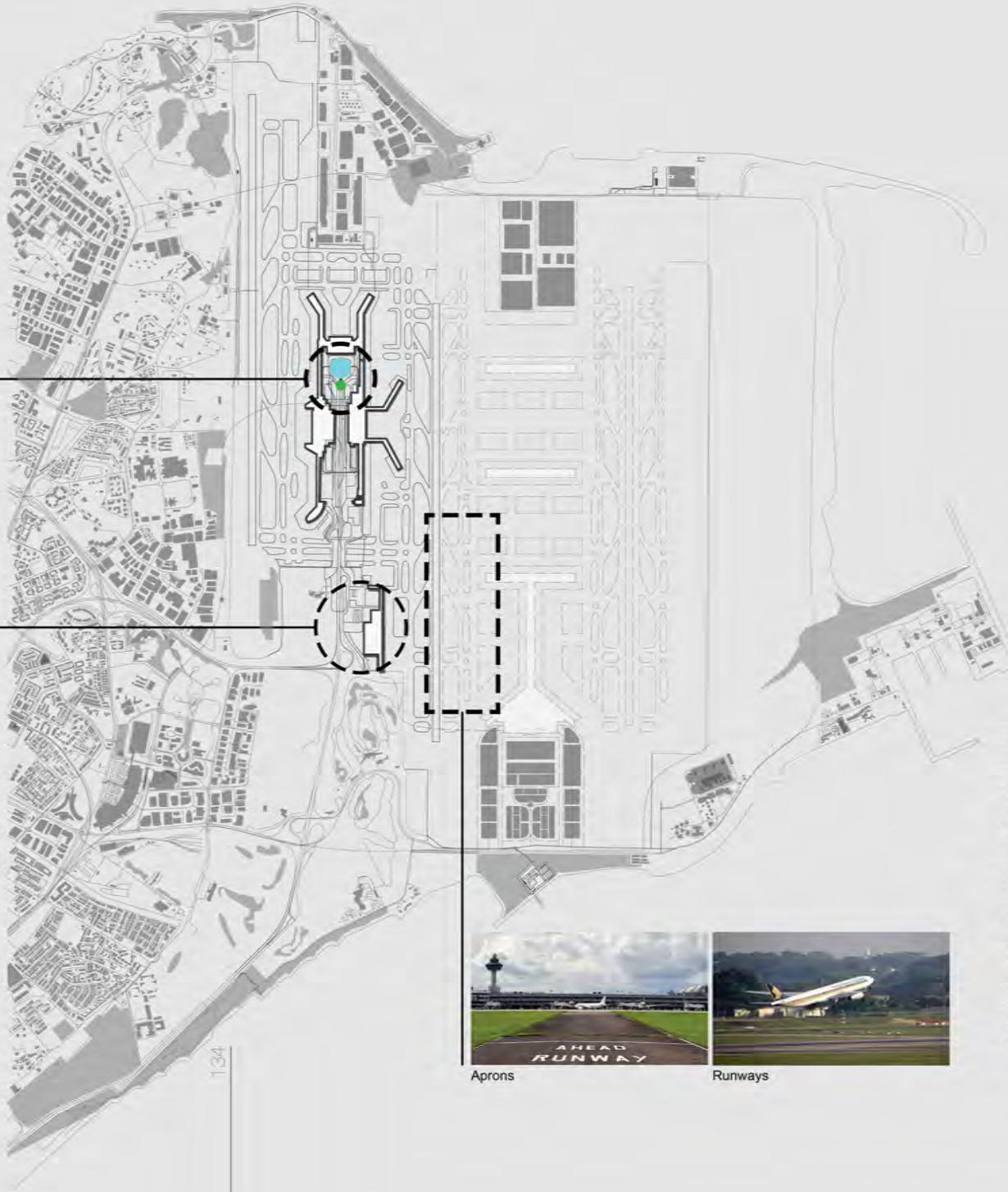
Jewel of Changi & Changi Control Tower Render

Jewel of Changi Interior Render

Changi Control Tower

Terminal 4 Departure Hall Facade Render

Terminal 4 Commercial Mall Render



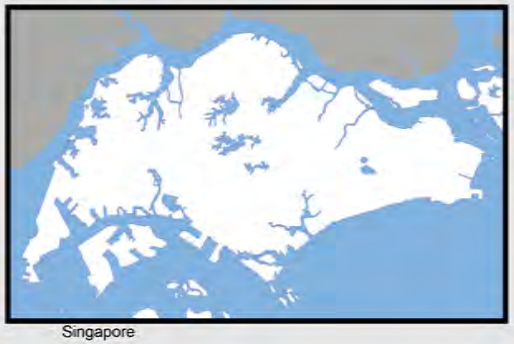
Aprons

Runways

Figure 27. Points of Interests.

Changi Land Reclamation

Future Terminal 6 Site



Singapore

Changi - Singapore

Pre-1950 Singapore Land

1950-Current Reclaimed Land

Future Reclamation Project

Terminal 6

Figure 28. Land Reclamation.

Mass Rapid Transit System

Current and Projected

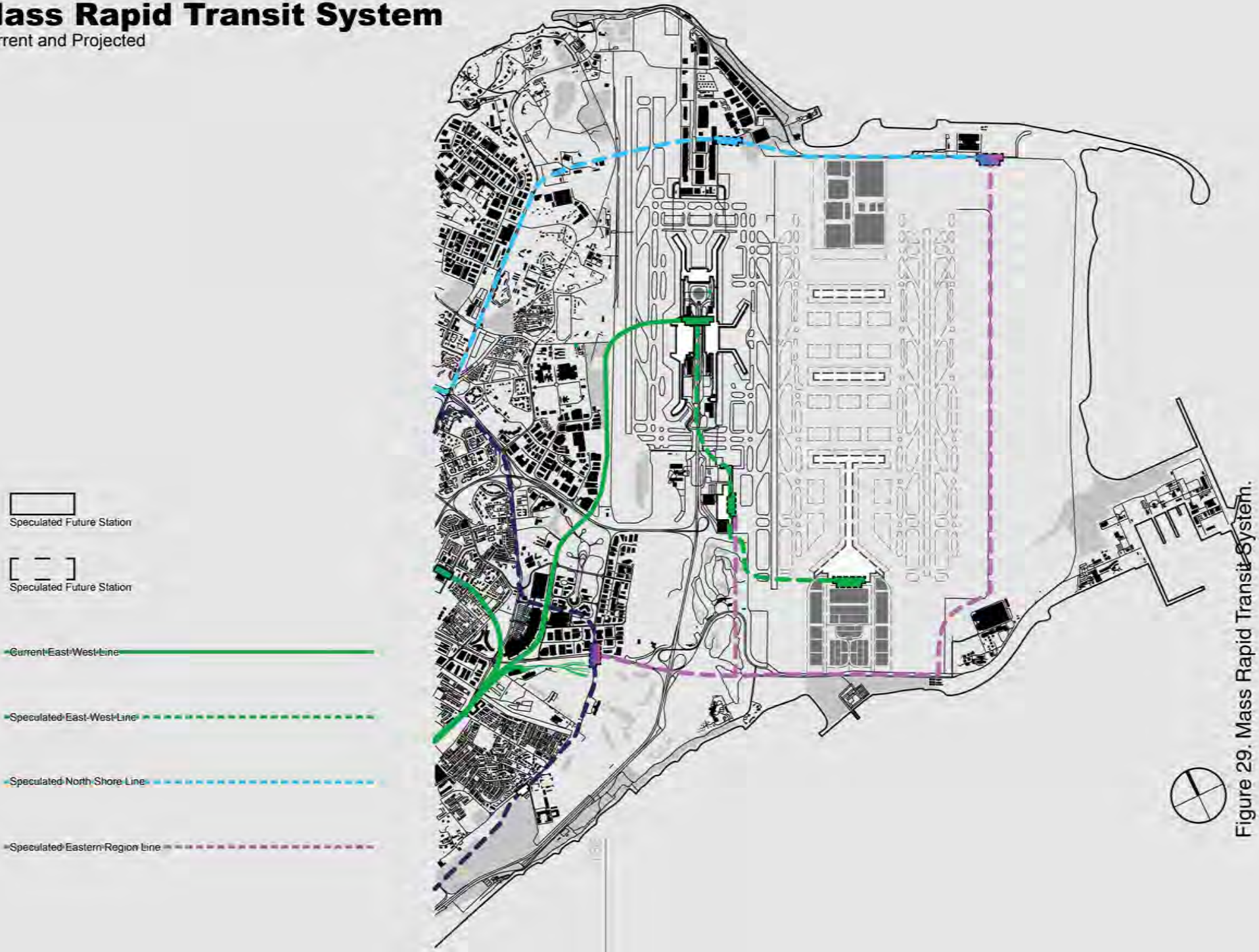
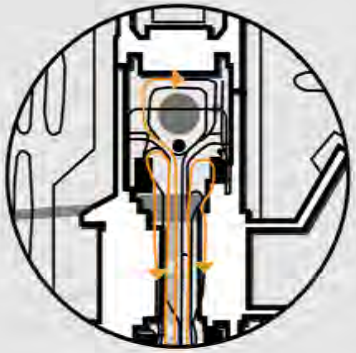


Figure 29. Mass Rapid Transit System.

Terminal Access Roads

Current and Projected



Terminal 1-3
Access Entry Roads

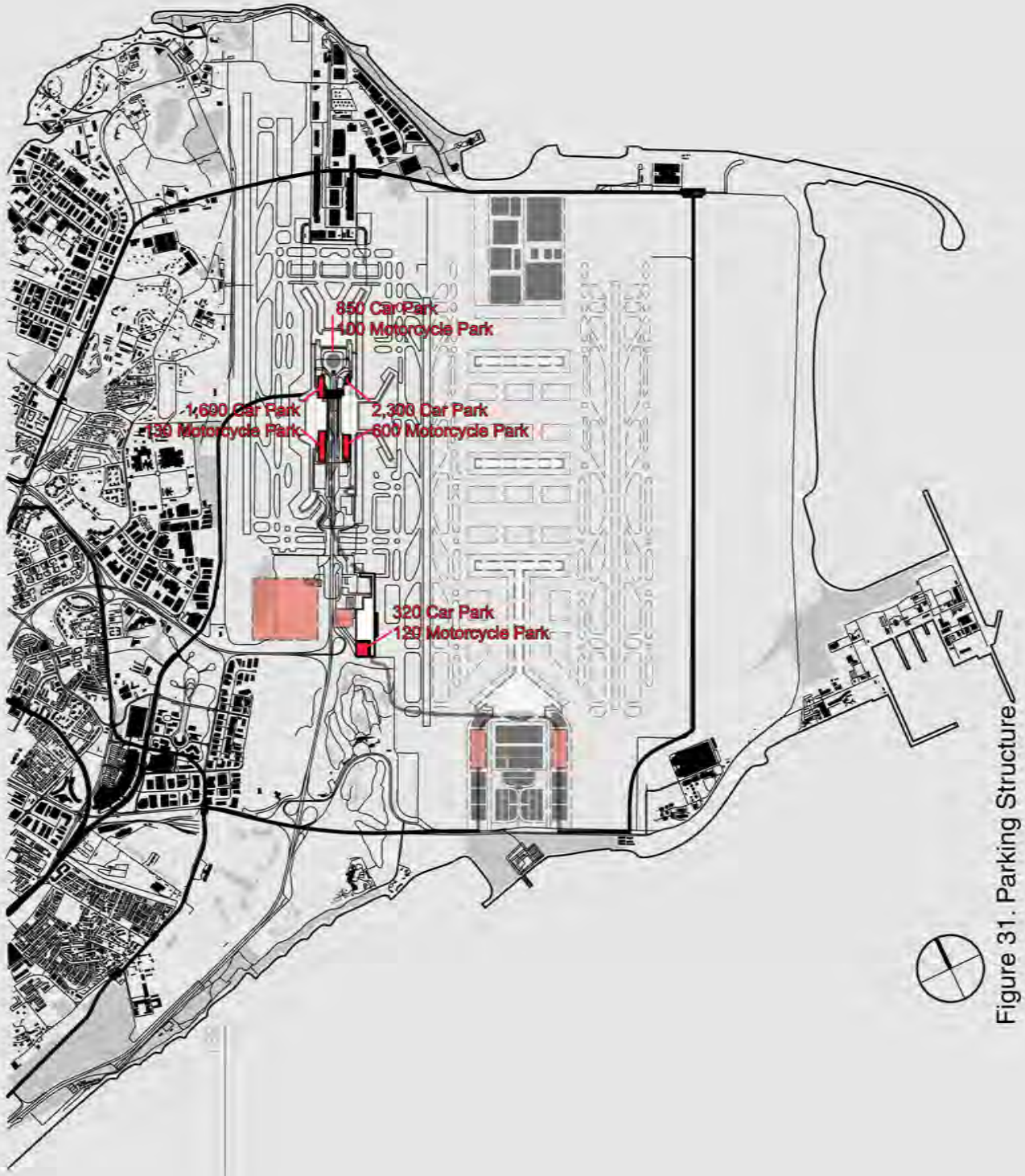
Terminal 4
Access Entry Road

Projected Terminal 5
Access Entry Road

Figure 30. Terminal Access Roads.

Parking Structure

Current and Projected



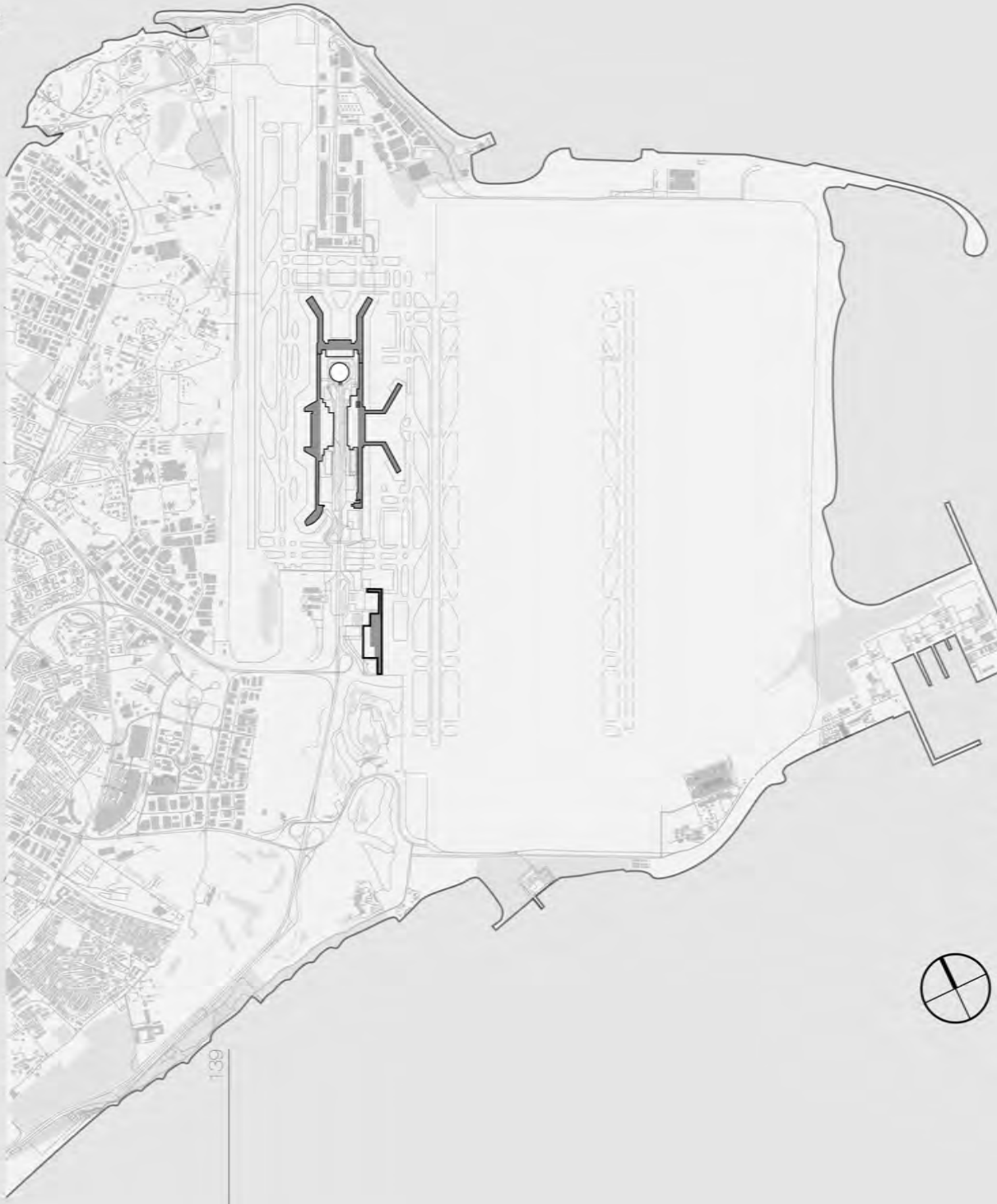
Parking Structure

Future Parking Structure

Figure 31. Parking Structure

Accessibility in Terminals

Airside and Landside Areas



Private (Air-side): Passengers Only

Public (Land-side): Open to Public

Figure 32. Accessibility in Airports.

Changi Terminal

Zoning for Current Terminal 5 Proposal

Figure 33. (Current) Terminal 5 Zoning.

Constructible Space

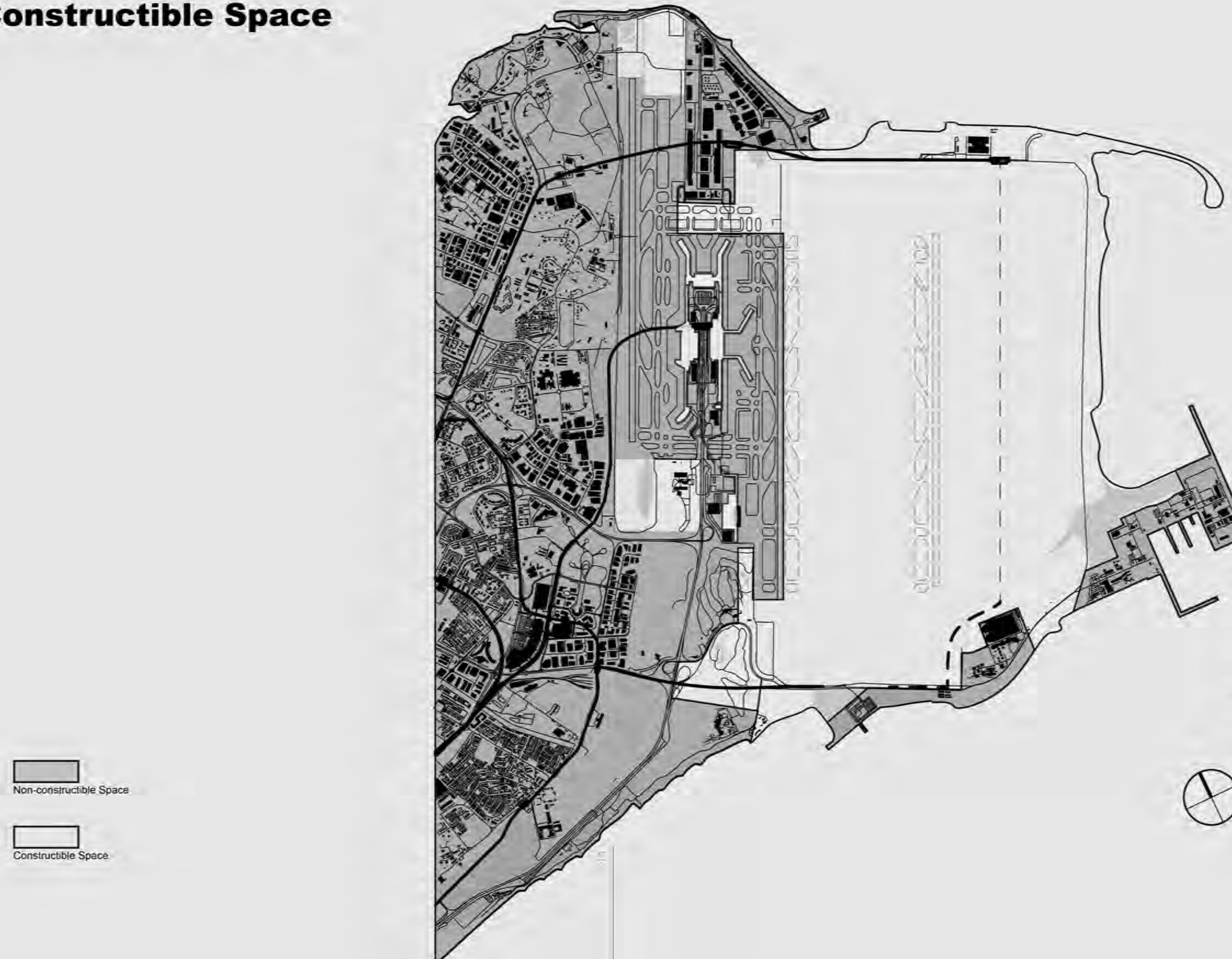


Figure 34. Hub Constructible Space.

Hub Location Analysis

Terminal 5 Hub Conceptual Scheme 1

+ Largest Area for Facilities
+ Closest Arrangement for Terminal 4 & 5.
+ Good Entry Point.
- Long Distance to Terminal 1-3 (Passenger & Baggage)
- Awkward Building Envelope

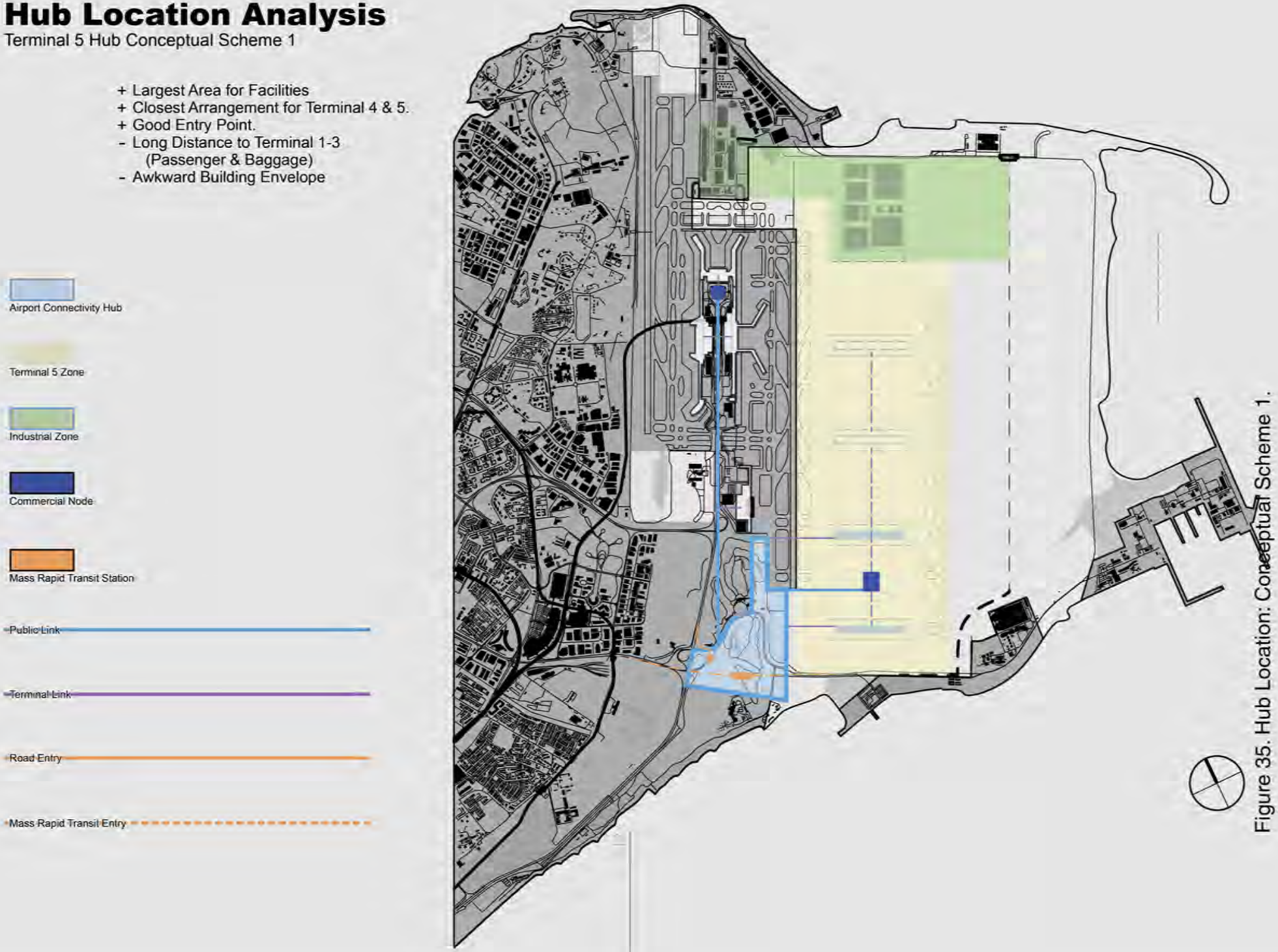


Figure 35. Hub Location: Conceptual Scheme 1.

Hub Location Analysis

Terminal 5 Hub Conceptual Scheme 2

+ Largest Area for Facility Expansion
+ Close distances to Terminal 1,2,3, & 5.
- Far from Terminal 4.
- Poor Accessibility from Main Road.
- Replace current Industrial Zone

Airport Connectivity Hub

Terminal 5 Zone

Industrial Zone

Commercial Node

Mass Rapid Transit Station

Public Link

Terminal Link

Road Entry

Mass Rapid Transit Entry

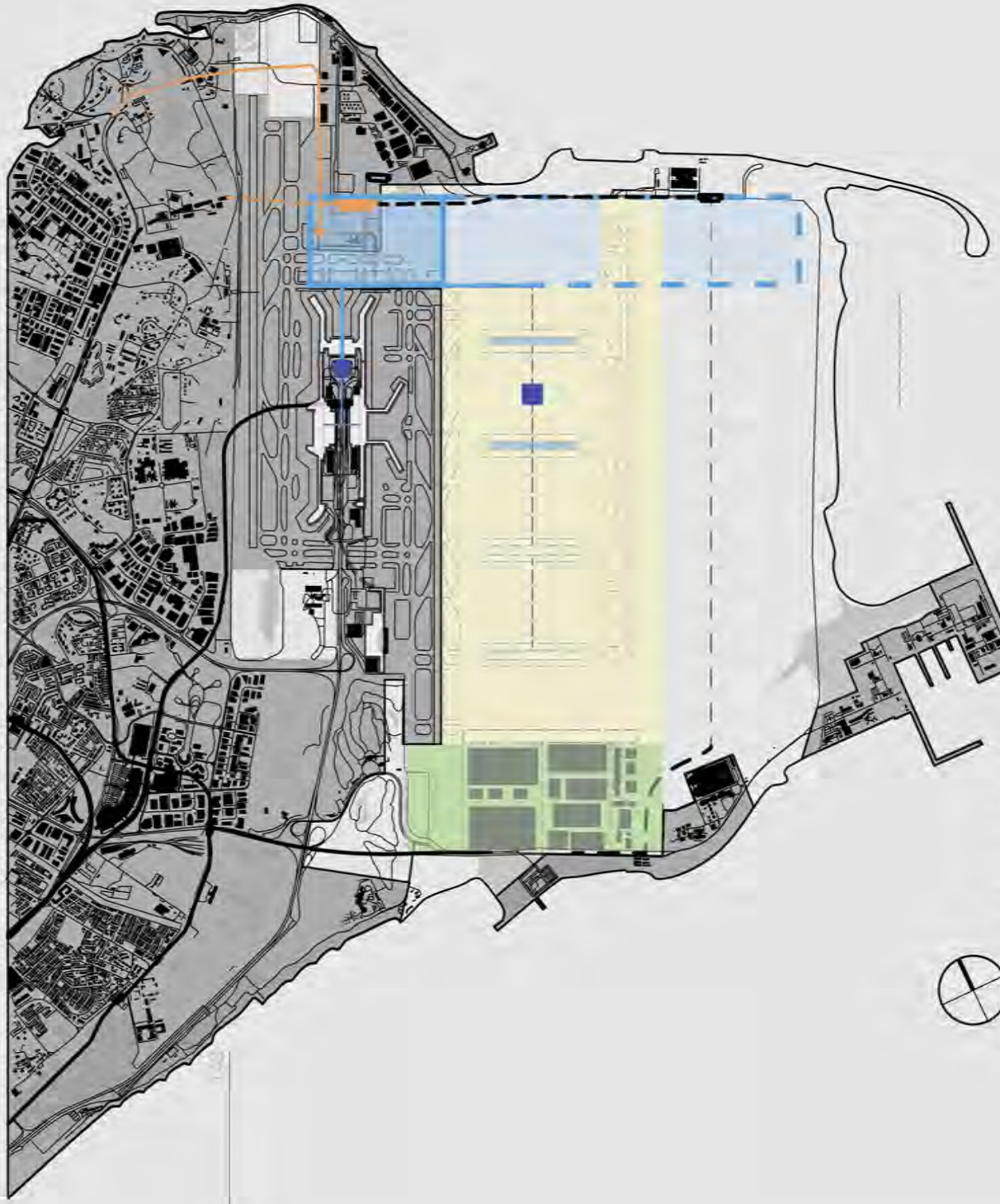


Figure 36. Hub Location: Conceptual Scheme 2.

Hub Location Analysis

Terminal 5 Hub Conceptual Scheme 3

+ Central Arrangement to all Terminals.
+ Good Entry Point.
- No Room for Facility Expansion
  (Unless Built on Adjacent Golf Course)
- 90 Bend in Link

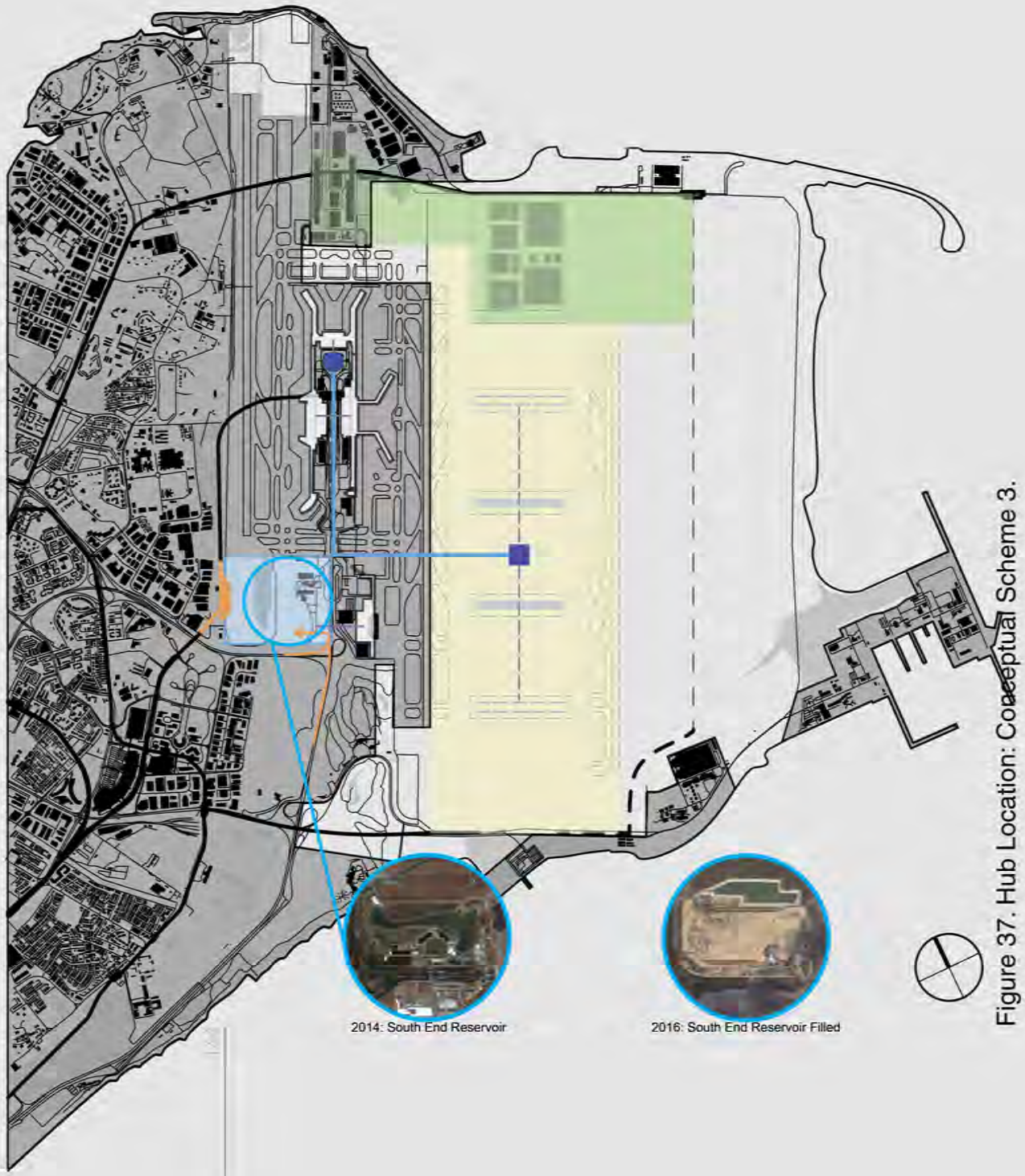


Figure 37. Hub Location: Conceptual Scheme 3.

6.2.1 Climatic Site Analysis

The site of Changi main axis is configured slightly off North to the East. Singapore lies only one degree north of the equator (88 miles). Due to this, Singapore faces very little variation of weather changes. With an annual median temperature of 80.5°F, the hottest day of the year is April 23rd , with an average high of 89°F, and the coldest day of the year is January 14 with an average low of 76°F.[250] With such little variation, and often cloud covered sky, the outdoor opportunities present itself as ideal for the site and Singapore in general.

The sun may be south or north of the location depending on the day of the year. North East winds arrive during the winter seasons and south winds come during the summer. The site of Changi Terminal 5, found near the edge of the island receives unobstructed.

6.2.2 Point of Interests

The main attraction upcoming to the site is the Jewel of Changi. A mixed-use complex now undergoing initial phases of construction. An estimated cost of S(ingaporean)$1.7 billion dollars, it is replacing the existing Terminal 1 outdoor parking site. Terminals 1 through 3 surrounds the Jewel, making the Jewel the heart of the three terminals offering leisure attractions, retail offerings, hotel, and airport operation spaces.

Formally, the curved geometric glass enclosure will for a a rain vortex at the center of the ceiling, creating the largest indoor waterfall at 40 meters tall (taking Singapores Gardens by the Bays current title).[251] Designed by Safdie Architects in partnership with RSP, aim to create a hub supporting Terminal 1, 2, and 3. The first concepts formed for Terminal 5 aim to support the goal of this

[250] https://weatherspark.com/averages/34049/Changi-Singapore

[251] https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwj5v_yI2KfSAhXmslQKHUr8DTkQFggkMAI&url=http%3A%2F%2Fsingaporerecords.com%2Fworlds-tallest-indoor-waterfall%2F&usg=AFQjCNFVrbf0UzJJYuDPA5d7tbPPitnATw&sig2=UuC9aUoEJ_haOrr6xf29qg

hub, but without alienating Terminal 4, and the future Terminal 5. Both terminals which are far-off from the Jewel.

Directly in front of the Jewel is the air traffic control tower, sits between the current two runways. Rising 81m Above Mean Sea Level, it offers control service to aircraft landings and departing Changi Airport, and aircraft maneuvering within the airport. The tower serves around 700 aircraft movements daily, and has become the symbol of Changi. With the Jewel planning on connecting the departure halls of each terminal, there is an opportunity presented to allow users an up and close perspective of the tower.

Terminal 4 which is to be finished by quarter four of 2017 takes over the now demolished Budget Terminal. The two-story, 25-meter-high buildings will be seven times larger than the old Budget Terminal, supporting 17 stands for narrow bodies, and 4 widebody fixed stands. Terminal 4 is becoming the testing grounds for new technologies planned for Terminal 5. Branded the FAST@Changi (Fast and Seamless Travel at Changi), self-service check-ins, self-bag tagging, automated bag drop, immigration clearance and departure gates will be tested and examined for its viability and feasibility.

The last intriguing opportunity that the Terminal 5 site offers are the runways itself. The two current runways are parallel to each other measuring at 4,000 x 60 meters each. Built of bituminous concrete (asphalt), it contains no cement, making it easy to quickly replace and set. The current Mass Rapid Transit line runs below the first runway.

6.2.3 Changi Land Reclamation

In 1975, 52,000,000 cubic meters of landfill and sea fill began at Changi. Built on cleared swamped land and replaced with reclaimed land, created an extra 2,150 acres of land costing about S$1.3 billion.

From 1992 till the mid-2004's, the Changi East Reclamation Project in the Republic of Singapore involved filling approximately 200,000,000 cubic meters of sand for the reclamation of a total land area of 7,166 acres.[252]

[252] http://scholarsmine.mst.edu/cgi/viewcontent.cgi?article=2919&context=icchge

The upcoming expansion of Changi will be built on higher reclaimed lands to protect against rising sea levels. Alongside raising the surface height, plans are already in place to expand the Singaporean island further out to sea, where Terminal 6 will inevitably be built.

6.2.4 Mass Rapid Transit System

The Changi MRT Station is an underground Mass Rapid Transit. Currently, the last stop on the East-West line, and the only MRT station to deliver passengers to Changi Interational Airport. Opened in 2002, allowed users to access Terminal 2 and the eventual Terminal 3. Terminal 1 however, is not connected to the MRT station.

While no plans set in motion currently, there are proposals in place to extend the existing Thomson-East Coastline, which stops at Sungei Bedok MRT (southwest of Changi) to connect to the future Terminal 5 and interconnected with the existing MRT station. There are other proposals that want to extend the existing Changi MRT line to extend towards Terminal 4, as well as a North Shore line that would connect to the upper edge of Changi, where the industrial zones are placed.

6.2.5. Terminal Access Roads

The main access road into Changi International Airport is alongside the edge of the coast on East Coast Park Service Road (ECP). This 3-lane highway that eventually turns into the Airport Boulevard, a long loop that rounds at the entrance of Terminal 1.

Others will take the Pan Island Expressway(PIE) which is often equivalent in time to the ECP except in the case of traffic laden times. Then the Pan Island Expressway becomes a bit faster at the price of a toll. This road is perpendicular to ECP/Airport Boulevard.

The last access point, Xilin Avenue, comes off another perpendicular road that merges onto East Coast Park Service Road. However, this road come off

Expo (convention center), Changi General Hospital, and ITE College East. Thus, it is avoided unless departing from one of these locations.

For the current proposal of Terminal 5, Xilin Avenue would turn into Changi Coast Road which becomes the main road for Terminal 5. It will still be easily accessible from ECP Service Road; however, it becomes much more confusing for those who must access any of the other four terminal as Terminal 5 would require an early exit. Those coming off the PIE would have to turn off the expressway, drive south on East Coast Park Service Road, and double back into Changi Coast Road to access Terminal 5. This becomes incredible cumbersome during peak traffic hours.

6.2.6. Parking Structures

With the removle of Terminal 1's outdoor parking spot to make room for the Jewel of Changi, there are 5 public parking structures available. Totaling, 4,220 parking spots and 850 Motorcycle parking spots. The Jewel of Changi is expected to add around 2500 parking spaces, replacing the demolished 850 cars/100 motorcycle parking spaces. Terminal 5 aims to add another two covered parking spaces, with no estimated number.

6.2.7. Accessibility in Terminals

The airport configuration for all terminals are divided by landside and airside. Landside are areas where the public may access the airport, and airside represents areas where only ticket holding users may access. All four terminal are organized in such a way that their landside and airside facilities are divided by half. Each halved parallel to the Airport Boulevard. Landside facing the boulevard and airside facing away. With a reconfiguration, a goal of Terminal Hub becomes to allocate most of airside space towards landside so that the public may enjoy the airport facilities.

6.2.8. Changi Terminal Proposed Zoning

The apron and terminals take most of the central space aside from the blip of commercial zoning the Jewel of Changi presents. In the current proposal of Terminal 5, the entrance serves as a landside commercial zone, hotel, office, and parking buildings.

6.2.9. Constructible Spaces & Hub Location Analysis.

The dissertation calls for the replacement of landside facilities of Terminal 5 to become more central to the existing terminals to build unity among all terminals.

3 locations are practical to be constructed upon, each with their own pros and cons.

The first location is south of Terminal 4. An oddly shaped parcel of land gives the largest area for a Hub. With the extra area, expansion necessities are readily available and helpful when Terminal 6 is eventually built. However, of the three arangements, it is the farthest distance from the Jewel of Changi and its adjacent Terminals 1 through 3. The parcel of land is very awkward due to the adjacent Changi Golf courses, making its envelope unique. But the adequate area will more than compensate for the awkward shape, so much so that it may not need to follow the envelope. While the conceptual link is clear and linear to every terminal, the long distances make it less appealing. The access point is very like the proposed Terminal 5, but much closer. So, while it outclasses the current proposal in terms of accessibility, it avoids the popular PIE access way.

The second favorable location is to move it above Terminal 1 and build along the coast, perpendicular to the Airport Boulevard. This site is ideal in terms of expansive planning. As reclaimed land expands the island of Singapore, so too will the Hub. It would also provide favorable access to Terminal 1-3, 5, and eventually 6. However, it will completely alienate Terminal 4 from the central organization. Only until phase 2 is built of Terminal 5 would it be viable to connect Terminal 5 to this arrangement. This would also have to take over the existing airfreight center and move it towards Changi Access Road, where all

future industrial areas will be zoned. This way they will have the available runways to support the facilities. The biggest problem with this organization is that there are no current access roads that would be able to support the incoming traffic to the Hub. While future MRT stations may be placed to aid in such an endeavor, all existing roads would not feed into the Hub making it ignorable to private vehicles and taxi's. A major avenue would have to be built parallel to the first runway and connected to the PIE. Even the, only one main access is available. In a vacuum, this may be the optimal solution, especially as it's buildable towards the future reclaimed land to support the heart of Terminals 1-6 (although 4 would likely be excluded).

The chosen conceptual scheme is a third one where it located on the other side of Terminal 4 on Airport Boulivard. This site is especially strong in both accessibility and interterminal connectivity. Built upon a now covered reservoir, the existing MRT link will be able to connect to the edge of the allotted area. Utilizing all existing access points, becoming the drop off hub is clearly it's strongest attribute. A benefit of the site is that it's also place along the midway of Terminal 5's parcel. This allows an L shaped main access to develop connecting 1 leg with Terminal's 1-3 and the other leg connecting 4, 5, and the eventual 6. Placing a transit bug along these created axis' will strengthen the transit passenger, interterminal connectivity while also providing the flexibility to modify the satellites hub design if the design group decides to change it.

By moving the Terminal 5 Landside facilities and creating a Changi Hub, it also frees up space for another terminal satellite. While the other organizations have considered this as well, this scheme creates symmetry; the transit hub becomes central to all Terminal 5 satellites.

This scheme however has the smallest parcel land to build a complete hub from. While capable of accommodating Terminal 5's expected developments, it has the least available expansion room. Solutions around this are to either go lower or higher. By going lower, the parcel may double in size due to being under the runway as building on the runways axis is an unavailable option.

The L organization also creates an organizational division. One leg connecting to the Jewel of Changi will be the more active side catering towards departing passengers and locals, while the transit hub on the other leg may appear exclusive to flyers. It'll be important moving forward to allow both end nodes (Jewel and Transit Hub) to intermingle with each other and not create a division. This is done by pushing landside further and further back and taking much of the airside back.

Master Plan Comparisons

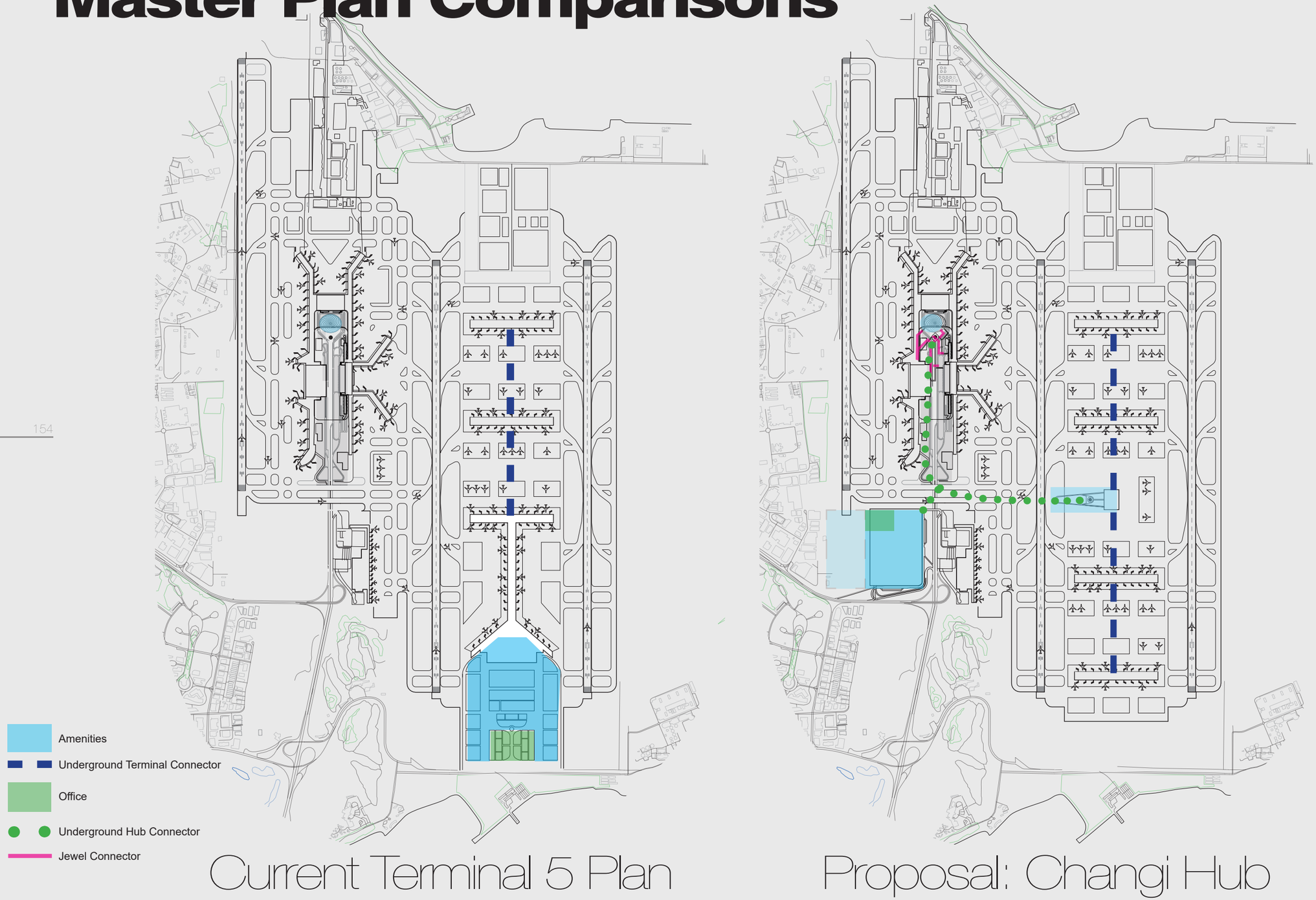


Figure 38. Master Plan comparison between Terminal 5 Proposal and Changi Hub.

CHANGI AIRPORT PROPOSAL:

Master Plan

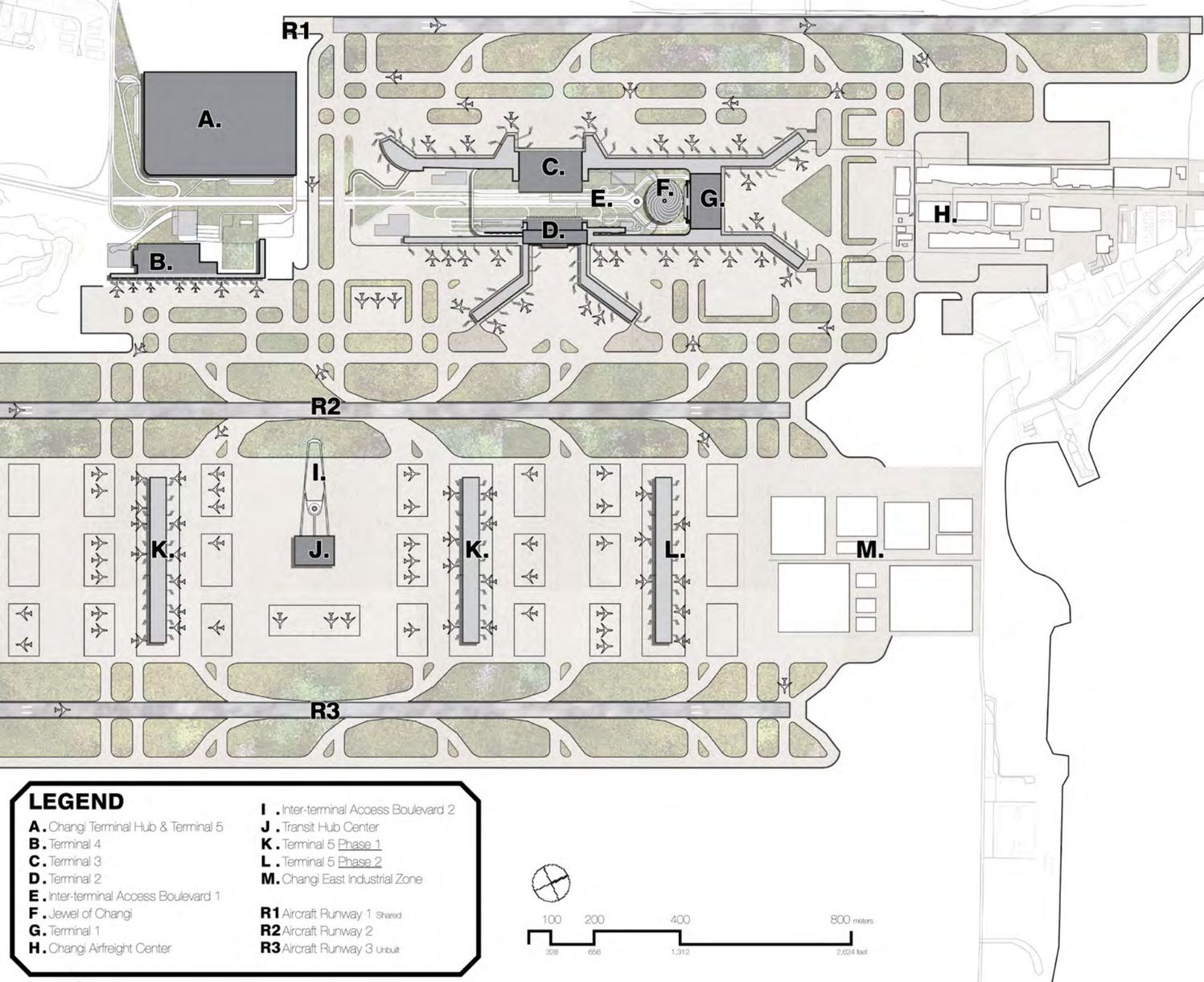


Figure 39. Changi Hub Master Plan.

6.3 Concept Design (Masterplan)

The intent for the Terminal 5 is to create the foundation for Changi Terminal 5 airport to utilizes existing technologies potential to reconfigure the way an airport can and (this dissertation argues), should be designed. By improving upon some current successful steps and challenging fundamental concepts that haven't been altered since Changi terminals have opened. Reiterating Changi Airport Group's statement,

> Changi Airport finds itself at the threshold of a new era as it undertakes planning to secure Changi Airport's future. The considerations today are multi-faceted and the challenges, dynamic. An airport is no longer just an incidental aircraft interchange, but is expected to be a destination on its own. This is something that many air hubs around the world recognize . . . . It is imperative that CAG does nonstop innovating and reinventing Changi Airport. [253]

Through rethinking of today's airports with the added capabilities of current technology and place making qualities in mind, an airport design can become more efficient without the need to diminish users' experience, challenging not only designers, but aviation passengers to look at airports differently.

In the new masterplan, Terminal 5 has been replaced with the Changi Hub. The Changi Hub serves as the landside facilities would for Terminal 5, but would also allow those who are in other terminals to use its services. This creates the initial node that binds all terminals together. Everytime the airport grows and expands, each terminal becomes its independent airport. This mindset maybe what cause each terminals amenities to be difficult to access from an adjacent terminal. The hub, located at the ideal access point allows all foreign visitors to have a central space in which they may be educated and sent out to their proper terminal or activity. Providing adequate bag drop and ticket counters that serve each terminal, on top of new baggage technology that allows bags

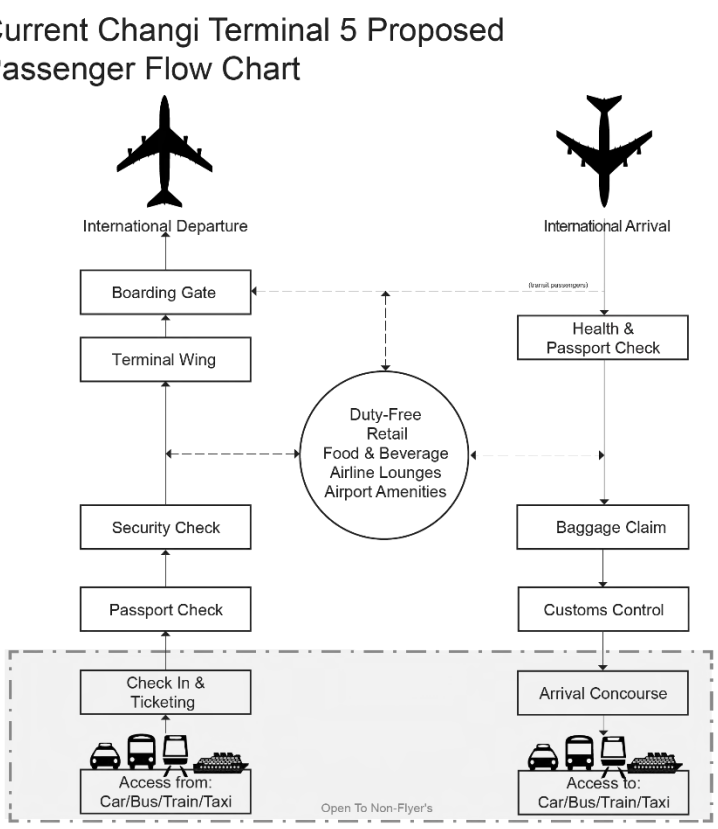
[253] http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

from the passenger's origin to be processed all the way through to their destination without having to pick their bags up from baggage claim. Creating a seamless experience that aids in all the stress of air travel will allow passengers to utilize the vast amenities of Changi International Airport as a whole.

Three concepts drive the planning and architectural execution of the dissertations proposal for Singapore's Changi Terminal 5. The streamlined transportation hub, airport as a destination, and transit hub. Viewed through the lens of three passengers, we are able to asses and value differing experiences within an airport, thus the three concepts are examined and explained from the viewpoint of three different passengers, the traveler using the airport to travel from point to point, a one-way departing traveler, and a transit passenger who has a long layover spent within Terminal 5.

Alongside the conceptual planning, it is a secondary goal of the project to keep in mind of the constant impact near-future technologies have on airports. Instead of retrofitting systems into previously designed space for differing purpose as it has been done previously in Changi airports, the components of the design expect spaces for future adaptations and improvements.

Airports in the future will look and act differently than they do in 2017. It's impossible to predict what an airport will specifically look like in 100 years and the Changi Hub is not the end all design for airports. However, through observations in history and design unconsidered before, it can become the bridge towards future designs. Vastly improving the airport experience currently missed in most airports, and shifting the mindset towards the future possibilities.



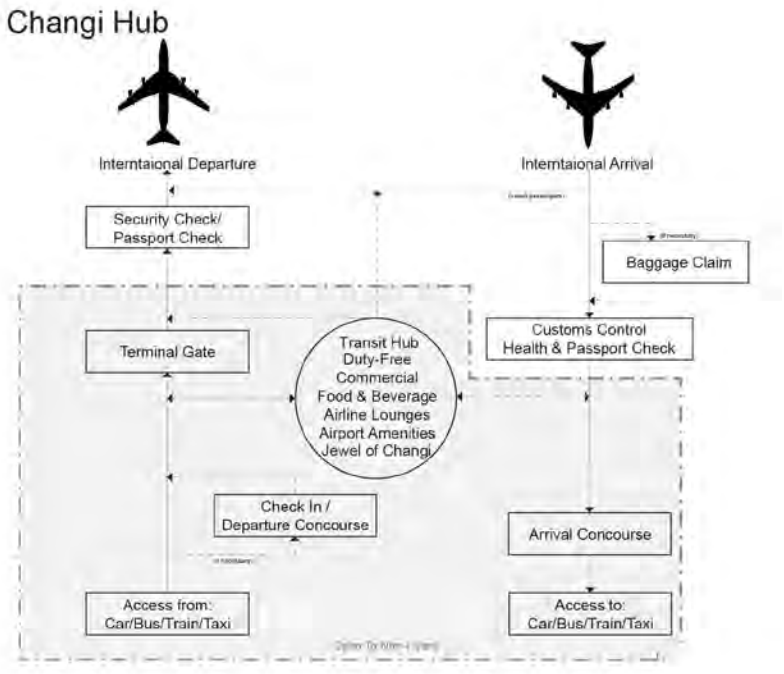


Figure 40 (Top). Current Chang terminal 5 proposal. Centralized configuration flow for departing and arriving passengers.
Figure 41 (Bottom). Dissertation's suggested revision to passenger flow. Changing the approach of how an airport is transverse through.

6.4 Concept 1: The streamline processing for the direct flyer.

Modern technology allows many of the time-consuming process of air travel to be bypassed. Currently, 97% of all flyers carry at least one electronic device while flying and 18% carry three devices according to SITA: Air Transport Industry Insights.[254] Even if the trend were to stagnate (and it hasn't really shown that it's going to). Assuming that even if those 79% of users became more versed in the technology, we can expect many to use their phones for boarding passes and check ins. Global Study Overview have found that 90% of travel bookings in 2014 involves going online compared to only 50% in 2006.[255] The average online flight purchaser visits about 22 travel websites total but visit at least 3 before purchasing their ticket.[256]

The direct, solo flyer is very straight forward and wishes to minimize the air travel process as much as possible. As soon as the direct person enters the halls of the terminal, like 89% of other travelers, prefers an automated or online check in. Then they proceed straight through the security and passport check, with papers ready, to haste the procedure as quick as possible. Once past the security gates, the direct flyer heads straight to the gates and waits to board. This is a situation in where many of us have gone through but have not thought to challenge the idea. Each new streamlining feat technology provides has us asking for more, as they make the process much more bearable.

Our quick to search of information reveal that our society relies heavily on this information gathering devices. In a 2015 survey, the International Air Transport Association found 93% of flyers would like to be notified proactively on the statuses of their flight.[257] Thus with the trend continuing, it is possible to imagine an airport without a ticketing desk. Thinning queue lines and removing

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[254] Design and Operation P302

[255] http://www.gfk.com/de-at/insights/press-release/around-90-percent-of-travel-bookings-today-involves-going-online-compared-to-only-50-percent-in-2006-gfk/

[256] http://www.iata.org/publications/Documents/2014%20IATA%20Global%20Passenger%20Survey%20Highlights.pdf

[257] http://www.iata.org/publications/Documents/Highlights%202015-Global-Passenger-Survey-Final.pdf

the need to wait for check in counters to begin. As more and more people carry personal electronic devices, as well as purchase boarding tickets online, the process to stand in check in halls may be diminished. Already in 2016, 69% of all passengers used an electronic mobile boarding pass to board their flight. Online check ins used at most airlines can be done before stepping foot anywhere near the airport. This allows for the airport main hall to become much smaller or repurpose the space for other uses.

There are many ways to arrive at terminal 5. Whether by, bus, shuttle, car, taxi, or MRT, each mode of transport brings the people into the terminal hall. Typically, in departure halls, vast rows of counters and kiosks are used to print boarding passes and check in bags. In Changi Airports history, it was not until the opening of Terminal 3 that bags were manually managed and transported to the aircraft. The invention of baggage handling systems has created more efficient and reliable means to transport bags to and from aircrafts. Using RIFD tags and conveyor belts, printed tags read and pair trays with bags and transport them to their designated destination. Giving operators real time information and position of said bags.

Changi's Terminal 5 will change the way airports approach checking in bags. Moving the common check in areas outside of the terminal and closer to people's transportation options. Airport passengers will have bags linked to boarding pass. All the public transportation options will allow passengers to pre-check in their bags at their initial station. This will allow the direct traveler to explore the city or airport freely without concern of checking in at a specific time. Bag drops will be available for cars to quickly drop off and leave to park at the garages. Incentivizing customers to pre-check, and eventually remove the need for check in stalls. For the first phase of its life cycle, the baggage handling building will also serve as the ticket check in, but as more and more people get comfortable with their smart phone devices within airports, the space will eventually be fully dedicated to baggage handling.

CHANGI SITE ANALYSIS:

Proposed Changi Flow Chart

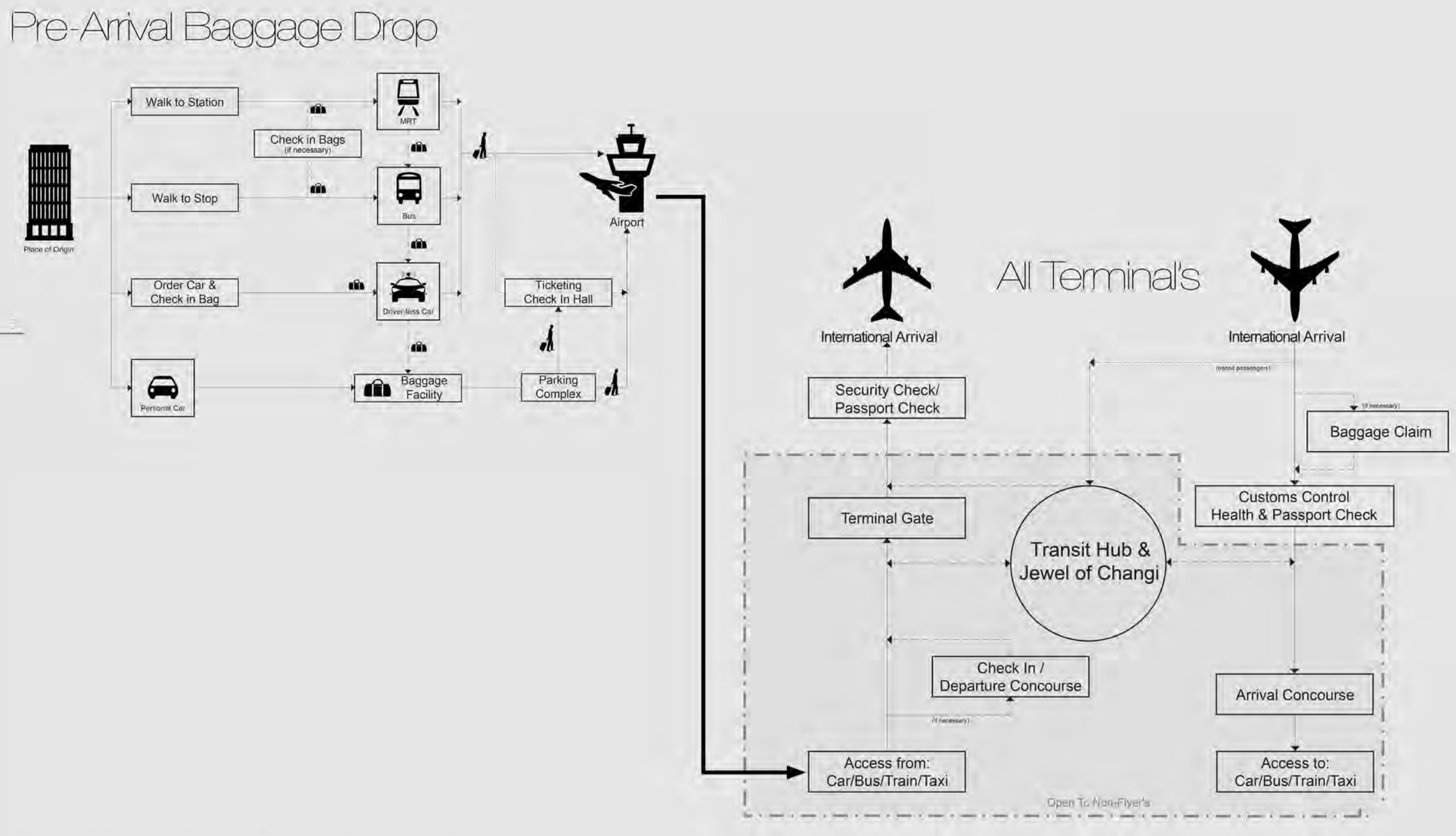
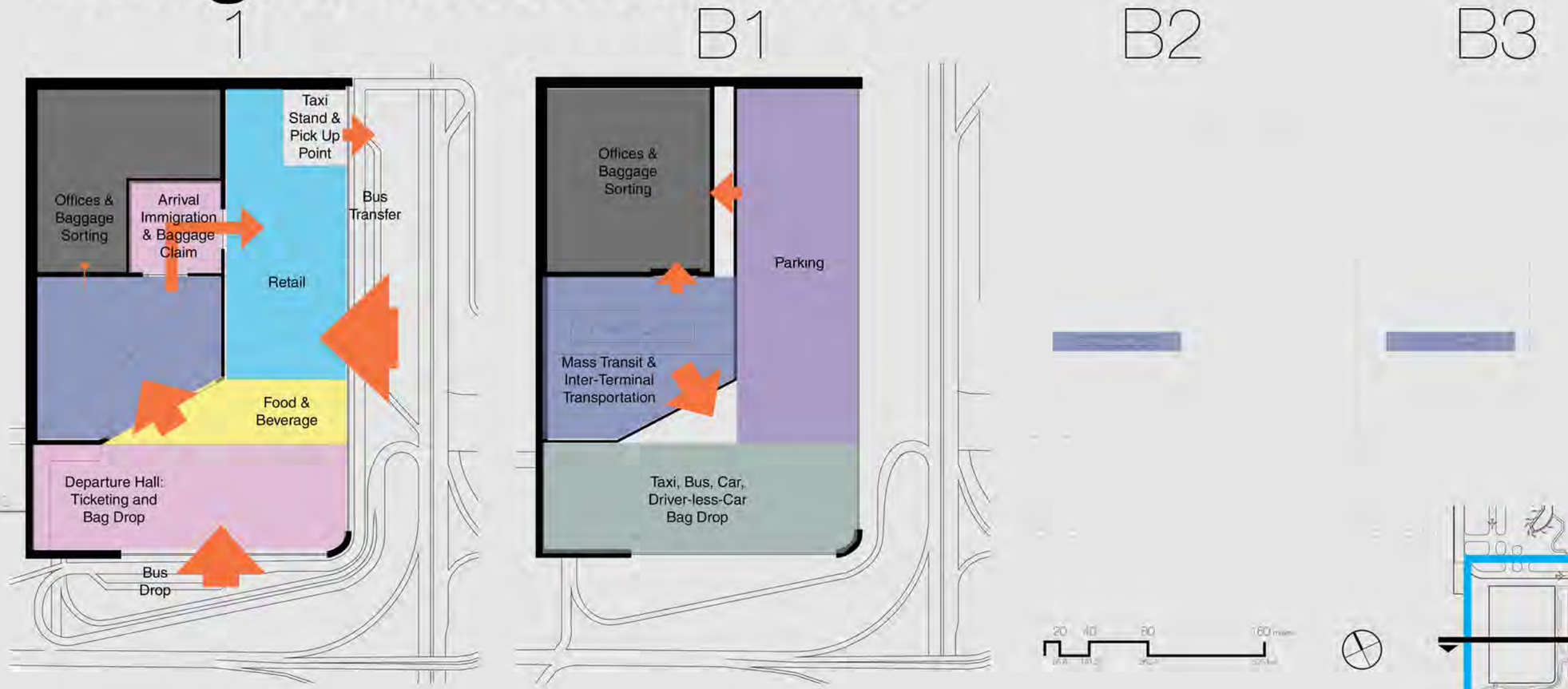


Figure 42. Modes of Arrival to Terminal 5 Dissertation Proposal

CHANGI AIRPORT PROPOSAL:

Changi Main Terminal Plan



CHANGI AIRPORT PROPOSAL:

Changi Main Terminal Section

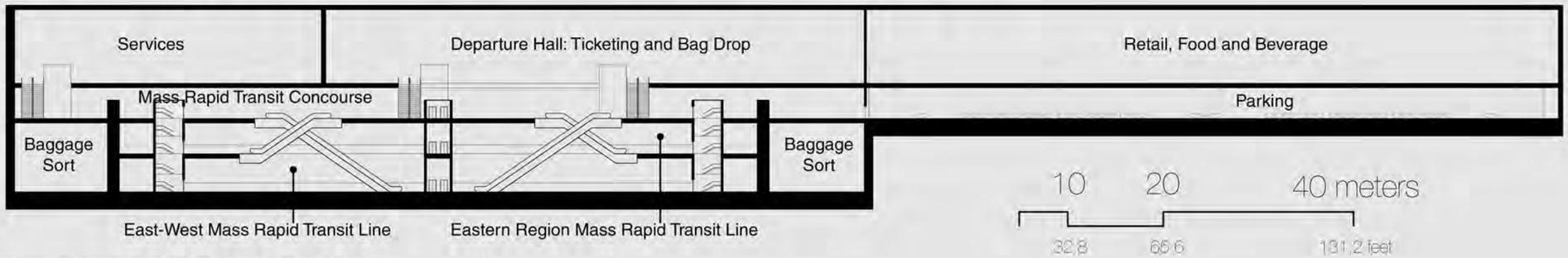


Figure 43. Plan: Diagram of Changi Hub, Section: Changi Hub Space Adjacency

In the future, not only will the bags be checked in remotely, by way of driverless cars, trains, busses, but will also be already be at your mode of transportation outside of the airport. If you prepare the driverless car as you land, the car will pick up your bags before you. Similarly, if you catch the bus, or MRT back, the bags will be dropped alongside you at your destination. This has been proven to work in Hong-Kong, where in-town check ins are available. The special line dedicated to airport travel, allows travelers to check in their luggage in town then proceed to the airport bag-free. The passenger who checks the bag in at the Subway station can then board the train stress free knowing that they won't have to lug around their heavy bags from rail to check in lounge. In fact, passengers may check their bags earlier and explore the city at their own pace knowing their bags will meet them when they fly out later in the day.[258] This is especially helpful for those who must check out of hotels at a certain time but their flights are much later. All public and private transportation will provide the service of checking in your bag before you even reach the airport. Creating a hassle-free environment and relieves the passenger of worrying about their belongings. Technology give us the ability to track, manage, and handle our belongings in efficient and in worry-free ways.

[258] http://www.citylab.com/cityfixer/2014/08/every-city-needs-hong-kongs-brilliant-baggage-check-system/378826/

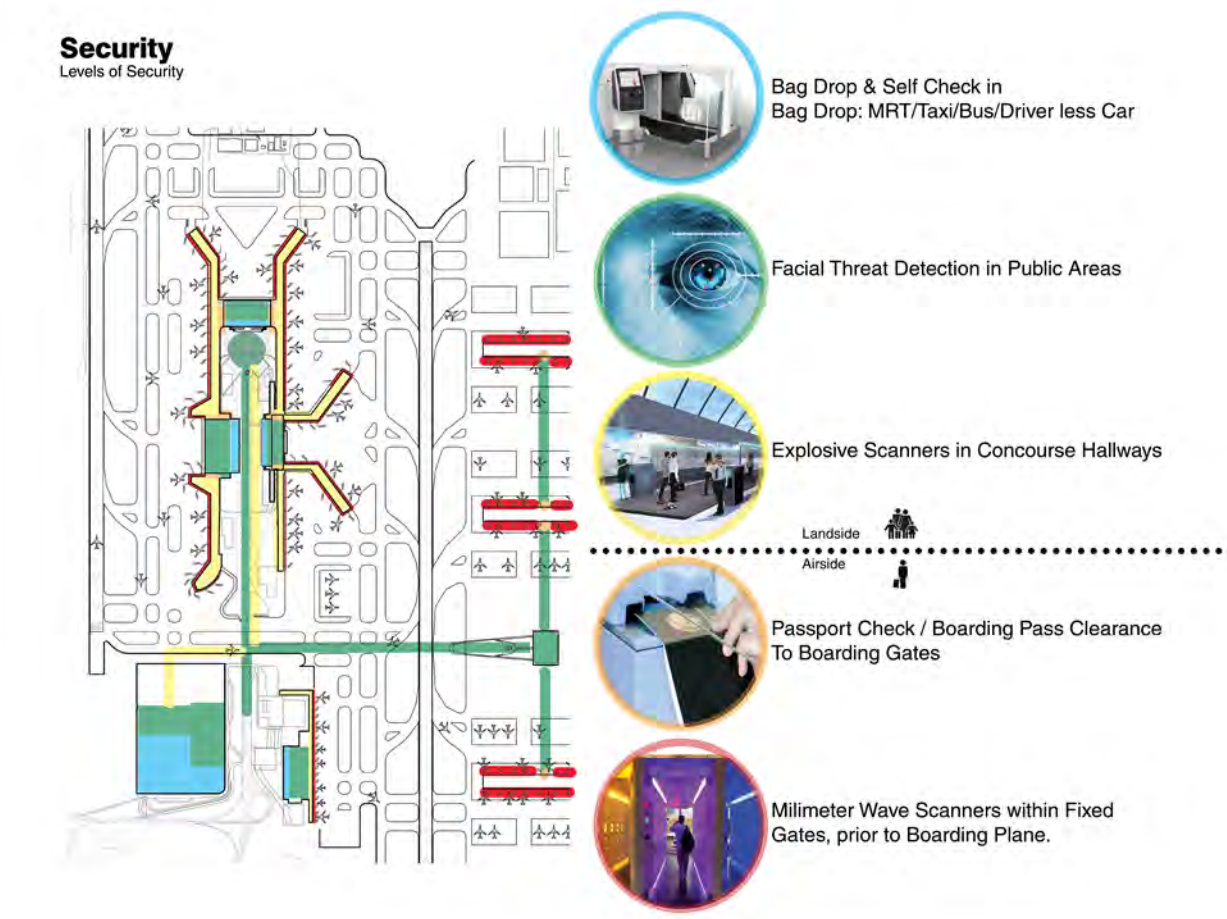


Figure 44. Security Levels within Changi Site.

Security is critical for the passengers, but also the most inconvenient. Most airlines require you to take off your shoes and have them x-rayed. This is due to a failed attempt by Richard Reid in 2001, where he attempted to ignite explosives hidden in his shoes. Although he was unsuccessful security is constantly heightening at every sense of danger. The inconvenience of security checks adds irritable moods to the passengers. In 2014, the IATA conducted another survey in which less than 10% of all people believed it was unacceptable for security checks to take over 10 minutes.[259]

[259]http://www.iata.org/publications/Documents/2014%20IATA%20Global%20Passenger%20Survey%20Highlights.pdf

In the proposed plan by CAG, the scheme is planning on changing its security to a centralized security organization. Although terminal 1 through 3 are decentralized security systems, Changi believes that more people would feel secure with a centralized format. The benefits of a centralized plan is economical and more easier to manage. Having higher utilization of technical equipment and personal allow for less security to be hired. With a central plan, most of the security members are standing in between the airside and landside. Passengers must pass through metal detectors, millimeter-wave scanners, x-ray units and possibly be chosen for a random pat down search.

This dissertation argues however, that the advancement of technology allows security systems to better correct for human error. As many new technologies in millimeter-wave scanners, facial detection, backscatter screens, gas analyzers, vacuum chambers, and even liquid scanners are all available for airports to use. Frequent flyers are required to provide biometric identification travels that are checked within a data base shared with all international airports.[260]

Inventive and innovative security technologies are being researched daily. Researchers from MIT's Research Laboratory of Electronics and Princeton University have developed a new quantum cascade laser. The laser is a part of a terahertz spectroscopy system that takes microseconds to identify an object's spectroscopic signature. Terahertz spectroscopy uses electromagnetic tradition bands found in between microwaves and infrared light, and is able to identify a wide range of materials such as chemicals and explosives.[261] It is able to detect and identify objects but currently it takes around 15 to 30 minutes to analyze and identify its spectroscopic scope.

When the levels of security are designed into the architecture rather than retrofitted after the fact, spaces that have previously been unwelcoming to nonfliers can now navigate around the airport and go with the flyer. Using not

[260] Design and Operation Page 331
[261] http://www.rle.mit.edu/thz/research/high-performance-thz-quantum-cascade-lasers/

obtrusive security measure when unnecessary allow progression into space. In the new Changi Airport, the security measurements start at home. Through background checks, and automated baggage drops, measurements can be insured to provide safe air travel from taking on hazardous baggage. This is not new, in fact this is ongoing in most airports today. With the convenience of the hassle-free technology, so will carry-ons be strictly enforced. No large bags will be allowed, they must be dropped at the baggage drop stations. In fact, only hand bags, back bags and laptop cases will be permitted. This will significantly increase speed times and security measurements needed when going through the airport.

At the base level of every hall, facial detection scanner will be used to identify wanted threats. Currently being tested at Changi Terminal 3, these unobtrusive security measures will allow passengers and their accompaniment further into the airport alongside the departing passenger, pushing back on airside vs landside space. Changi Airports have already hired Morpho, a biometric facial recognition to check terminal 4 when it opens in 2017.[262] These first layer of checks will persist throughout the transit areas and commercial avenues of every terminal, without the need of a boarding pass. Only when the passenger get to their holding room will the passenger need to separate from their accompanied guests. This allows maximum amount of time that they may enjoy with their loved ones while ensuring safety for flyers. The passenger then scan their passport by automated machines that verify flight, boarding ticket, thumbprint, and passport all belong to the individual.

Millimeter scans are becoming much more reliable and harder to fool, and those can also be added within the entrances of both satellites. Only when something is found to be harmful will there be a need to thoroughly search. Limiting human error by relying on technology to find and notify the trained authorities. Only when you board the plane, will a standard xray/millimeter wave scanner be used to thoroughly inspect.

[262] http://www.morpho.com/en/media/20160315_changi-airport-chooses-morpho-facilitate-passenger-experience-new-terminal-4-through-biometrics

In theory, a direct person may easily walk from his choice of arrival straight to the boarding gate without ever being hassled. This is one of the conceptual goals Changi Terminal 5 should be sought after. By sticking with the decentralized security plan, the flow of passengers in high peaks flow much more swiftly than centralized systems. Expecting double the passengers of Terminal 1 through 3 combined, it would be wise to invest in unobtrusive security systems rather than create the funneling security systems most airport utilize today. The adaptations with upcoming technology only makes the decision more beneficial.

To illustrate the potential of using these existing technologies, Figure 45 shows the difference in time that each of the terminals need to board from arrival to airport to departure of plane. In terminals 1-3, the decentralized security systems need more time than the centralized security systems of Terminal 4 and current proposed Terminal 5. As criticized earlier, Terminal 4 and 5 will introduce automated systems within the current infrastructure already present. While this will increase the speeds of obtaining tickets and need less workers, the operational order does not change whatsoever. If the technological potential is observed, then baggage and ticketing can be processed prior to the arrival of the airport. This will allow a more streamlined process for a passenger to walk straight to the gates, rather than the queue times needed when obtaining tickets and going through security checks.

Passengers like Rachel Yun in Figure 46 further shows how a passenger may move through Changi Airports at a more direct approach. On the day of her flight, she had many errands to run and sees herself a bit late to the airport. Thankful for the infrastructure of the Changi Hub, she verifies intent of boarding and checking in her bags through her phone on the taxi ride towards the airport.

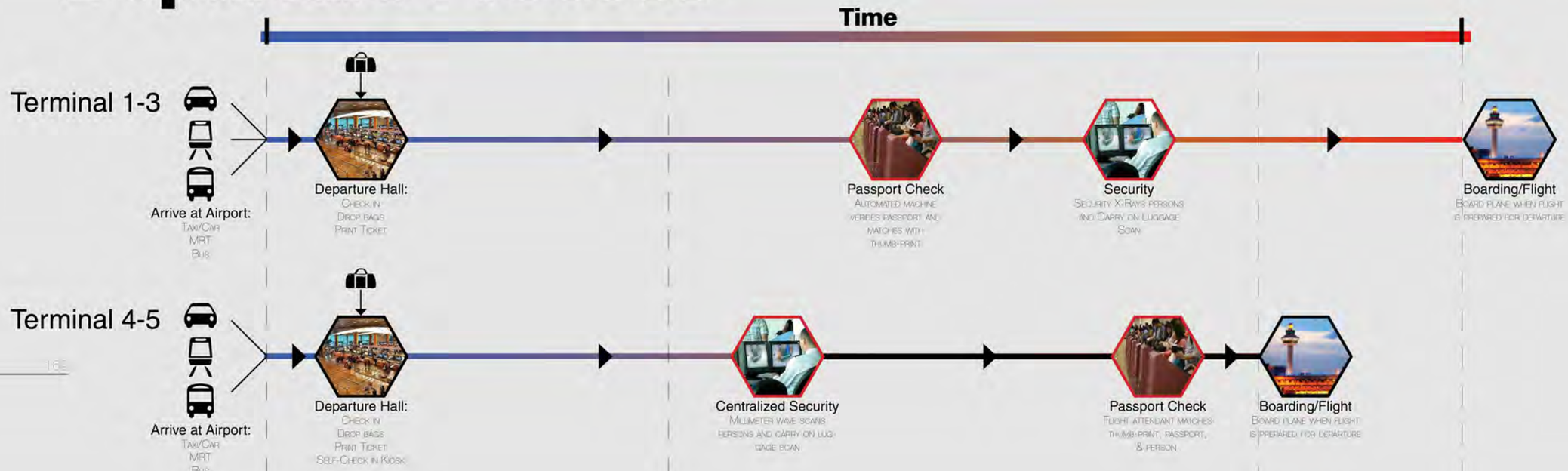
While she enters the airport halls, the taxi will then drive to the baggage drop off area and the automated systems will process the bags through security checks and ensure proper sorting so that Rachel will not have to worry about her bags flying alongside her.

Rachel enters the terminal directly and walks straight towards her gate. To enter airside, she goes through the only security check point she will have to go through, which makes the time much more manageable in comparison to the earlier organizations where up to three checks may have been done.

For a non-Singaporean who doesn't know exactly which terminal to enter from the start, the Terminal Hub becomes the great entry point that connects to all the built departure hall terminals. Rather than each terminal being its own airport, as it is in the current iteration, the central hub provides all passengers with the information and direction to access all boarding gates. Most people will enter the airport through these doors as many visitors will not know exactly where their terminals are located.

CHANGI AIRPORT EXPERIENCE PROPOSAL:

Departure Process



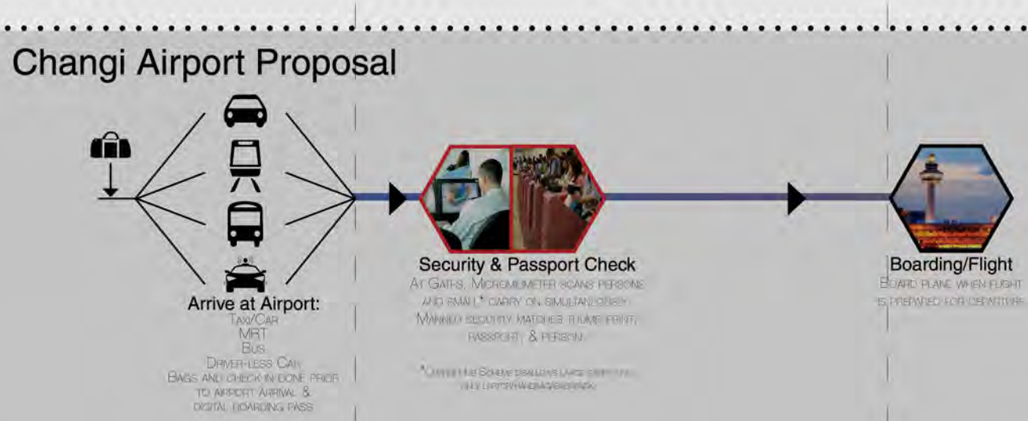


Figure 45. Departure Flow Chart Comparisons.

Direct Departing Passenger

Rachel Yun

Direct Passenger
Nationality: Singaporean
Age: 26

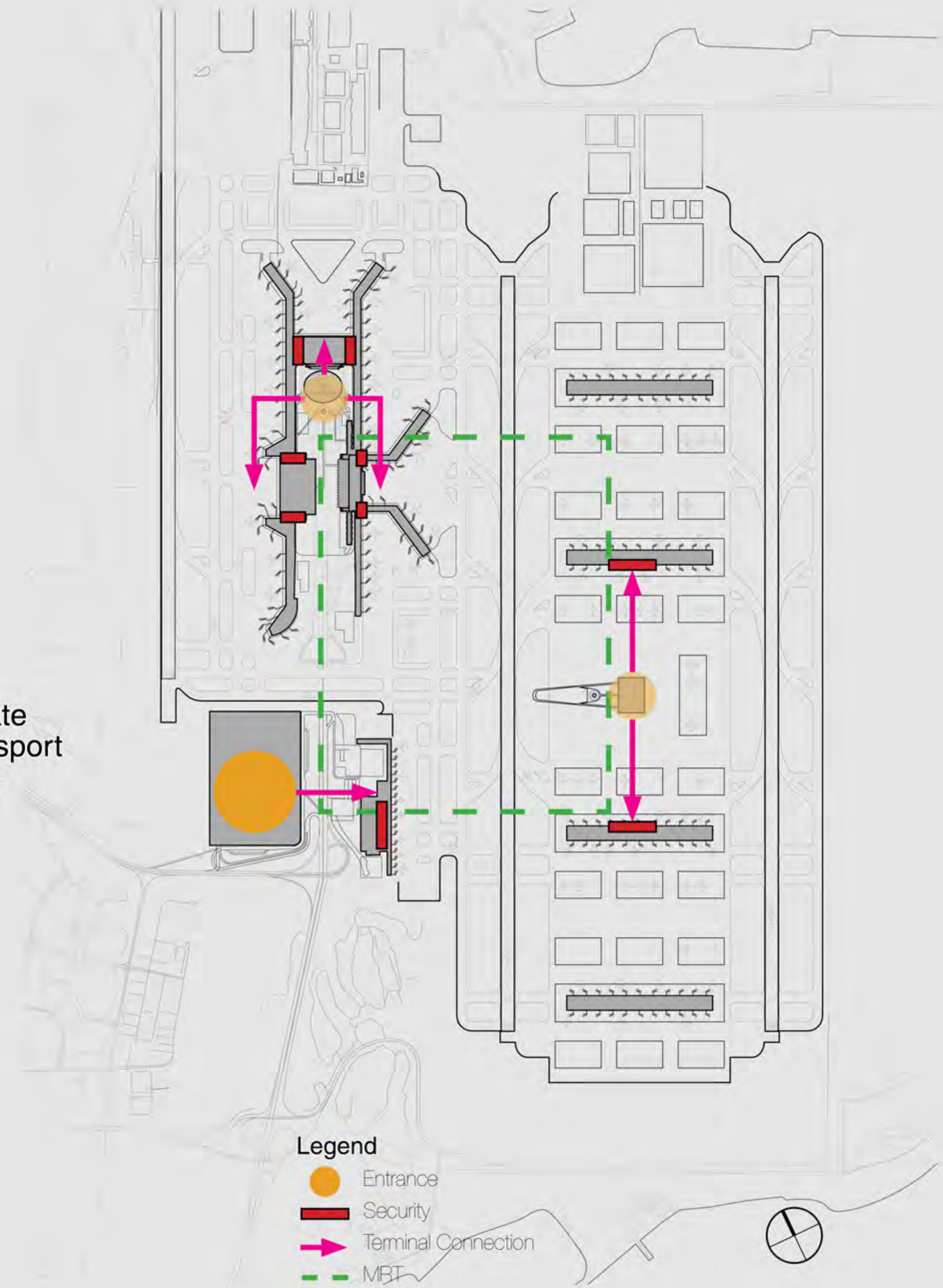


Figure 46. Conceptual: Departure Passenger Experience.

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http://geargather.org/wp-content/uploads/2017/03/changi-airport-arrivals.jpg
http://www.albawaba.com/sites/default/files/im/uae/drugscanner.jpg
http://www.tsp.com.sg/photo/[illegible].jpg
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6.5 Concept 2: The long layover for the transit passenger.

Changi was most recently awarded the airport for leisure amenities by Skytrax in 2016, but fell a little short to 2nd in best transit airport awards. [263] As discussed earlier, CAG's current terminal 5 would likely resemble Atlanta Hartsfield Airport scheme in amenity design; blocking space for monotonous commercial and airport services to be later puzzled in. Changi Airports reputation as a HUB airport brings in around 30% transit passengers from all its travelers. Thus, it is important to keep in mind the areas in which Changi airport can facilitate towards the needs or desires of those many passengers.

In terminals 1 through 3, Changi dedicates special areas for airside passengers. With unique amenities to offer not typically found in airports, such as a swimming pool, movie theatre, and sunflower garden. However, if you were in Terminal 1 airside and wanted to see a movie at Terminal 2 airside, you would have to leave the airside and exit through immigration checks. Once cleared, you then would have to either walk to take the sky train to terminal 2 and reenter their air side to access the amenities. Terminal 1 specializes in leisure, Terminal 2 specializes in entertainment, and Terminal 3 specializes in galleries and small art collections. Because Terminal 5 is planned to be as big as the other three terminals combines, it's important for passengers to not only have the convenience of an all in one central location, but to provide them with the vast amount of unique amenities Changi is regularly recognized for.

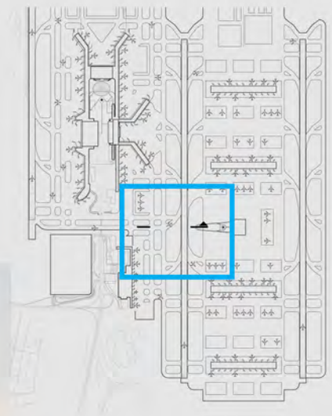
The transit center is centrally located between the two satellite configurations to minimize the walking distance from their original arrival gate, and their future departure gate. Having it centralized also makes way finding very simple while also enticing wanders to accidentally stumble upon the center. On the basement level, here the MRT runs two parallel automated people movers converge onto the area suited for business and pleasure amenities to be shared. Such amenities as work tables with high ceiling for quick email and chats, libraries, media consumption, and an area for children to play video games as well. The ground level perimeter lined with retail shops and Duty free

[263] http://www.worldairportawards.com/Awards/best_airport_leisure_amenities.html

merchandise, a Kopitiam – food court style atmosphere famous in South East Asia for its variety –, and other delectable and market options. The upper floors would have areas open to the sky and a signature garden as is tradition in every Terminal built. In addition, lounges for sleeping, showering, working out, and massages.

The transit passenger will not have to worry about what to do during the long layover as a transit center concept would have something for everyone. The center would be centralized for easy access and clearly defined areas catering towards all the different senses and a lasting impression, giving the most individualized Changi Experience of any Terminal thus far.

Sectional Diagram of Transit Hub



Leisure & Rest
Garden Space, Pool, Jacuzzi,
Gym, Shower, Massage, & Sleep

Retail, Food, & Beverage
Kopitiam/Hawker (Food Court), Restaurants, Coffee,
Duty Free, Cosmetics, Alcohol, Cigarettes, & Electronics

Business & Pleasure
Library, Temporary Offices, Conference Rooms, Entertainment,
News/Stocks, Sports, Video Games, & Children's Play Area

Transportation & Convenience
Mass Rapid Transit Center, Inter-terminal Connector,
Baggage Holding Area, Baggage Transfer, Ticket Print, & Banks

Figure 47. Mood images of Transit Hub organization.
Double ceiling entertainment and work space.
Ground floor space with retail mall, food, and beverage options.
Upper floor provides relaxation, sunshine, pools, resting rooms,
showers and massages.

http://www.keyworking.com/material/slides/sl_1_1394740501_keyworking-10.jpg
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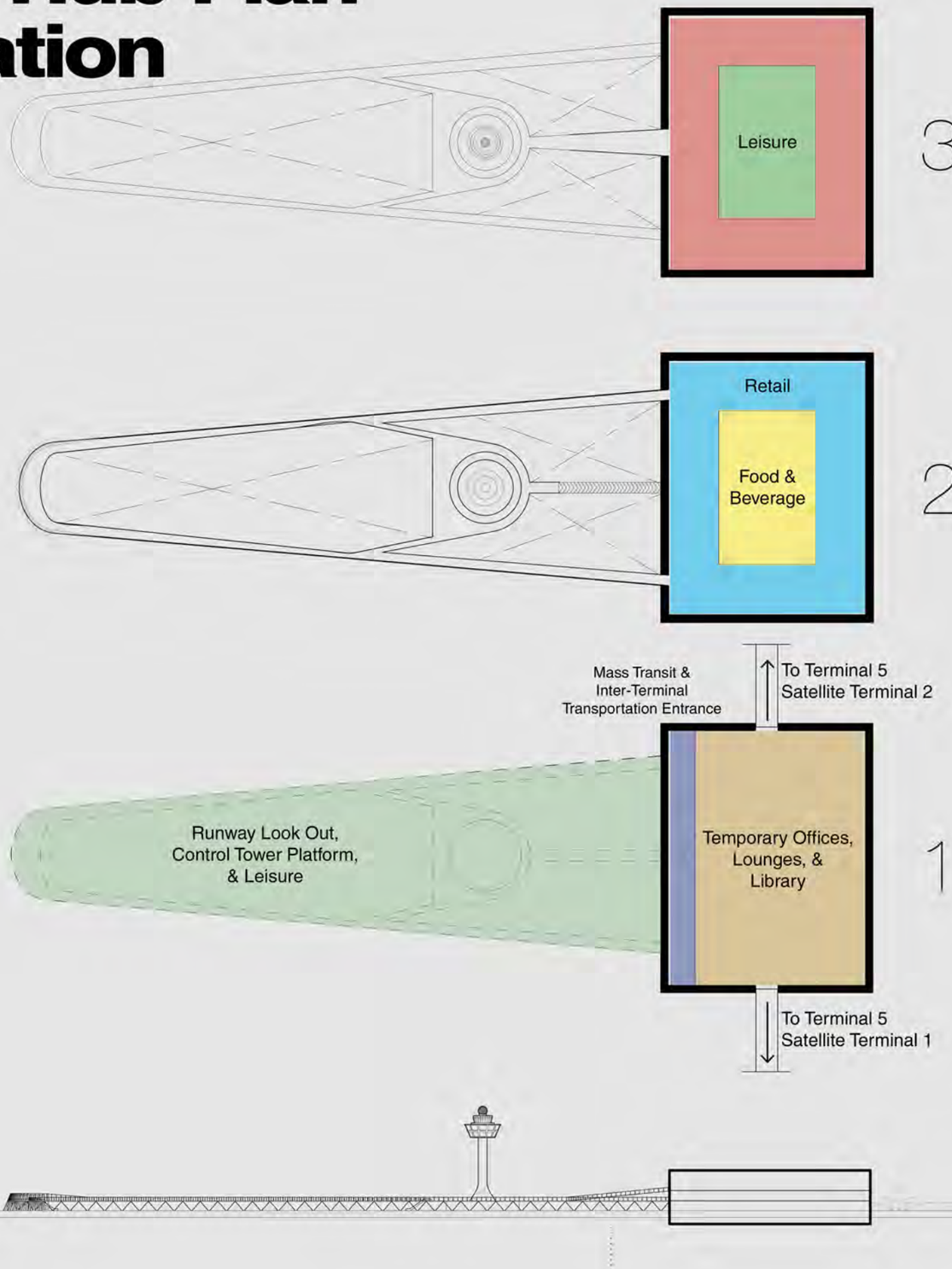
CHANGI AIRPORT PROPOSAL:

Transit Hub Plan & Elevation



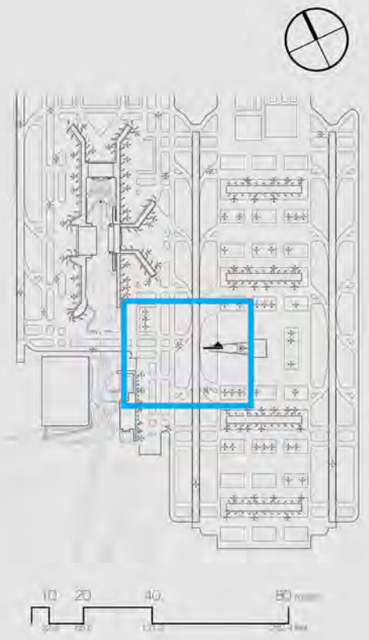


Figure 48. Transit Hub Plan: Program Relationships.

Transit Hub Plan Experience Render

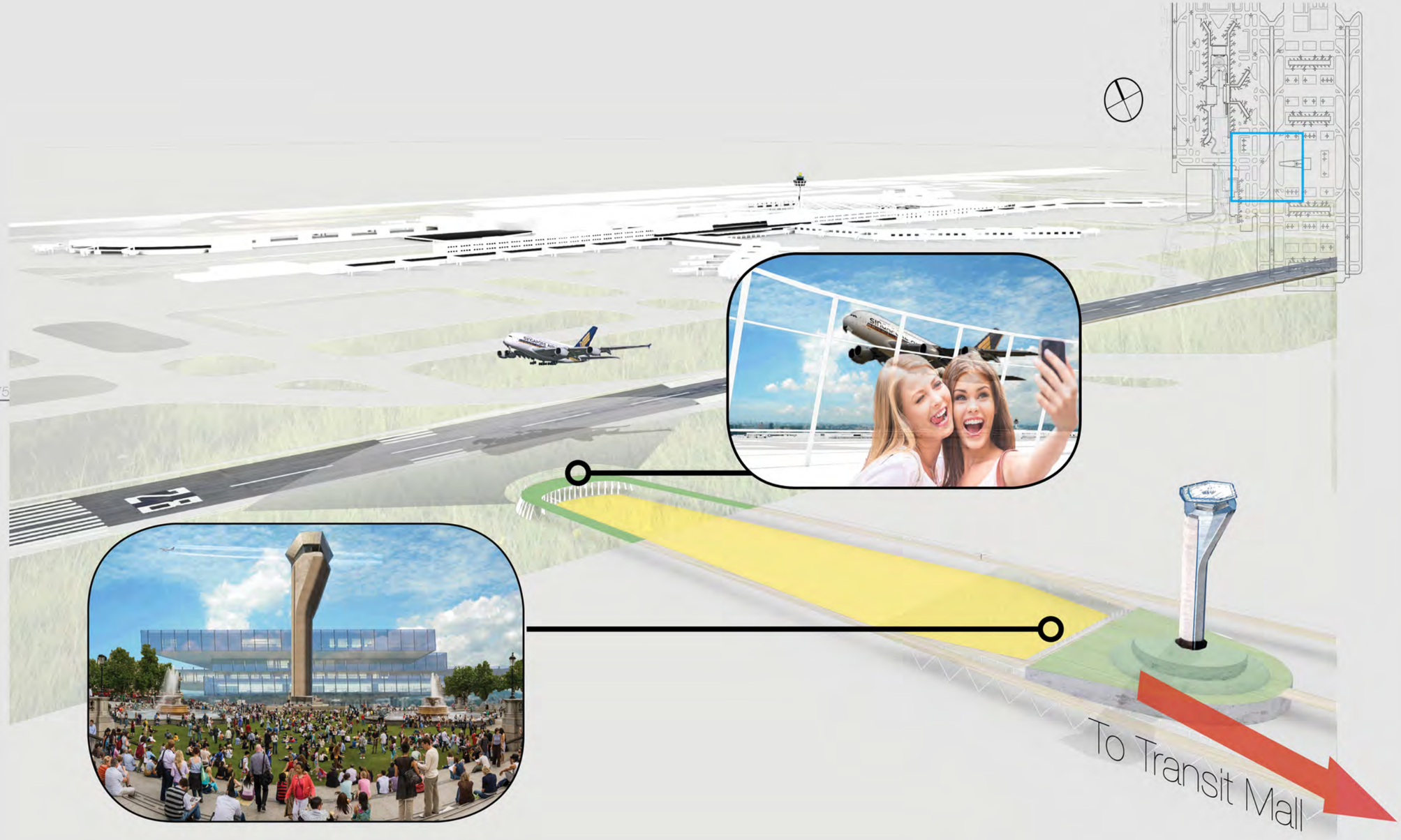


Figure 49. Experience Render of Transit Hub.

With the addition of a Hub to the Jewel of Changi, in-transit passengers are much more accommodated. In the current organization of Changi airport, many of the transit passengers are limited to the amenities of their destination gate. This is because of the security and transfer methods operated. When a passenger arrives at Changi, they will transfer to their gate through busses or if fortunate, can catch a tram from certain areas between Terminals 2 and 3.

All arriving guests are circulated towards the two centralized transit areas. Terminals 1-3 will share the Jewel of Changi and Terminals 4 and 5 will lead passengers towards the in-transit hub. Both hubs are interconnected by rail and will give passengers and guests a variety of options. A variety of amenities, restaurants, retail stores, and more discussed earlier will all be available.

In addition to the array of amenities, the hub acts as transfer points to way find towards destination gates. In todays airports, finding the gate may be difficult if the organization of the airport is unfamiliar to the traveler. This will only be compounded the more terminals and gates that are added. By unifying the design, these hubs connect with all the existing and future terminals and gates making it easy for all travelers to locate and guide towards their designated boarding gates.

When business travelers who travel often use Changi as a transit hub, people like Anita Shyama who run multiple startups appreciates the hub for its opportunities during long layovers. Having office spaces and conference rooms available, Anita can answer emails, call into conferences, and complete all of the works that is required in comfortable and designed spaces. Unlike the existing transit amenities, find such spaces become very difficult and are often very small and placed within the unused spaces within the halls. For Anita, having these dedicated spaces not only aid her guidance and comfortability, but its adjacency to other amenities makes it easy for her to take small breaks to grab food or other services.

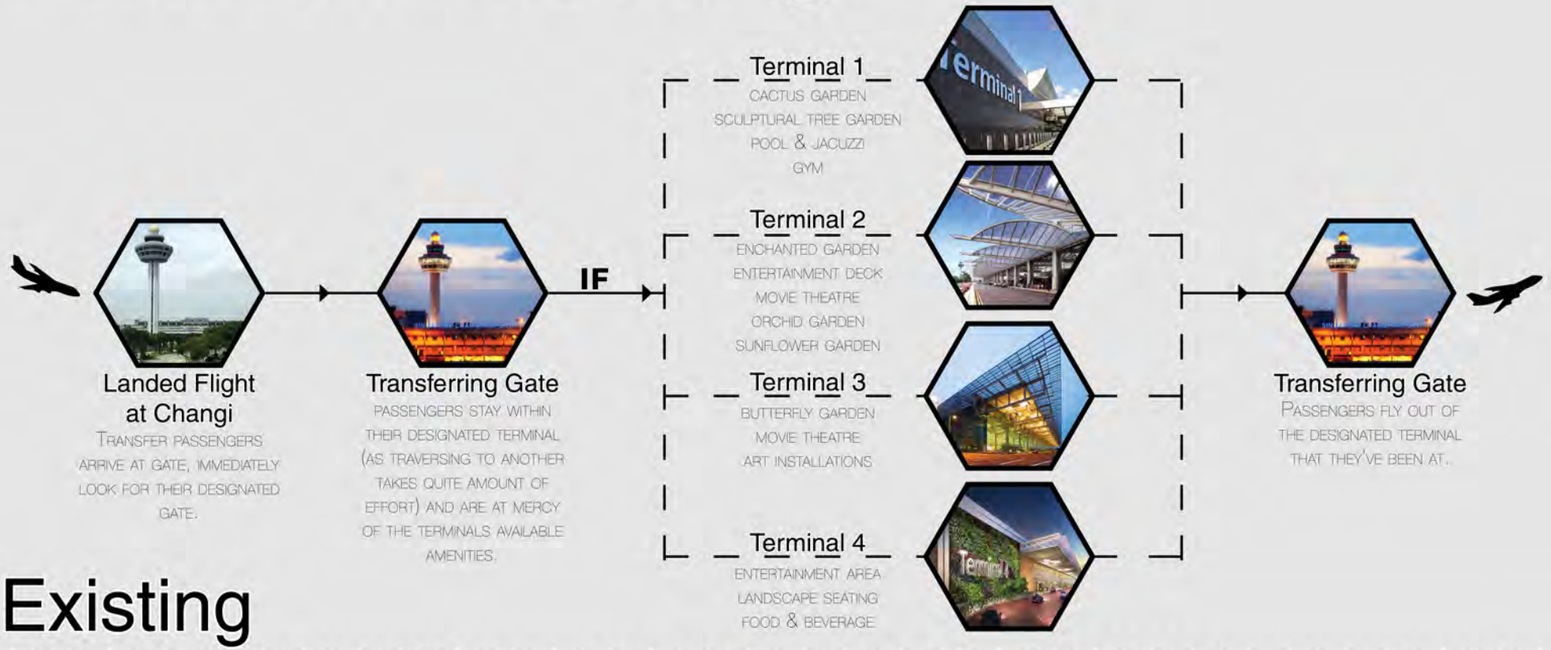
For tourist travelers who are transiting in Changi, the Jewel becomes an ideal place to experience Singapore in a confined area. Large garden spaces and an abundance of retail opportunities give these transit passengers many to

do during there long layover. Duty free shops which are popular for travelers as they are exempt from local or national taxes and duties appeal to even the locales because of the duty placed on alcohol and cigarettes in Singapore. Jacob and Joseph Miller, two brothers who are traveling around Southeast Asia find the mix of travelers and locals within an airport a unique experience. Buying last minute souvenirs, they enjoy all the amenities the Jewel has to offer. As they've been frugally traveling, the budget airlines transfer window was over 10 hours. Luckily for the Millers, the hotel areas integrated within the Jewel were more than enough for an overnight stay.

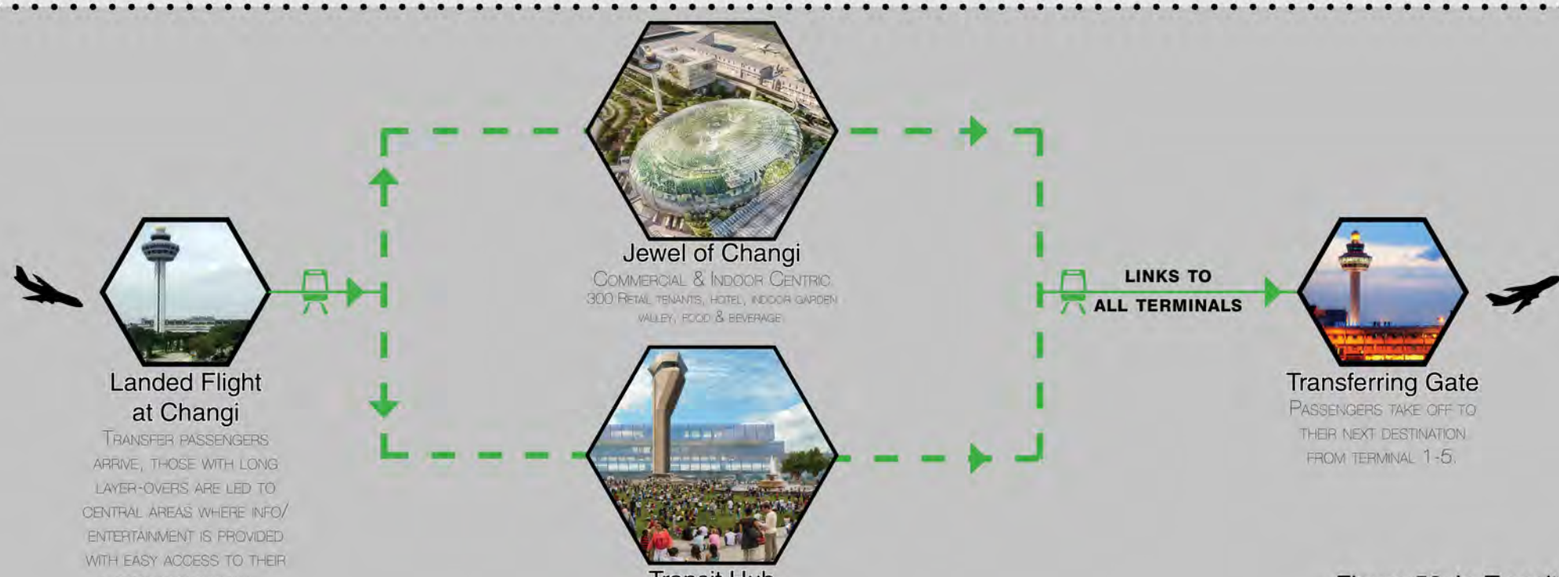
When it's time to leave Singapore, they are already in the perfect area to transfer towards their gate as both the Jewel and transit hub are connected with all terminals and gates.

Changi Airport Experience Proposal:

In-Transit Passenger



Existing



Proposal

Figure 50. In-Transit Passenger Flow Chart Comparison.

CHANGI AIRPORT EXPERIENCE PROPOSAL:

In-Transit Passenger

Anita Shyama

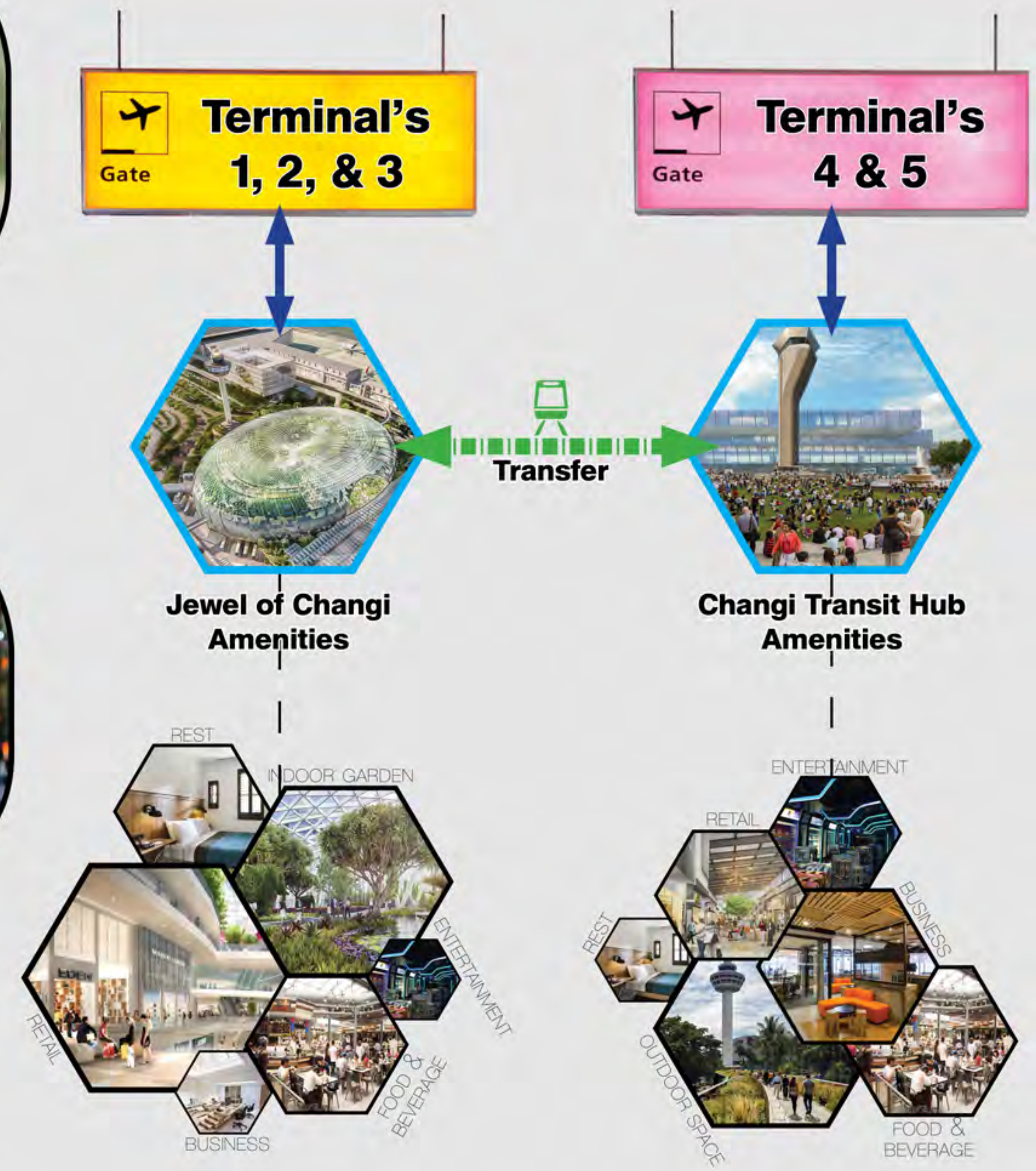
COMPANY EXECUTIVE FOR MULTIPLE STARTUPS AROUND ASIA, TRAVELS OFTEN.

NATIONALITY: INDIAN
AGE: 37

Jacob and Joseph Miller

TWO BROTHERS TRAVELING AROUND ASIA ON BUDGET AIRLINE HAVE A LONG LAYOVER AT CHANGI INTERNATIONAL AIRPORT.

NATIONALITY: AMERICAN
AGE: 24 & 26



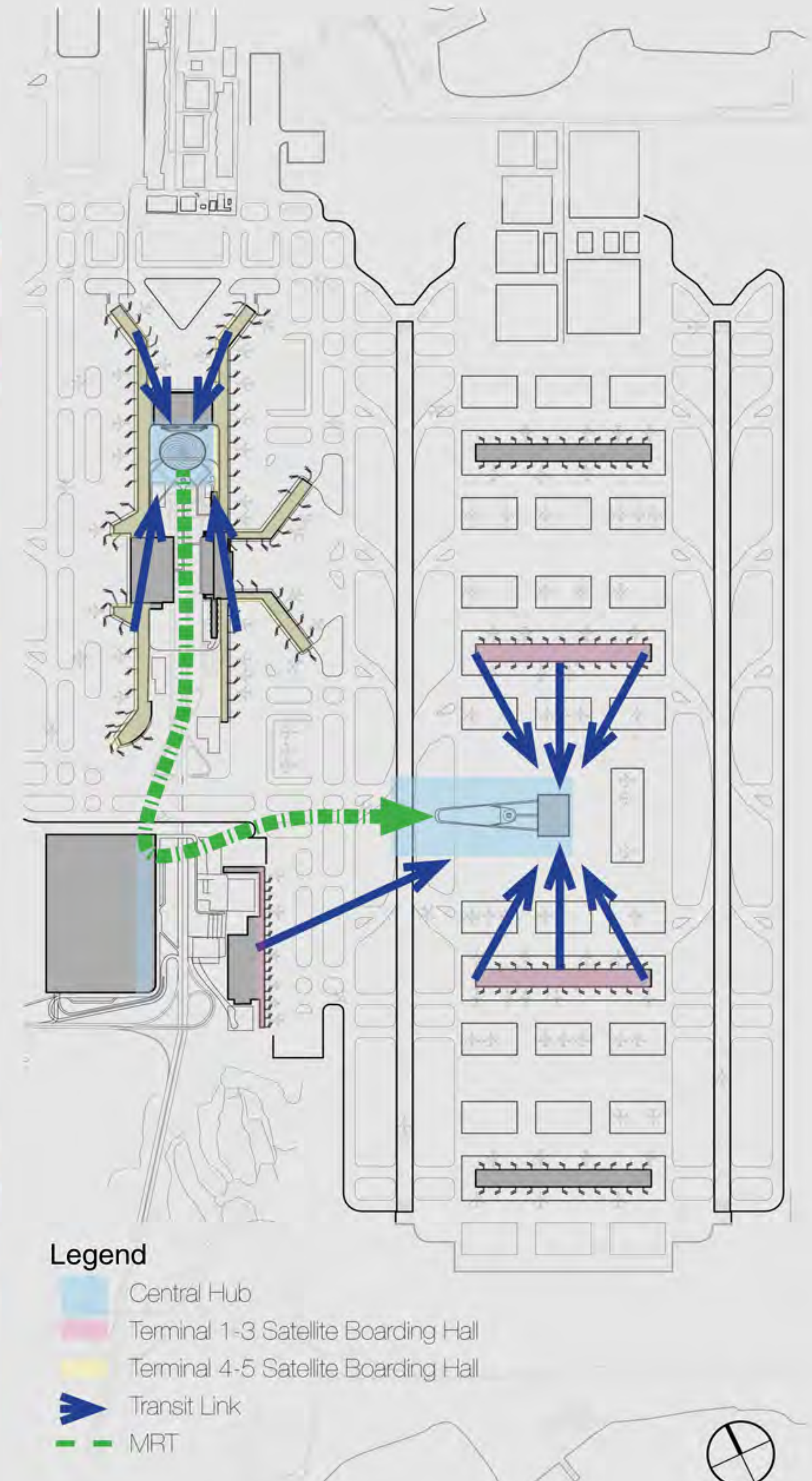


Figure 51. In-Transit Passenger Experience.
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https://travellerczech.files.wordpress.com/2016/08/img_5685.jpg
http://pic.pimg.tw/banbjkp-goplay/1411718380257206296_n.jpg
http://www.indiabitcoin.com/wp-content/uploads/2014/12/hello.jpg

6.6 Concept 3: Airport as a final destination preflight.

In a centralized airport organization, people accompanying passengers are prevented from having free access to the whole terminal building; this decreases commercial use in the part of the terminal.[264] Commercial revenue being the highest non-aeronautical revenue stream, it is in the best interest of the Changi to maximize its effort. Not only does a strategy such as this concept strengthen commercial revenue, it also enhances the experience of airport user.

Since the baggage claim, ticketing services, check in, bag drop kiosks and counters have moved outside the terminal, the space within the terminal should be utilizing the passenger who has a one-way ticket and is spending their last moments with their loved ones. By moving the restrictions towards the gate, as a decentralized plan does, Changi can become a destination. Groups may plan their last moments around an airport. Instead of it just being a farewell like it is today, whole days can be centered around meeting and enjoying each other's company within the architecture of an airport. To enhance the Changi experience, the airport should invite the whole group to partake in commercial experiences such as retail shopping, duty free, and enjoying the last moments with each other together. A much more desirable choice than having to say goodbye at the central security check.

[264] Design and Operation Page 318

Jewel Inter Terminal Connector

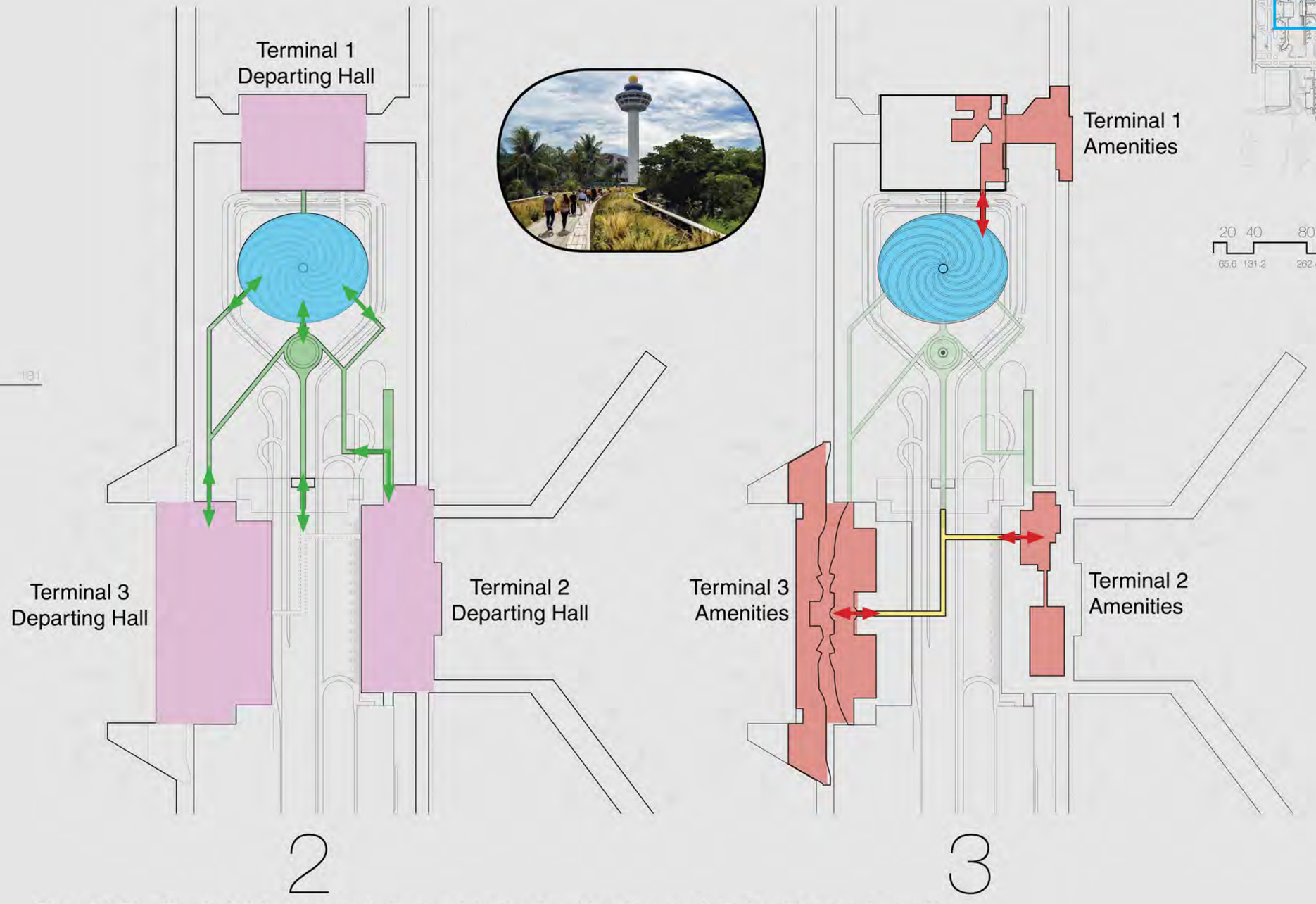

Figure 52. Plan: Terminal Mall – Inter-terminal connectivity plan. Level 2 to departure halls, Level 3 to transit amenities.

Current Amenity Overview & Jewel Connector

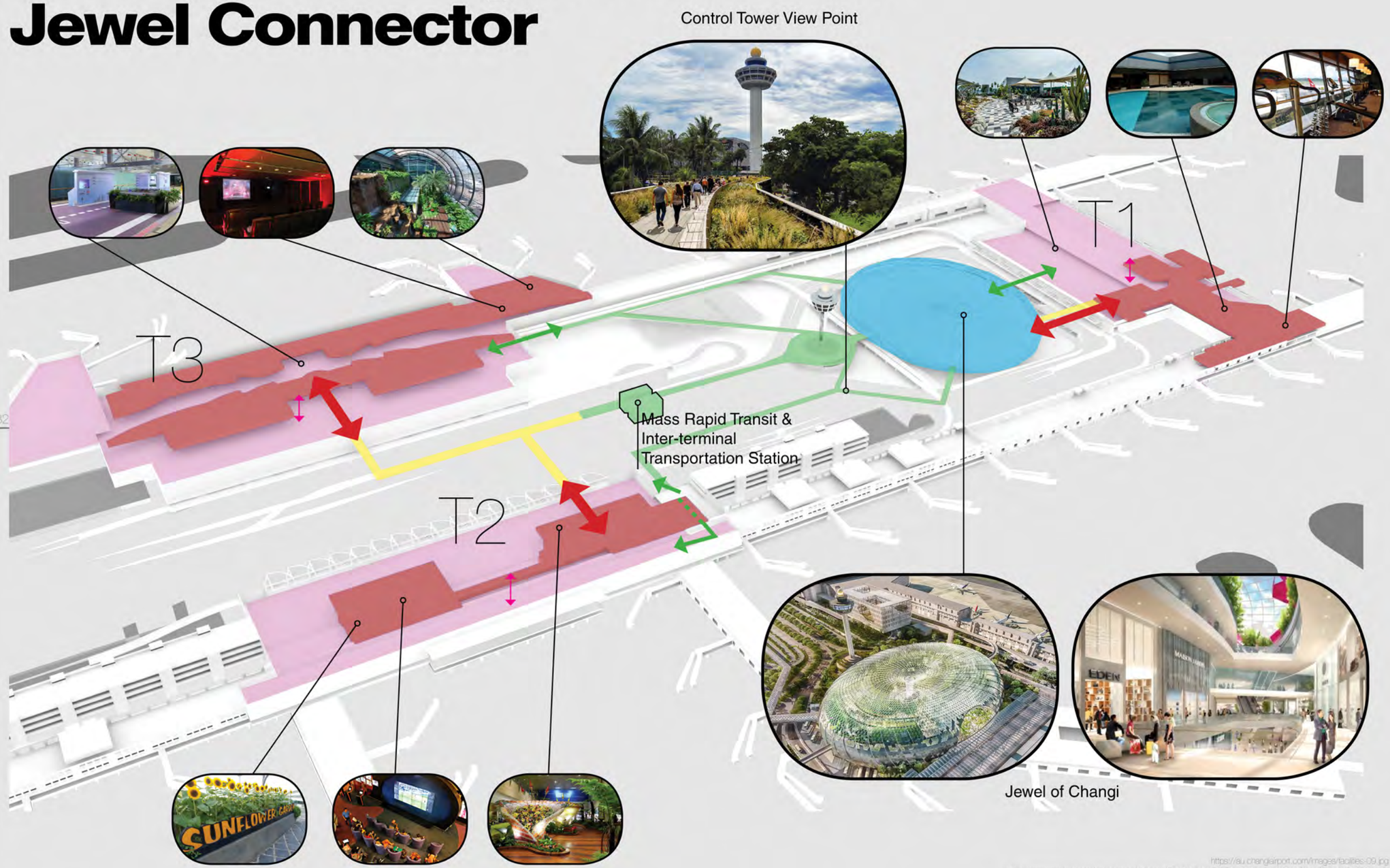

Figure 53. Terminal Mall Intervention. Inter-terminal connective route.

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http://www.wjinsight.com/wp-content/uploads/2015/12/1196921_757636464e694cf6aacf06c4fb232211d.jpg
http://www.flyscoot.com/images/2017-campaigns/AU/Jan-Mar/Movie-Theatre.jpg
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By designing the airport experience from the ground up, through the potential technology offers, the airport can become a destination for travelers and locals alike. Steps towards including non travelers can be seen with the proposal of the Jewel, but like all things within Changi currently, it is a singular event that is exclusive to all the terminals. By extending the idea with another transit hub and pushing the security boundaries of airside further back as security technology improves, the airport itself becomes a public space. With the appeal of duty free products, retail abundance, and unique amenities.

The benefit of this organization not only aids travelers and locals individually, but collectively as well. Often times when accompanying people to the airport, the most the group can do together is support the passenger while checking in their bags. The airport becomes a sort of scythe that divides passenger and loved one. But this organization allows not only the further accompaniment of passenger but an event to be created.

Cody Christensen for example is a recent high school graduate. Attending a university abroad for the first time, his family want to make sure he has everything accounted for prior to leaving Singapore. The airport then becomes the bridge between independence and dependence, but the transition doesn't have to be so swift as it is in all airports. The loved ones can accompany Cody to his gate and so they arrive much earlier to the airport than is accustomed to today. Enjoying the full last minutes together, without worry of logistics, the family and friends enjoy a Singaporean tradition of spending the whole day together at Changi airports eating, exploring, purchasing, and most importantly bonding. Changi becomes a locale for all users and diverse purposes; creating a unique and lively place.

Changi Airport Experience Proposal:

Sending a Loved One Off

Existing

Pre Airport Arrival
Missed economic opportunity

Love Ones Gather

When a passenger is leaving for good, love ones gather together to enjoy each others last moments together.

Quality Time

Group ends up eating a last meal together at a restaurant or ones home.
The departing passenger may need last minute things, so the group spend time helping gather supplies.

Changi Arrival

Family and friends meet the departing passenger at the airport.

Ticket Retrieval

While the departing passenger checks in, drops off bags, & print tickets; family and friends wait aside.

Farewell at Security Check

Immediately after tickets are obtained, farewells are shared, and the group splits.

In Terminals 1-3 this is a passport/fingerprint automated machine.
In Terminals 4-5 this is a centralized security point.

Departing Passenger walks Alone to Gate

Departing passenger then finds their way around the airport, towards his/her gate.

Depart

Departing passenger boards plane and travels to destination.

Proposal

Loved Ones Meet at Changi

When a passenger is leaving for good, loved ones gather together to enjoy each others last moments together.

Quality Time

Changi's Transit Hub and Jewel provide the group with an abundance of eateries, supply gatherings, & an array of amenities/event places to enjoy the last moments together.

Love Ones Accompany Departing Passenger

Family and friends guide the departing passenger to boarding hall.

Farewell at Boarding Hall

While the departing passenger checks in, drops off bags, family and friends wait aside.

Depart

Departing passenger boards plane and travels to destination.

Figure 54. Sending a Loved One Off Flow Chart Comparison.

Changi Airport Experience Proposal:

Sending a Loved One Off

Cody Christensen

Recently Graduated High School Student, Family and Friends Accompany Cody Around the Airport & Enjoy Quality Time with Each Other.

Nationality: Singaporean
Age: 18

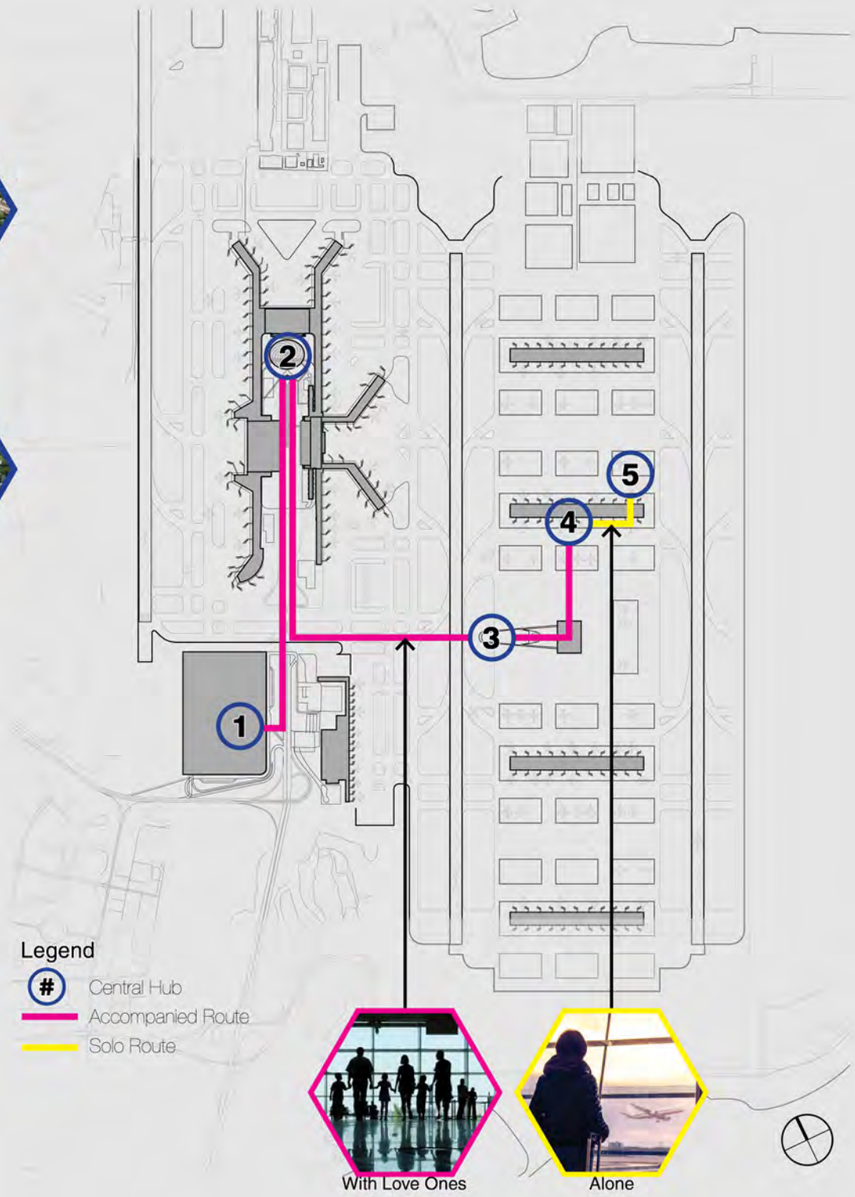

Figure 55. Conceptual: Sending a Loved One Off Experience through Changi.

http://architizer-prod.imgix.net/media/1458166920971150116_jewel1.jpg?q=60&auto=format,compress&cs=strip&w=1680
http://www.irishtimes.com/polopoly_fs/1.2221637.1483180845!/image/image.jpg_gen/derivatives/box_620_330/image.jpg
http://wp-saturn.s3-eu-west-1.amazonaws.com/wp-content/uploads/2015/09/image-7-40-metre-tall-Rain-Vortex.jpg
https://sgtuleskyfiles.wordpress.com/2014/05/singapore_changi_airport_control_tower_2_dec_05.jpg
http://www.firstfinancialsecurity.com/wp-content/uploads/2015/09/LatinoFamilyCelebrateGraduation.jpg

The main hall is designed with the automated processes of baggage drop, boarding passes, security, and check in, the energy that would have naturally gone into worrying about the details may then transfer onto fully enjoying the moments. Once technology removes the burdens and stress inducing necessities, the architecture may come in and provide the experience that leaves lasting impressions. Creating avenues to perceive space through our senses, and ultimately end up defining the atmosphere, experience and, environment as place.

By observing CAG's statements and looking at their current proposal, there is a clear disconnect between message and execution. This dissertation believes in CAG's dissertation, "An airport is no longer just an incidental aircraft interchange, but is expected to be a destination on its own… It is imperative that CAG does nonstop innovating and reinventing Changi Airport," [265] and "CAG prides itself in delivering an exceptional passenger experience that is cutting-edge and at the forefront of technology… creating an airport of the future.[266], but disagrees on the approach. Changi Airport is a unique case study in architecture as it presents a clear snapshot of each terminals origins, but also its constant desire to keep up with current technology by cladding innovations on top of innovation while the structure and concept of operations still be the same. The exact same thoughts and approaches appears to be repeating itself within terminal 5's proposal plan. In fact, the dissertation believes Terminal 5 is taking a step back from the unbuilt Terminal 4, where it's design evolution and purpose is made clear in its plans.

The foundation for Terminal 5 is once again, an overly cladded structure with no true intention of delivering a "cutting-edge… forefront of technology… airport of the future." This dissertation project provides the first step in honoring Changi Terminal 5's ambition while providing a lasting impression on those

[265]http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

[266]http://www.changiairport.com/content/dam/cacorp/publications/Annual%20Reports/2013/Changi_Airport_Group_Annual_Report_20122013_Full_version.pdf

privileged enough to walk through the terminal halls by rethinking the way an airport should be operated in 2016.

Through technological advancements and future anticipation, many of the current forms of operation can be reimagined to a more idealized form. Once seemingly impossible, can currently be realized and even more available the farther technological innovations evolve. From logistics, services, economics, to passenger experiences, all aspects of the airport can be greatly improved. However, this is not limited to airports but all of architectural design. The constrained thought of architectural program is holding back the potential for improvements in place design and architectural growth. It is important for architects to rethink the ways all programs can be realized through modern and near-future technology as the potential for place becomes exponentially possible. Changi Airports show the current design thought of looking only to improve. With technology as a key driving force to the improvements but restricting it's design with old programs and processes. Innovation often requires a reset of the foundational elements; thus the architect must be the first to undergo this realization in order for technological advancements to conform to the potential desires. Architecture in all areas can be vastly improved if we allow technology to improve our idealized version of architecture, rather than forcing it to adhere to dated processes.

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