AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ARCHITECTURE DEPARTMENT

THE DEVELOPMENT OF TRAIN STATIONS' DESIGN

A thesis submitted in a partial fulfilment of the requirement of the MSc. in architectural engineering

By

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B.Sc. in Architecture, June 2010

Supervised by

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STATEMENT

This thesis is submitted as partial fulfilment of MSc. Degree in architectural engineering, Faculty of Engineering, Ain Shams University.

The author carried out by the work included in this thesis, and no part of it has been submitted for a degree or qualification at any other scientific entity.

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ABSTRACT

The research reviews the development of train station design theory; since the building type's inception in the late 19th Century to this current age.

The researcher depended on the determined research problem: which is the interference and overlapping of different design elements for the process of designing a train station from **different engineering departments**; making it hard to determine the project's components separately, leading to the difficult task of selecting the **priorities** in a required design programme that serves the designated station, and according to its specifications.

The researcher assumed that there are **four design parameters** that govern the interrelationship between all various engineering works: *technical, urban, spatial, and style*. The researcher conducted a typical analysis of the [*train station*] building type's design elements, which are function, and form. As the design elements of the station are basically the station components, they were studied in their relationship to the aforementioned station parameters. The researcher found that each parameter -regarding its effect- is variable according to the design conditions that govern the function and the form for each station, and that each parameter faced elevations and depressions during the past decades; affected by economic, social, and political changes.

After dividing the timeline of train station history -since the inception of the definition of "train stations"- into 3 eras, there was the determining of the pattern changes in each parameter in each era, and as a result: the activity of each parameter in function and form, the research was able to conduct a comparative analysis between assorted examples of train stations that vary in age, size, and local cultural environment; leading to the forming of diagrams that explain the changes and interrelationships between all parameters, and formulating a design programme that considers the constraints and condition of each station, and should fit each case of train stations; whether the process of redevelopment or the new construction, that fits the changes in the conditions of city economy, society, and culture, and the necessities for achieving their goals.

Keywords: Train, Railway, Station, Intermodality, Renaissance.

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I would like to express my deepest appreciations for all the help, encouragement, and support I received: my mother and father at the peak, my brothers and family, and my friends.

DEDICATION

To my parents, family, and friends…

May you be proud of this work; for with your support, you are contributors to this work.

To who may be interested in the fields of knowledge and practice…

May this work shall guide you in your path in life, and to your desired destination.

To my mentor…

Prof. Dr. Amr Farouk Elgohary.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

PRELUDE

In the midst of the prosperity of the Industrial Revolution in the 19th century, one of its results was the technological development in machinery and manufacturing; which was a result of the development of the means of transportation using the engines, from which the idea of transporting goods and also in humans evolved after using rail mobile carts which ran on mechanical force. From there, a new concept was presented to connect communities with each other, and the emergence of an economic and social boom as a result of the expansion of markets and new urban areas where distances between them have become shorter, and the possibility of community expansion became more hopeful, in the same country or outside its borders, and depending on the community activity in the surrounding environment.

Train stations were represented as gates; a symbol of the crossing to the other centres of cultures, and multi-cultural and economic opportunities, so that the station has become the optimized expressive image for the entrance to the city, and to visualise the form of urbanization and economic activity and social community within the urban or rural areas.

The basis of linking urban communities together lies in the means of transportation. With the expansion of urban masses, the need for rapid transport lines was found, and that the oldest and most abundant solutions in modern times is the train.

Architects have a big role to play in this change. The station is the flat-bearer of the railway, and if it can be designed in a responsible and yet exciting way it will have a big effect on the public's perception of rail transport.[1]

[1] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.203.

• Introduction

Treatment of visual composition, style, and functions of train stations have evolved during successive decades; from the domination of the classic cultural character of the state in the form and proportions, passing through a period of post-World War II; where directing towards function became more important than the form and the historical value of the stations buildings, which led -with its excess- to the loss of many of the old stations buildings.

The ideas and designing process of train stations had evolved to follow the several philosophies of design-led elements, such as: highlighting the cultural development of the surrounding community, space division for several activities and uses, axes planning for human gathering and the quality of the prevailing economic activity in it and divide the assembly elements and its distribution, and also keep up with the rapid evolution in rail transport technology which requires the development of infrastructure, and community activities of the surrounding population and what relates to it.

A new design axis was created: respecting the human dimension; in materials, and the distribution and development of spaces of which has integrated transport with shopping and tourism, energy conservation, visual and thermal comfort internally, integration of modern technology in passenger service and queries, and security; until train stations became similar to airports in demonstration of technological development, economic renaissance and planning for the future; expressing the basis of the development of civilizations is the evolution of communication and transportation.

Satisfiers & dissatisfiers of train stations

Since railway users are considered customers of a service, every railway company or operative aim to satisfy them; using an improvement strategy to reach maximum operational excellence and using regular customer satisfaction surveys. The operational quality and the response of users towards the train experience (and its facilities) are measured regarding “**dissatisfiers**” and “**satisfiers**”. As a service and not just a product, a train journey is made and consumed at the same time[2]:

1. *Dissatisfiers:*

The collective elements of design paradigm for basic needs for users; such as safety, reliability, speed, and ease. If the service is not available when and where customers expect it, it will result in their being dissatisfied, i.e. those quality needs have a negative value if they do not meet expectation. The dissatisfier needs are applied as basics in each journey.

2. *Satisfiers:*

The collective elements of design paradigm for the customers' emotional element; such as comfort and pleasant experience. Satisfiers are noticed when the journey has a positive evaluation, despite the fact that the explaining a satisfaction can vary with each passenger; according to their classes, interests, and wealth.

The explanation of both dissatisfiers and satisfiers came from the analysis of the users' needs in the form of a pyramid of needs; which is a derivative of Maslow's pyramid of needs that was established in 1954[3].

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[2] Hagen, M. v., & Bron, P. (2014, August), *Enhancing the Experience of the Train Journey: Changing the Focus from Satisfaction to Emotional Experience of Customers*. Transportation Research Procedia, volume 1, issue 1, p. 254-256.

[3] Maslow, A. H. (1954), *Motivation and Personality*, New York: Harper & Brothers, ISBN: 978-0060419875

Pyramid of Customer Needs

Following the same methodology in establishing a hierarchy for a person's needs, the new pyramid of customer needs reflects the perception of the quality the operator offers, with several qualitative and quantitative studies are conducted by transport scientists to establish the pyramid with its interest layers: speed, ease, comfort, and experience[4] (**Figure 0-1**).

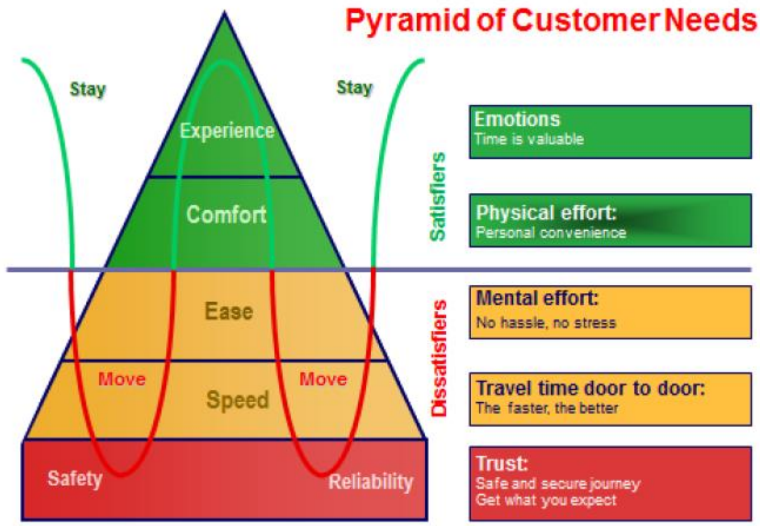

Figure 0-1: *Factors that determine customer satisfaction and dissatisfaction.*

Source: Wilson, T., & Yariv, B. (2015).

[4] Hagen, M. v., & Bron, P. (2014, August), *Enhancing the Experience of the Train Journey: Changing the Focus from Satisfaction to Emotional Experience of Customers*. Transportation Research Procedia, volume 1, issue 1, p. 254-256.

Table 0-1: Comparison between dissatisfiers and satisfiers for railway users.

Source: Hagen, M. v., & Bron, P. (2014, August). Format: Author of the thesis.

	Dissatisfiers	Satisfiers
Definition	Basic needs for users.	Customers' emotional elements.
Vitality	When passengers move in and out of the train, or through the station. Passenger expects the carrier to be aware of his/her most important needs, such as safety, reliability, speed (travel time), ease, comfort and experience.	When passengers are in a moving train or have to wait at a station. Experiences the service within the physical facilities of the place.
Levels	**Level 1:** -Safety: *(physical, social).* -Reliability: *(presence, accuracy).* **Level 2:** Speed: *(travel time).* **Level 3:** Ease: *(convenience).*	**Level 4:** Comfort. **Level 5:** Experience: (pleasant; physical, sensory).

Focusing on priorities

A main problem that the designers and operatives can face is focusing their planning on raising the dissatisfiers to good levels, based on calculations and statistics; as the absence of customer satisfaction can occur, which can be considered the actual needs and emotions of users. Therefore, railway companies are unable to offer a service that provides a positive impact on customers' emotions. So, a paradigm shift is required by changing the focus on dissatisfiers to one on satisfiers (emotional experience); in order to achieve a breakthrough. As we live in an economic era, emotional experience and its characteristics mean that everything revolves around the emotional gratification of the consumer, which adds an emotional value to the service.

However, before managing the customer's emotions, a railway company must be aware of what drives the customer as the only way to increase satisfaction (**Figure 0-2**).[5] Therefore, station designers must become more open to involve the community in defining what their station is, what it will contain and how it contributes to the surrounding area.[6]

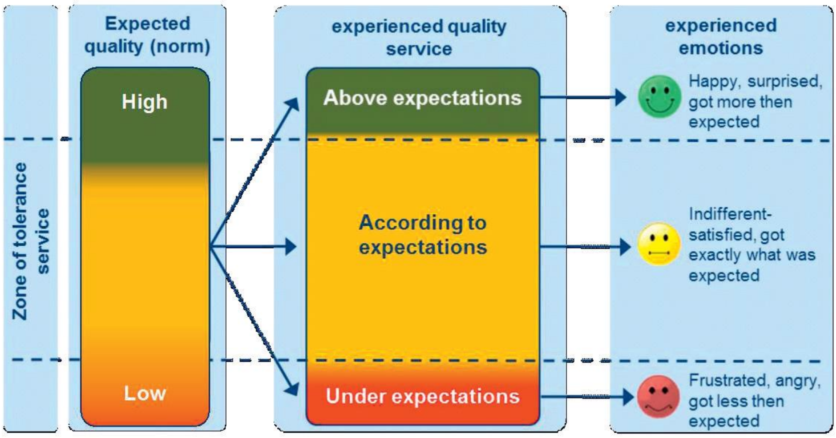

Figure 0-2: *Expected quality, experienced service quality and emotions.*

Source: Hagen, M. v., & Bron, P. (2014, August).

- ## Research Problem

During the 20th century, train stations went through many changing factors. Those factors influenced the functions of the station, its resources, its layout and capacity; therefore, influencing the train stations' overall elements, form, and definition. That was until the mid-1960's that railways witnessed a shift in architectural

[5] Hagen, M. v., & Bron, P. (2014, August), *Enhancing the Experience of the Train Journey: Changing the Focus from Satisfaction to Emotional Experience of Customers*. Transportation Research Procedia, volume 1, issue 1, p. 254-256.

[6] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Stations in the City – How are Transport Hubs Evolving to Meet Local Needs?* Retrieved July 2018, from ARUP: https://www.arup.com/perspectives/cities-and-stations

expression started with standardization, and passing through revitalizing of railway systems and buildings.

The problem of **finding** & **defining clear design criteria** to be used for **a functional train station design**; either within the city context, or outside it.

• Hypothesis

The research assumes that train station designers, owners, and operators found theories that defined the train stations as an urban centre that served many purposes: cultural, social, and commercial; aside from the main purpose of transportation; and also expanding the role of transportation to become the travelling hubs of farther distances; even beyond railway line extensions. The design theories, in turn, became parameters that can be analysed and compared. The research hypothesis assumes:

a. The earlier design of train stations -despite the different styles and sizes- adapted simple methodology in designing them. The research assumes that there are 4 main guiding design parameters that affected the design process of train stations: **technical, urban, spatial, and style.**

b. Those 4 design parameters are shaped by the basic architectural design elements: of **function & form**; which express the essential spaces and volumes of any basic train station.

• Objectives

Setting **design criteria as basis** for designing a train station.

• Research Methodology

1. Information gathering (historical & theoretical review):

The information gathering process begins by reading the historical beginnings of the railway concept, the establishment of its stations, and the turning points of designing.

2. **Analysis of historical stations for setting design elements:**

   The analysis of the philosophy within the establishment of train stations from the beginning of railway technology in the 19^{th} Century to the early 1940's.

3. **Proposed analytical design criteria hypothesis:**

   Criteria that should be the categories of station design parameters, and should be used for measuring the strength of influence of each parameter, intersections of parameters, and the development (and/or recession) of each category during each era of study.

4. **Contemporary case studies analysis:**

   Selecting existing train stations that vary in age, nationality, urban conditions, type, and impact on transportation.

5. **Comparative analysis:**

   Using the selected case studies analysis for comparing the evolution of the categories of train stations, and design theory of the stations.

6. **Findings & conclusions:**

   Using the results of the comparative case study analysis to achieve the objectives of the research, and using its results for determining conclusions that should lead to recommendations for intended groups and further research.

- ## Research Structure

Part 1

Chapter 1: A Historical Introduction to Railways:

Definitions, etymology, historical background of the inception of railway technology, and its transfer to several empires in the 19^{th}

Century, resulting in the emergence of the building concept of a train station.

Part 2

Chapter 2: Development of Station Parameters Pre-WWII:

A theoretical showcasing of the development of the idea of a train station building since its beginnings till just before the Second Great War; by conducting an analytical demonstration for the spatial parameters of the structure, which gradually accumulated and integrated with each other through time, and through the development of mechanical and human needs. Analysis of exemplary projects according to the preliminary hypothesis of using 4 design parameters: spatial, technical, style, and urban.

Chapter 3: Standardisation & Renovation:

Following the same methodology of the previous chapter for Post-WWII. Using analytical demonstration of the conditions of train stations and its facilities, their dilapidation, then the technical leap of trains. Analysis of the effect of the mechanical factor on other design parameters; particularly the urban and spatial parameters.

Part 3

Chapter 4: Updating Station Principles for a New Age:

Showcasing issuing governing rules for companies, operators, and designers in management and designing / development of station buildings.

Chapter 5: Intermodality & Complexity:

Analysis of “complexity of using” problem, through reviewing the results of development of needs, accumulation of facilities, development of transport modes and technologies, and the development of functions of train stations through the last decades. The analysis leads to the upgrading of the guiding designs parameters from the development of function & form elements.

Part 4

Chapter 6: Case Studies:

Analytical review of existing examples of train stations. The analysis depends on newly-built stations, newly-built stations linked to another main transport mode, and a developed old station.

Part 5

Chapter 7: Results, Conclusions, and Recommendations:

The comparative analysis from the previous analysis operations, its application with the research hypothesis, its conclusions, and recommendations given for future researchers, designers, business operators, and decision makers.

CHAPTER 1: A HISTORICAL INTRODUCTION TO RAILWAYS

1 Topics of Chapter 1

1.1 Introduction

In order to understand the concept, definition, and elements of a train station building, the chapter first offers an introduction to the beginnings of railway transportation in the modern sense; the introduction of locomotives, beginning of passenger transportation. The chapter also reviews the reasons for developing railways and the personal views of their respective countries on the matter of railway expansion; which led to specific view in handling the design and philosophy of creating train stations in both the functional & aesthetic points of view.

1.2 Background

1.2.1 Etymology

A railway station can be defined as: "*a place where trains load or unload passengers and goods. It usually consists of the combination of a platform and a station building or shelter, or only one of either. Usually every station has a platform to allow the passengers to get on and off the train but smaller station may not have a station building or shelter*".[7]

The first names given to stations did not clearly indicate their function. In some countries (such as France or Spain), stations were initially called "pier" where people aboard ships. With airplanes, similarly, the word "airport" derived its name from ships as "the port for air traffic". Intermediate stations were simply known as "halts"[8].

[7] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design*. Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.58

[8] Ignacio Barrón. (n.d.). *History of Stations*. Retrieved May 2016, from International Union of Railways (UIC): http://www.uic.org/com/?page=eslider_iframe&id_article=4015

1.2.2 Definitions for some of the geometric designs of railway track

Geometric design should be such as to provide maximum efficiency in the traffic operation with maximum safety at reasonable costs.[9]

1.2.2.1 Shunting

Operation related to moving a rail vehicle or set of rail vehicles within a railway installation (station, depot, workshop, etc.). It mainly concerns the assembly and disassembly of unit trains.[10]

1.2.2.2 Gradient / Grade

Definition:

Any departure of track from the level. It is used to:

- Provide uniform rate of rise or fall.
- Reduce cost of earth work.
- Reach different stations at different level.[11]

[9] Singh, S. (n.d.). Railway Engineering: Elements of Geometric Design. Retrieved January 2018, from https://blogs.siliconindia.com/civilengineering/Railway_Engineering_Elements_of_Geometric_Design-bid-Q3qK82yo88997190.html

[10] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

[11] Singh, S. (n.d.). *op. cit.*

Table 1-1: *Gradient types.*

Source: Singh, S. (n.d.). Railway Engineering: Elements of Geometric Design. Retrieved January 2018. Format: Author of the thesis.

Ruling gradient	Momentum Gradient	Pusher / helper gradient	Gradient at stations
• The steepest gradient allowed on the track section. • Determines the max load that the locomotive can haul that section. • Needs more powerful locomotives, smaller train loads, lower speed, resulting in costly hauling.	• Steeper than the ruling gradient. • Requires sufficient momentum to meet the gradients.	• Limits the maximum weight of a train which can be hauled over the section by a locomotive. • Much more severe than ruling gradient. • Needs the help of extra engine to pull the same load than this gradient.	• Low gradient. • Prevents movement of standing vehicle. • Prevents additional resistance due to grade.

1.2.2.3 Rail gauges

Definition:

The clear minimum perpendicular distance between the inner faces of the two rails (**Figure 1-1**) and (**Figure 1-2**).[12]

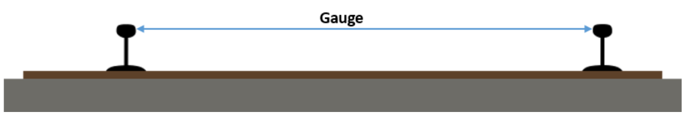

Figure 1-1: *Railway track gauge.*

Source: Rail Gauges. (2015). Retrieved January 2018, from Railsystem.net: http://www.railsystem.net/rail-gauges/

12 *Rail Gauges*. (2015). Retrieved January 2018, from Railsystem.net: http://www.railsystem.net/rail-gauges/

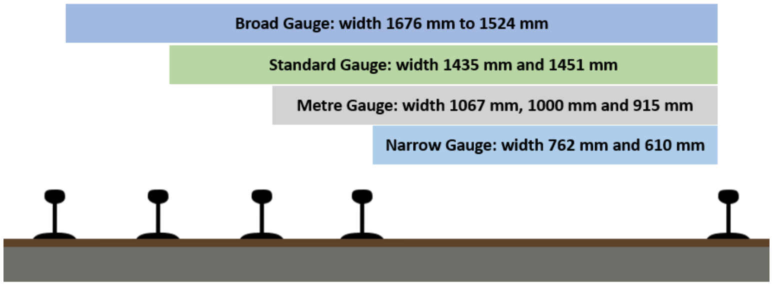

Figure 1-2: *Types of rail gauge.*

Source: Rail Gauges. (2015). Retrieved January 2018, from Railsystem.net: http://www.railsystem.net/rail-gauges/

Factors affecting the choice of a gauge:

Table 1-2: *Narrow gauge vs. broader gauge railways.*

Source: Rail Gauges. (2015). Format: Author of the thesis.

Narrow gauge railways	Broader gauge railways
• Using smaller cars and locomotives (smaller loading gauge), and smaller bridges & tunnels (smaller structure gauge) and tighter curves (mountainous areas). • Usually lighter in construction. • Less cost. • Often used in mountainous terrain • For low-population areas, with low potential, and temporary uses; such as for construction, the logging industry, the mining industry*, or large-scale construction projects, especially in confined spaces.	• Generally more expensive to build. • Capable of handling heavier traffic • Capable of handling faster traffic.

**Other commodities are more common in other countries; such as Egypt with sugar cane industry & transporting.*

The five-foot gauge (*1524 mm gauge*) became the British standard gauge and widely accepted and there were 1524 mm gauge railways in America. Russia, unlike using their standard six-foot gauge (*1829 mm gauge*) (Tsarskoe Selo railway for example), turned to using the shorter 1524 mm gauge for St Petersburg to Moscow; to save money, and it was also theorized that it makes it difficult for invading armies to use the Russian railway network; especially during WWII.[13]

1.3 Historical Review

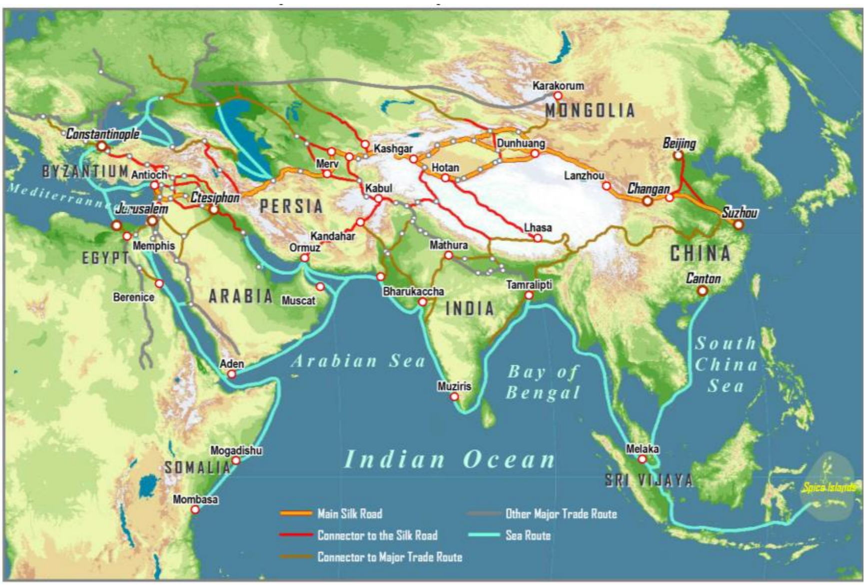

Figure 1-3: *Map of Silk Road and Arab Sea routes (8th - 14th Centuries).*

Source: Rodrigue, J.-P. et al. (2017)

Before the start of the Industrial Revolution in 18th century, transport technology had its limitations: land transport from animals, and maritime transport used wind power; with the latter was the most efficient transport systems available, and cities that were next to rivers (i.e. started as agricultural societies) were able to hold political, cultural, and economic strengths as they were able to trade over longer distances. Examples can be found in Tigris-Euphrates, Nile, Indus, Ganges, and Huang He. International trade did exist, but mainly for trading in high-value (luxury) goods such

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[13] Shirres, David. History of Russian Railways: Part 1 - The Tsars. (2015, September). Retrieved January 2018, from Railstaff: https://www.railstaff.uk/2015/09/25/history-of-russian-railways-part-1-the-tsars/

as spices, silk, wine and perfume, notably along the **Silk Road**: which was the most enduring trade route in human history, being used for about 1,500 years (**Figure 1-3**). Around the Mediterranean, A form of **intermodalism** was present as an effective standard transport product of goods.[14]

1.3.1 Beginnings of railway technology

The 19th century witnessed the blooming of the industrial revolution that transferred the society to a modern age that affected all aspects of life. Changes reached the human lives in the social and urban life; such as currency, architecture, urban planning, and transportation. Railway systems succeeded in linking remote parts of Europe together, and opened the fields for new opportunities.[15]

The railway station as a type has had very little, if any, other functional precedents to rely upon previous to its introduction in the early 19th century. The Industrial Revolution sparked the development of a new system of transportation for the masses. The station became an essential part of this new transportation system, and had to reflect the impact of technology on the new found mobility of the masses.[16] After the invention of passenger transportation on rails mine cars moved by stationary steam engines were already used in mining earlier.[17]

[14] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

[15] Idriss, N. (2010). Architecture as an Expression of Identity:: Abbas Hilmi II and the Neo-Mamluk Style. *Fifth International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics*, San Diego, p.1

[16] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway*. Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 9

[17] *Features: Stockton and Darlington Railway*. (2014, September 24). Retrieved May 2016, from BBC: http://www.bbc.co.uk/tees/features/railway/railway.shtml

Figure 1-4: *Robert Stephenson (1803-59)*
Source: www.wikipedia.org

The limitation of the track network was the problem that faced the development of train technology and stations; leading to their decline in certain parts of the world including the USA, Canada and Australia, where automotive transport is priority. With the more environmental-aware age, the role of the railway is again brought to the front; particularly Europe in developing new rail-focused transport hubs. After **Robert Stephenson** (**Figure 1-4**) had invented the locomotive called "The Rocket" in 1825, and the opening of the **Stockton and Darlington Railway** in the 1820's, trains began to haul freight between stations at opposing ends of the Liverpool and Manchester Railway. Liverpool Road station in Manchester, a goods-handling depot styled as a row of Georgian houses, is today part of the Museum of Science and Industry (**Figure 1-5**).[18] There had been other railways before the tracks were laid down between Stockton and Darlington in the 1820s. Mostly these so called **waggonways** were used to take coal by horse drawn carriages from the pits to the rivers, but it was realised that they could haul people across country as well.[19]

[18] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.202

[19] *Features: Stockton and Darlington Railway*. (2014, September 24). *Op. cit.*

Figure 1-5: *The former Manchester Liverpool Road railway station.*

Source: https://en.wikipedia.org

By definition, the station is the first space where passengers interact before travelling most passengers have with the railway. The design should be, aside from the efficiency of operation, pleasing to the eye, comfortable and convenient; adding to that the proper management and maintenance.[20] However, back when the railways were young, there was a vague idea about the form and design of a station should be. The function was simple: **to accommodate staff and passengers**. For that, some cases used old buildings to serve as a station.[21]

[20] Railway Station Design. (2016, January). Retrieved May 2016, from Railway Technical Web Pages: Railway Systems, Technologies and Opeations Across the World: http://www.railway-technical.com/stations.shtml#Side-Platform

[21] Ignacio Barrón. (n.d.). *History of Stations*. Retrieved May 2016, from International Union of Railways (UIC): http://www.uic.org/com/?page=eslider_iframe&id_article=4015

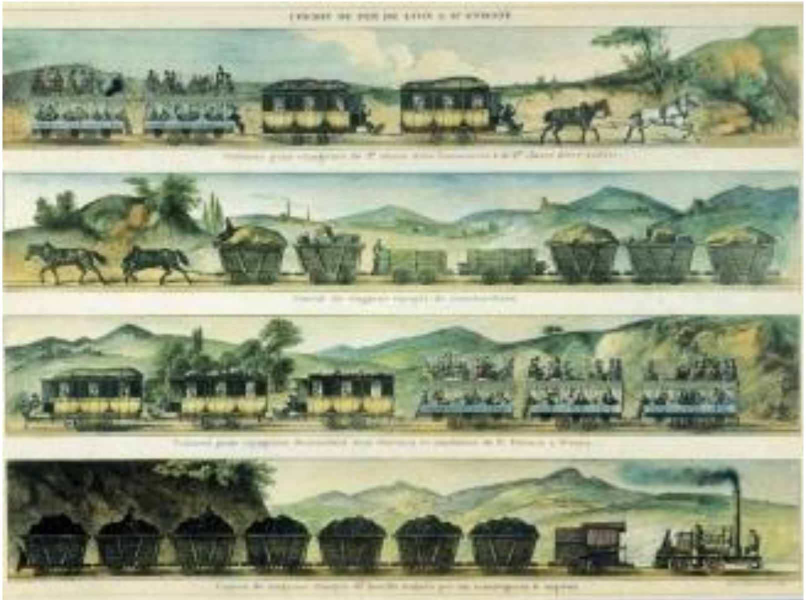

Figure 1-6: *Development of the force of railway transport.*

Source: The Story of French Rail. (n.d.).

1.3.2 Empires, and their reasons for railways

"Once there was an Empire that governed roughly a quarter of the world's population, covered about the same proportion of the earth's land surface and dominated nearly all its oceans. The British Empire was the biggest Empire ever, bar none".[22]

As the technological advancements in communications and transportation evolved, they made the world more connected; or "smaller". Global empires tried to seize the chance to expand.

1.3.2.1 The British Empire

With supporting the free market, constructed the first railway network after 1826 mostly by private sector companies. In 1853, the first line was opened in India, linking Bombay to Thane 34 km far; within less than fifty years, track covering more than 38,000 km had

[22] Ferguson, N., "*Empire: The Rise and Demise of the British World Order and Its Lessons for Global Power*", Basic Books, New York, 2004, p.7.

been laid, and changed India’s economic and social life; the Indian railways created a huge market for British locomotive manufacturers, since most of the tens of thousands of engines put into service in India were made in Britain. Yet this network was from its very inception strategic as well as economic in purpose. Next, the British plans for the African Continent stated the construction of lines from Cape Town to Cairo as the “*ultimate imperial railway*”.[23] Not only the industry of locomotives & railway technology were present for British colonies, they reached and influenced other countries outside the territories of the British Crown; like the United States, and Russia.

1.3.2.2 The American Colonialism

The British were at the forefront of railway technology and architecture in the 19th century[24]. America was quick to follow the British example; with its engineers had visited the UK and in 1830 work began on the colossal undertaking to connect **Baltimore with Ohio** by rail. The line revitalized Baltimore as a port and provided a new outlet for the coal and iron industries, greatly accelerating Maryland’s economic growth.[25]

Before the Civil War (1861-1865), the American rail network took 30 years to reach 46,500 km. Away from the connection through Washington, however, the two halves of the yet-to-be-United States: **Northern Union States (more urbanised)**, and the **Southern Confederate States (mostly rural)** were two different sociopolitical system; requiring two different railway systems and servicing:

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[23] Ferguson, N., "*Empire: The Rise and Demise of the British World Order and Its Lessons for Global Power*", Basic Books, New York, 2004, p.170.

[24] RIBA. (n.d.). *The Architeture of Railway Stations*. Retrieved October 2016, from The RIBA Library: architecture.com: https://www.architecture.com/Explore/Stories/TheArchitectureOfRailwayStations.aspx

[25] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.202

- The railways servicing the same city were often not connected, meaning that the schedules were not organized; needing to transport cargo from one terminal to the other and for passengers to spend a night to catch the train the next day.

- Then there was the issue of different natures of the two factions. For the South, it was mainly serviced by penetration lines seeking to connect the agricultural areas to ports for exportations (e.g. New Orleans & Charleston). As such, the network was not very cohesive. The North developed a network by interconnecting its main urban centres with agricultural regions in the Midwest using a complex lattice. At the end of the Civil War the expansion of the network continued as well as its level of integration to complete the transcontinental line.[26] In the following century, further advances were made on the other side of the Atlantic. Across Europe, journals in the early years of the 20th century began showing growing admiration for the emerging architecture of the United States, including their railway stations. New York had just seen new stations built whose size and good design overshadowed those built on the other side of the Atlantic.[27]

1.3.2.3 The Japanese modernisation vs. isolationism

In 1635, Japanese isolationism stopped all travels abroad & set limitations to its contacts with the West to the Netherlands. In 1854, the isolationism was over with introducing American trading ships; beginning the West's advance into Asia that would affect Japan

[26] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018. https://people.hofstra.edu/geotrans/eng/ch2en/conc2en/american_rail_network_1861.html

[27] RIBA. (n.d.). *The Architeture of Railway Stations*. Retrieved October 2016, from The RIBA Library: architecture.com: https://www.architecture.com/Explore/Stories/TheArchitectureOfRailwayStations.aspx

deeply. In 1868, changing the politics with the Meiji government started to focus on fast modernization; as in the West.[28]

The goal was to start a modern nation by industrial development to increase wealth and army power; railways were important for industrial transport. In 1872, Japan opened its first railway between **Shimbashi and Yokohama** of 29 km distance, and was built by British engineers. This was just 47 years after Britain introduced the first steam engine; which put Japan on the path of competing with the West, that even the architecture used Western styles.[29]

1.3.2.4 The Russian Empire

Despite the presence of several water routes in Russia, it took several months for lower Volga grain to reach the city as frozen rivers halted boats in winter. Tsar Nicholas I approved in 1836 a demonstration line between the capital and his summer palace at Tsarskoe Selo, by Austrian engineer, Franz von Gerstner. Opened in 1837, the 23 km-long and 6-foot gauge line was suitable for Russian weather and geographical conditions, and carried 726,000 passengers in its 1st year.

- Warsaw to the Austrian-Hungarian frontier (opened 1848): The 2nd railway, was for military reasons; a standard gauge line from to end a Hungarian uprising.[30]

- St. Petersburg to Warsaw (opened 1863). Against the Polish rebellion.

- St. Petersburg to Moscow (opened 1851): Russia's first commercially useful railway. At 644 km, it was also to be the

[28] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 26

[29] *Ibid*., p. 26

[30] Shirres, David. History of Russian Railways: Part 1 - The Tsars. (2015, September). Retrieved January 2018, from Railstaff: https://www.railstaff.uk/2015/09/25/history-of-russian-railways-part-1-the-tsars/

world's then longest double-track railway, included extensive earthworks and 190 bridges.

- The Trans-Siberian: Alexander III saw the railway as part of a bigger scheme involving mass immigration from the overpopulated European Russia where there were frequent famines, economic development and co-ordinated railway construction with other projects such as building a line from the Urals for metal products and re-equipping waterways crossing the route to deliver materials.

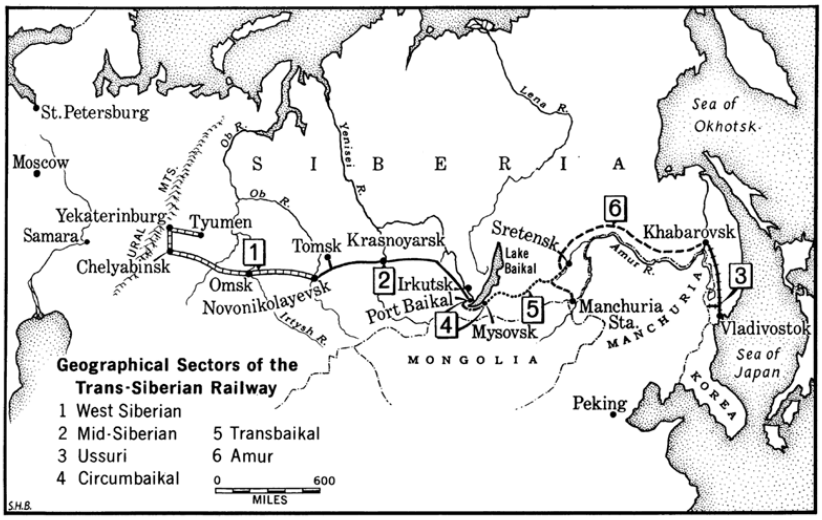

Figure 1-7: The old Trans-Siberian Railway.

Source: Liliopoulou, A., Roe, M., & Pasukeviciute, I. (2005).

By the start of WWI, Russia became an important industrial power; with a network of 70,500 km in 1913, Russia had almost twice as many railways as Britain. However, this caused the immigration of hundreds of thousands of peasants to the cities; living in hard conditions and were clustered together. This, and the repressive Tsarist regime, triggered the abortive 1905 revolution. When combined with the horror of WWI, it was to lead to further revolution and civil war. The railways would play a significant role in this next part of Russia's history.[31]

1.3.2.5 The French Empire

On the other hand, the **French Empire** expanded in North Africa, reducing the territories of the **Ottoman Empire** faster than the British. However, the French changed their direction of expansion: in 1830, starting with Algeria; and controlling most of it within 7 years. Simultaneously, the French leaned towards supporting **Mohammad Ali Pasha**, the modernizing Egyptian leader who opposed the Ottoman Sultan's authority. So, French investors led the economic development of Turkey and Egypt. Examples of the matter were in such transportation projects like the Suez Canal was a Frenchman, by Ferdinand de Lesseps, and planning of the capital city of Neo-Cairo.[32]

In the 15 years from 1827 to 1842, only 569 km of line were built in France, but it was clear that rail could play a vital role in economic growth—advancing the industrial revolution, facilitating trade and making people more mobile.[33] The French utilized the English mechanical technologies in providing trains; first in 1846, when a 120-km line linked Avignon to Marseille, and another time in 1852, Compagnie du Chemin de Fer de Paris à Strasbourg bought steam locomotives built under license in Paris.[34]

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[31] Shirres, David. History of Russian Railways: Part 1 - The Tsars. (2015, September). Retrieved January 2018, from Railstaff: https://www.railstaff.uk/2015/09/25/history-of-russian-railways-part-1-the-tsars/

[32] Ferguson, N., "Empire: The Rise and Demise of the British World Order and Its Lessons for Global Power", Basic Books, New York, 2004, p.172.

[33] National Society of French Railways (SNCF), The Story of French Rail. (n.d.)., from: http://www.sncf.com/en/meet-sncf/sncf-history, Retrieved July 27, 2016

[34] *Ibid.*

1.3.2.6 The Beginning of Egyptian Railways

Figure 1-8: *Mohammad Ali Pasha (1805-48). Source: https://en.wikipedia.org*

The idea of building the railway came in 1833 to Mohammad Ali Pasha **(Figure 1-8)**; with him consulting his Scottish chief Engineer, T. Gallway, about linking Europe & India using a route between Ain Shams, Cairo and Suez. Mohammad Ali started to initiate the project with bringing the rails for starting the rails & stations. However, France hindered the project because the French government wanted build a canal between the Red and the Mediterranean Seas; substituting the need for railroads. The line between Suez and Alexandria in 1834 was short-lived; as Mohammad Ali was conflicted between the two ideas, so he discontinued both.[35]. The railway plans started in 1851, Viceroy *(Wāli)* Abbas Hilmi I negotiated with Robert Stephenson the construction of a railway from Alexandria to Cairo.[36]

In 1854, the first railway route in Egypt was built between **Alexandria and Kafr Eissa,** and it reached **Cairo** in 1856. A new route was built in 1867 to connect Cairo with southern Egypt, with building Imbaba Bridge in 1891 for helping the trains to pass over the Nile near Cairo. And from this point on, the railway has become one of the most important means of transportation in Egypt. Railways could be used to go as far as Matrouh in the west and as far as Aswan in the north; making travelling with train a dependable way.[37] (**Figure 1-9**)

[35] Kamel, S. (2011, June). *The Egyptian Rail Museum (Trains and other Transport)*. Retrieved October 2016, from TourEgypt.net: http://www.touregypt.net/featurestories/trainmuseum.htm

[36] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

[37] Kamel, S. (2011, June). *Op. cit.*

shows that ESR owned around 3533 km of standard gauge track, and a number of auxiliary lines. The State Railways are linked with the Egyptian Delta Light Railways, a narrow-gauge system of about 1000 km serving the Nile Delta.

Within its service years, **Egyptian State Railways (ESR)** achieved a wide outreach orbit. Already in 1884 there was a railway from Aswan to Sudan, which was used for military purposes. In 1898, at the close of the final Sudan campaign, the railway from Luxor to Shellal became a part of the state railway system; a system that in the 20th century an important international line that crossed Sinai reaching Palestine.[38]

[38] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

Figure 1-9: *The Egyptian State Railways in the late 19th century.*

Source: http://mikes.railhistory.railfan.net/r050.html

1.4 Overall Evolution of Transport Technologies, 1750-2000

The era after 1750 (the beginnings of the Industrial Revolution) witnessed an evolution in motive methods and vehicles for each transportation mode through mechanization; providing the ability to use across several modes. The first important innovation was at the end of the 18th century with the steam engine; improving the performance of the maritime and railway transportation[39].

1.4.1 Road transport

The internal combustion engine brought the large-scale mechanization of transportation modes, especially road transport. In railway transport, diesel locomotives replaced steam which in turn, was replaced by electric motor with the development of High speed rail (HSR) to serve general high speeds.

Table 1-3: *Important dates in railway history.*

Source: http://www.trainhistory.net/railway-history/railroad-timeline/

Format: Author of the thesis

Industrial Revolution	
1774	Scotsman James Watt managed to build first stationary steam engine. Over the next few years he and his associates improved their design, enabling machine to produce enough power slow 6-8 mph train movement.
1798	First above ground railway opened in Wakefield, West Yorkshire, England. It was named “Lake Lock Rail Road”. It primarily transported coal with horse powered wagons.
1800 to 1804	American Oliver Evans created first working non-condensing high pressure stationary steam-engine. This engine was first implemented on a boat.

[39] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved June 2018. https://transportgeography.org/?page_id=1599

1803	First public railway was created in London. It transported goods via horse power on the line that was 14 km long.
1804	Englishman Matthew Murray created first steam based locomotive in Leeds. Richard Trevithick showcased his locomotive in public.
1807	First passengers started traveling on trains between Swansea tom Mumbles.
1812	First commercial passenger railway opens in England on the Middleton Railway.
1825	George Stephenson builds his famous LOCOMOTION No. 1, capable of pulling 90 tons of coal at 15 mph (about 24 km/h).
1826	Quincy, Mass became first place in North America with working railway. Materials were hauled by horses.
1827	Railway between Baltimore and Ohio River in Virginia became first of many westward railroads in the United States. In the beginning trains were powered by wind power, horses, and even horses that were stationed on trains themselves, who walked on the treadmills which powered carriage wheels.
1829	First steam locomotive started working in America, but its excessive weight forced it to become stationary boiler.
1829	Stephenson's locomotive "Rocket" became fastest train ever built with its top speed of 30 mph (about 48 km/h). It was capable of carrying 30 people.
1830	Americans built their first steam engine. It worked great until 1931 when it exploded.
1832	Charles Fox patented railway track switch.
1856	First railroad bridge over river Mississippi enabled expansion of trains to the west.
1863	First underground railway started working in London. Success of this track gave birth to the modern subways.
1869	The First Transcontinental Railroad completed in North America, successfully bridging Pacific and central United States.
1872	American inventor George Westinghouse patented his first automatic air brake, which soon became primary brake system in all future trains.
1881	First public electric tram line opened in Berlin.
1888	First electric tram system opened in Richmond, Virginia, United States.
1890	London underground trains switched to electrical engines, starting the era of modern rapid transit systems.
1913	Diesel powered locomotives started being used in Sweden.

1937	German inventor Hermann Kemper patented train system that used magnetic levitation (maglev).
Post-WWII	
1953	Japan locomotive Odakyū 3000 series SE Romancecar reached world record speed of 90 mph (145 km/h).
1964	First bullet train introduced in Japan. It travelled between Tokyo and Osaka with the average speed of 160 km/h.
1960s	U.S. finished their transition from steam models to diesel-electric power.
1979	France began using their high speed train – TGV. It had average traveling speed of 213 km/h and top speed of 300 km/h.
2007	Spain began using their first high-speed trains with speed of up to 350 km/h.
2010	Shanghai Metro becomes world's largest urban transit system with 420m of lines and 278 stations.

1.4.2 Air transport

Air transport benefited from the internal combustion engine (piston engine) serving heavier planes; leading commercial services in the 1920s. Innovations in air propulsion lead to jet planes that can quickly transport a large number of passengers and large freight, which was later improved further with the introduction of wide body jets (like the 747) [40].

1.4.3 Maritime transport

The economies of scale are the most important result of the technological evolution of maritime transportation (despite being slower), with metallic hulls and fuel propulsion increased ship size as well and adding types (oil, freight, containers).[41]

[40] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved June 2018. https://transportgeography.org/?page_id=1599

[41] *Ibid.*

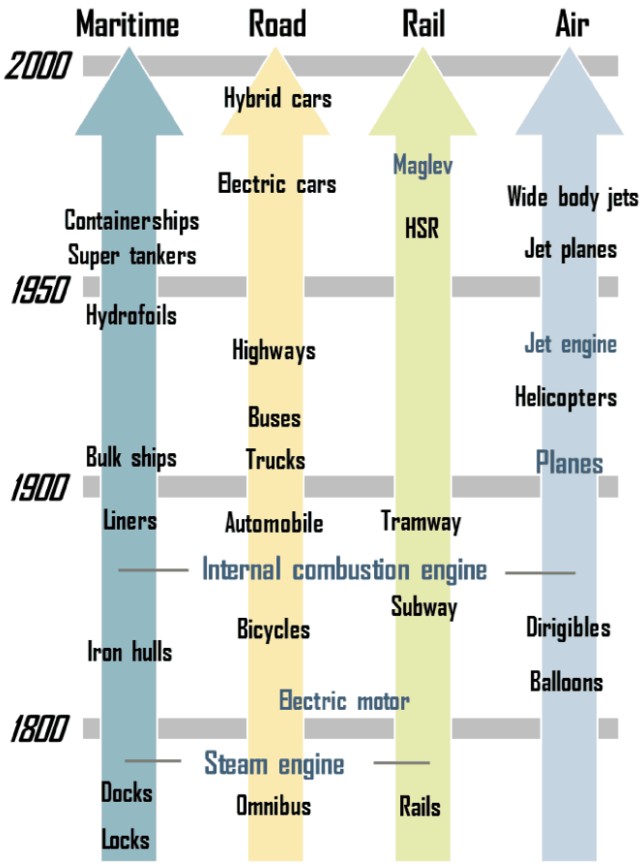

Figure 1-10: Evolution of the Transport Technology, 1750-2000.

Source: Rodrigue, J.-P. et al. (2017).

1.5 Early Station Design Criteria & Principles

1.5.1 Site planning

Despite their 180-year history, stations are a relatively new form of architecture. The first stations were often modest, functional buildings. In many cases, stations also served other purposes of the railway company such as main offices, sometimes headquarters or maintenance workshops, etc.[42] The first building prototypes were initially based on postal stops, such as at the Stockton-Darlington line.[43]

A station is usually from either a **platform** (for boarding and alighting of trains) or a **station building or shelter** (not a necessity in small stations), or adding both of them. In the early days of train station buildings in the 19th century, large railway halls for the train terminals built in all major European cities had their large station halls of the train terminals built as structural engineering.[44]

In the second half of the 19th century large, iconic buildings started to emerge in big (and smaller) cities and the names of architects began to appear alongside those of railway companies.[45] Stations were located out of the city centre, due to:

- Avoiding (or postponing) the disrupting and re-planning of the cities at that.
- The unclean conditions of railway travelling in its early age.

The first problem regarding the functional design of stations (and railway operations in general) in big cities was whether they should be the terminus, a junction station, or a through-station. In brief: **Terminus** is a station that lies on the beginning or on the end of railway line; such stations have reversal track layout, while a **junction station** lies in crossing of at least 3 lines, and a **through-**

[42] Ignacio Barrón. (n.d.). History of Stations. Retrieved May 2016, from International Union of Railways (UIC): http://www.uic.org/com/?page=eslider_iframe&id_article=4015

[43] Uffelen, Chris Van (2010), *Stations*, Braun Publish, Csi, Germany, ISBN: 9783037680445, p.7

[44] Hatherley, O. (2016, December). "With a good culture war, you can ignore the real reason why British transport architecture is so grim". Retrieved January 2017, from Dezeen.com: https://www.dezeen.com/2016/12/08/owen-hatherley-opinion-culture-war-ignore-why-transport-architecture-britain-grim/

[45] Ignacio Barrón. (n.d.). May 2016, *op. cit.*

station lies between main junctions (nodal stations); such stations have a passing-through track layout.[46]

In big cities it was thought that stations should represent the end of the railway line, and consequently tracks should end at the station terminal.[47] Therefore, train stations can be classified according to **operational considerations** or **functional considerations.** The focus is on the functional; based on the functions they are required to perform[48]. Before viewing the types of stations (according to their functional criteria), there should be another look at the role of stations. Stations play joint functions of a meeting point and an order control post. The main elements of station are[49]:

Track layouts	**Posts**	**Technic equipment**	**Auxiliary constructions**
	control tower (master) and signal boxes (slave)	objects and devices for freight & passenger service	locomotive shed, car workstates etc.

Nevertheless, station's basic requirements themselves are basically the same since their inception; there must be:

Passengers arrive at **grand halls**, **administrative spaces, ticketing spaces**, **waiting spaces with a cover,** and**, (covered) accessibility to the trains**.

It has been a problem for designers in finding solutions for spatial requirements; such as passengers' movements, separations, and

[46] Zwolski, J. (2014, October). *Pracownia Kolejowa Katedry Mostów i Kolei Wydział Budownictwa Lądowego i Wodnego Politechniki Wrocławskiej.* Retrieved May 2018, from Infrastruktura Transportu Szynowego: http://www.zits.pwr.wroc.pl/zwolski/source/CE12_Stations.pdf

[47] Ignacio Barrón. (n.d.). History of Stations. Retrieved May 2016, from International Union of Railways (UIC): http://www.uic.org/com/?page=eslider_iframe&id_article=4015

[48] Chandra, S., & Agarwal, M. (2016, August). *Classification of Railway Stations*. Retrieved August 2017, from ReadOrRefer.IN: http://www.readorrefer.in/article/Classification-of-Railway-Stations_4346/

[49] Zwolski, J. (2014, October). , *op. cit.*

repeating services.[50] There is also the issue of the inconsistency in transport volumes. For example: In Japan, constructing stations had the main goal to accommodate passengers; leading to the early stations to adapt simple wooden structures of a single floor.[51] The stations had plenty of facilities for these wealthy travellers, such as a restaurant, a kiosk and, of course, a clock. The station clock was a minor revolution in the 19th century. Before the railways appeared, each town and village set its own time according to the sun's position in the sky[52].

1.5.1.1 Crown Street Station, Liverpool

Crown Street Station	
Location	Lancashire, Liverpool, England.
Designer(s)	George Stephenson (Chief Engineer)
Date	1830-1836 (closed for passengers)
Construction	Wood, stone
Style	Postal, simple classical elements.

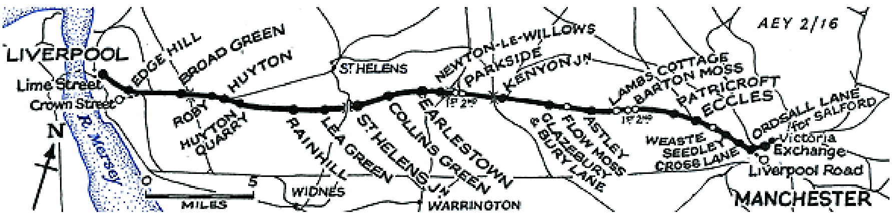

Figure 1-11: *Liverpool & Manchester railway line.*

Source: http://www.disused-stations.org.uk/l/liverpool_crown_street/

The Crown Street Station in Liverpool **is considered the first railroad station in definition, and first intercity station**, which was created in

[50] Guedes, P. (Ed.), *Encyclopaedia of Architecture and Technological Change*, Macmillan, London, United Kingdom, , 1979, p.68

[51] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 26, 27

[52] *Stations were gateways to the world*. (2004, July). Retrieved August 2016, from Swiss Info (swissinfo.ch): http://www.swissinfo.ch/eng/stations-were-gateways-to-the-world/3974686

1830 as part of the railroad track to Manchester (**Figure 1-11**). Liverpool Crown Street station was the western passenger terminus of the Liverpool & Manchester Railway (L&M). It closed completely on 1 May 1972. In the 1980s the site was landscaped as a public park and the western portal of the Crown Street tunnel was buried. In its final months of operation Crown Street had twelve departures and arrivals.[53]

Planning & design aspects:

To the left a train can be seen standing at the departure platform which is adjacent to the main building and all of the stations facilities. The reception building was still at the longitudinal side, while a wooden hall protected the platform area along the track to Manchester. The arrival platform is to the right (**Figure 1-12**) and passengers can be seen making their way from it to waiting omnibuses that would transport them to the city centre. In the 1830s and the following decades, railroads initially spread across the rest of Europe and the USA, then into the countries that were colonized by these nations.

[53] Wright, P. (2016, February 14). *Station Name: Liverpool Crown Street*. Retrieved September 2016, from Dissused Stations: Site Record: http://www.disused-stations.org.uk/l/liverpool_crown_street/

Figure 1-12: *Liverpool Crown Street station looking east in 1831.*
Source: http://www.disused-stations.org.uk/l/liverpool_crown_street/

The postal manor houses, the duty or customs stations of the pre-industrial area, remained the dominant prototype, while the hall and the main building continued to be built separately as in Liverpool.[54]

The zoning of spaces led to two features:

1. **Transit station:** Separate buildings for each of the reception area and the hall.
2. **The division of stations:** into two buildings, a primarily representative and for engineering purposes; a decision that remains to this day in designing.

[54] Uffelen, Chris Van (2010), Stations, Braun Publish, Csi, Germany, ISBN: 9783037680445, p.7

Form & aesthetics:

A two-storey building for the facilities with a restrained classical appearance, Venetian windows faced the low-departure platform covered by a long, flat canopy supported by columns close to the platform edge. The arrival platform was covered with a wood and glass overall roof of shallow pitch supported by the canopy columns to the north and a screen wall to the south covered the tracks[55].

1.6 Functional Classification of Railway Stations

The layout of stations varies in size and importance according to the type and volume of traffic handled and according to their locations with respect to cities or industrial areas. Generally, the layouts required for passenger stations and their yards can be divided into the following categories for the purpose of study[56]:

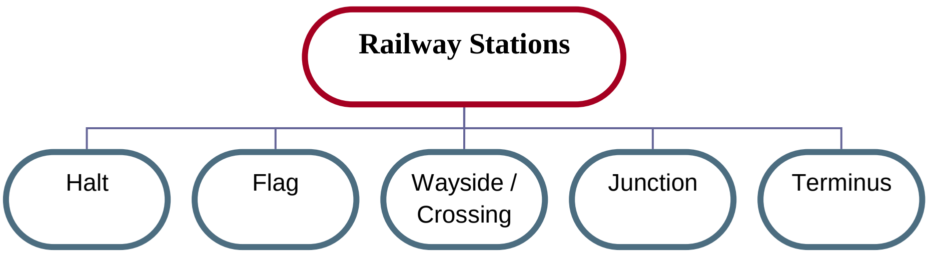

Figure 1-13: *Railway station types according to the functional considerations.*

Source: Chandra, S., & Agarwal, M. (2016, August). Format: Author of the thesis.

[55] Wright, P. (2016, February 14). *Station Name: Liverpool Crown Street*. Retrieved September 2016, from Dissused Stations: Site Record: http://www.disused-stations.org.uk/l/liverpool_crown_street/

[56] Chandra, S., & Agarwal, M. (2016, August). *Classification of Railway Stations*. Retrieved August 2017, from ReadOrRefer.IN: http://www.readorrefer.in/article/Classification-of-Railway-Stations_4346/

1.6.1 Halt

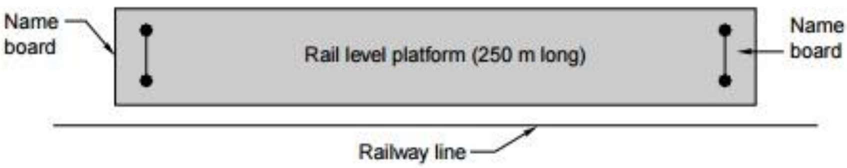

Figure 1-14: *Layout of a halt station.*

Source: Chandra, S., & Agarwal, M. (2016, August)

- The simplest type of stations.
- Usually has only a rail level platform with a name board at either end.
- Sometimes a small waiting shed, with a booking office as well, is also provided
- No yard or station building or staff.
- The booking of passengers is done by travelling ticket examiners or booking clerks.

1.6.2 Flag station

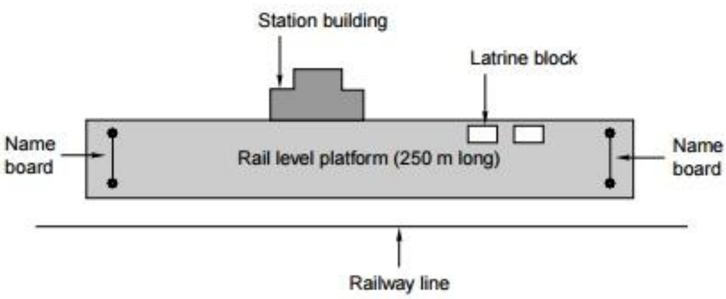

Figure 1-15: *Layout of a flag station.*

Source: Chandra, S., & Agarwal, M. (2016, August)

- Acts as a stop-over for trains; unlike halts.
- Provided with a station building and staff.
- On controlled sections, a flag station is equipped with communication methods, which are connected to one of the stations on either side to facilitate easy communication.

- Usually provided with a small waiting hall and booking office, platforms and benches, and arrangements for drinking water.
- In the past, sometimes was also provided with a siding for stabling wagons booked for that station.

1.6.3 Wayside / crossing station

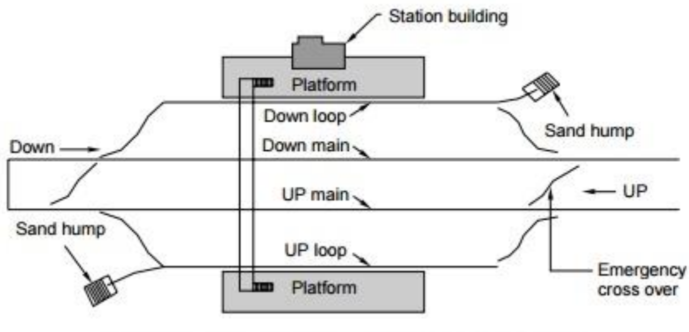

Figure 1-16: *An example for a layout of wayside station.*

Source: Chandra, S., & Agarwal, M. (2016, August)

- Have arrangements for controlling the movement of trains on block sections; unlike flag stations.
- Initially conceived for single-line sections, to facilitate the crossing of trains going in opposite directions so that there may be a more rapid movement of trains.

1.6.4 Junction station

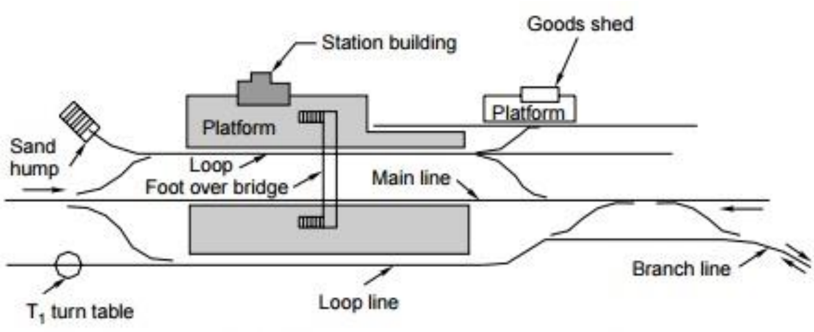

Figure 1-17: *An example for a junction station.*

Source: Chandra, S., & Agarwal, M. (2016, August)

- The meeting point of three or more lines emerging from different directions.

- Normally at junctions, trains arrive on branch lines and return to the same station from where they started or proceed to other stations from where they again return to their originating stations.

1.6.5 Terminal station / terminus

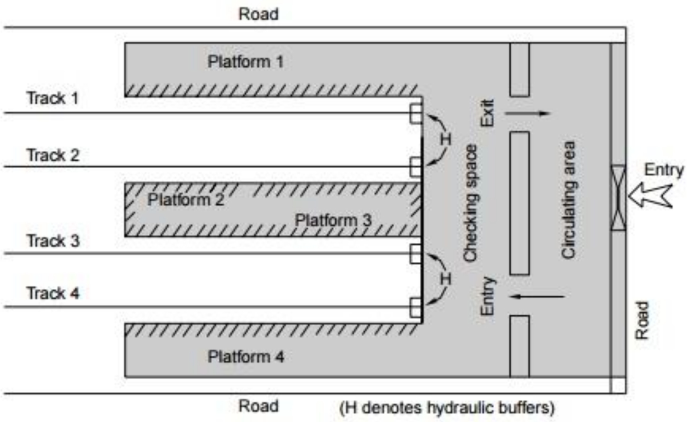

Figure 1-18: *Terminus layout.*

Source: Chandra, S., & Agarwal, M. (2016, August)

- Where a railway line or one of its branches ends.
- The reception line terminates in a dead end and there is provision for the engine of an incoming train to turn around and move from the front to the rear of the train at such a station.
- May need to be equipped with facilities for train services, like: watering, cleaning, fuelling, inspecting, etc.
- On unimportant branch lines, the terminal station had only one platform; later were provided with elaborate facilities.

1.7 Conclusion

The chapter views the beginnings of the transportation method by rail, of which the technology of rail transport started with the purpose of transporting goods and any non-human elements. A comparison was reviewed between the new rail technology to other transport modes; at the start of rail mode, and later with the emergence of new transport technologies (like fast ships and aeroplanes); to emphasise the importance of rail mode. Thus, leading to the emergence of what to be known as a “train station” for people; leading to the issue of developing a meaning or a concept for such new type of buildings that, as mentioned before, served the technology mainly for machinery. With the Industrial Revolution and the progress of locomotive technologies, the 19^{th} century witnessed the railway technology being utilised by the dominating empires then for territorial expansions, opening new commercial networks, starting new communal settlements, and connecting different cultures. All of these elements helped in shaping a new meaning for the new type of buildings that acts as a volume serving the purposes of transportation, and connectivity between societies. Over time, shown in Liverpool Station, the requirements of a station to serve human needs -in addition to mechanical needs- began to emerge and join together in the site planning; whether it was a simple shed, a water tower, offices, a simple waiting place, and most importantly: an access to the trains. Finally, a review was conducted to view the relationship between planning the railway system and positioning the platforms and services which, in turn, affects the position of the train station related to the planned layout.

CHAPTER 2: DEVELOPMENT OF STATION PARAMETERS PRE-WWII

2 Topics of Chapter 2

2.1 Introduction

The train stations for people started from the 19th century and into the 20th century before WWII to have principle function spaces, and also visual functions. Over time, each of the main elements of a station building (platforms, sheds, or concourses) appears one by one and begins to have a definitive function and form; i.e. the building elements seemed to acquire their properties individually and then "interlocked" together. On the other hand, the station building as an exterior volume starts to become a visual expression, mainly as an entrance to its specific location. The visual representation either represented an absolute, classical form, a new art form, a contemporary visual style, and sometimes an expression of a new era and collective culture of a place.

With these new railways came station buildings. Humble at first, they soon grew importance as the influences of the railways were realised. Britain understood the economic value of railroads, and invested abundantly in railroads, which led to the station buildings to use in its style a vernacular language representing the region rather than the typical railroad style; setting an example for other countries.[57]

In the 1830's, critics debated about the defining look of a station, and the defining featured volume; whether it is the **shed, the hotel, the clock tower, etc.** The railroad station was to become the gate into the modern city. The symbolism of the *gateway* for stations was considered the **"Grand Hall"**; the large volume that welcomes the travellers also provides a lack of visibility from street level of the trains and other operational functions.[58]

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[57] Guedes, P. (Ed.), *Encyclopaedia of Architecture and Technological Change,* Macmillan, London, United Kingdom, , 1979, p.68

[58] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway.* Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 12

2.2 Deconstructing the Concept of Stations

The final product of the train station was the combination of several solutions and reasons altogether; mainly serving a mechanical reason (the train). Over time, the concept of a train station grew differently from its start; whether in its layout, interior planning, or size. Those happened due to the attempts to accommodate several factors, like: the trains, equipment, structure, workers, travellers, visitors, and even the residents near the station; which happened gradually.

So, the research found that the best way to analyse a train station as an architectural entity properly is to deconstruct the station to four basic parameters that affect the decision of the designer (**Figure 2-1**):

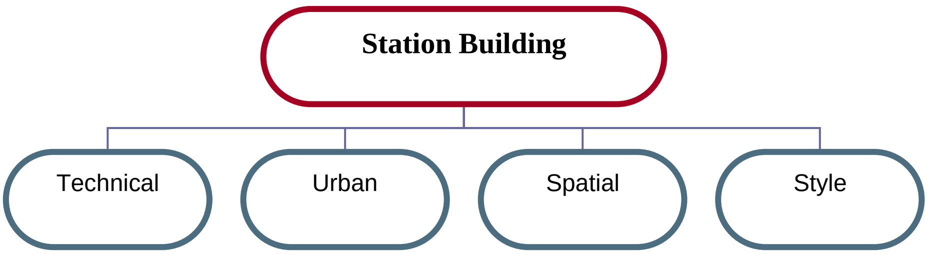

***Figure 2-1**: Train station's design parameters.*

Source: Author of the thesis.

2.3 Urban Parameter of Train Stations

Station designers often limit themselves to project the building solely considering the organisation of passenger flows, and the immediate functional programme- without bearing the urban factor in mind. The building capable of contributing a particular image, unlinked from the homogenous mass of similar buildings rural or urban areas, thus, become a sign of the locality's identity.[59]

[59] Cerver, F. A. (1997). *Architecture of Stations and Terminals.* USA: Hearst Books International, p.71

<u>The three main structuring effects</u> of rail terminals involve **adjacency**, **accessibility** and **network** effects. As before: The research will view only the passengers' facilities.

A. Adjacency

Where land uses directly adjacent or in close proximity to a rail terminal strongly influences and are influenced by the nature and the level of terminal traffic. In sufficient quantity, they form a cluster. Hotels, retail outlets, restaurants, offices, etc. are usually close. New passenger terminal developments, particularly high speed rail stations, offer the opportunity to establish office parks, including hotels, large surface retail and convention centres. Still, these developments often take place not particularly because of the presence of a high speed station, but because of land availability and road connectivity.

B. Accessibility

Intensity and frequency of use affects the distance decay element which affects the users of station. As more users rely on the rail terminal regularly the more sites with high accessibility to the facility are preferable; a generally small effect as most passengers do not use rail regularly, the rail terminal is reaching a user base when the terminal keeps being is accessible through road or public transit systems.[60]

C. Network

A set of interconnected rail terminals are supporting the specialization and interdependency of locations.

The network is a reflection of a regional urban system with increasing intercity commercial and social interactions. While this effect has managed to stay in Europe, India, China and Japan, it stopped to be relevant in North America with the exception of the Northeast.

[60] Loo, B. P., & Comtois, C. (Eds.). (2015). *Sustainable Railway Futures: Issues and Challenges* (1st ed.). Routledge, Abingdon, UK, p.23-25

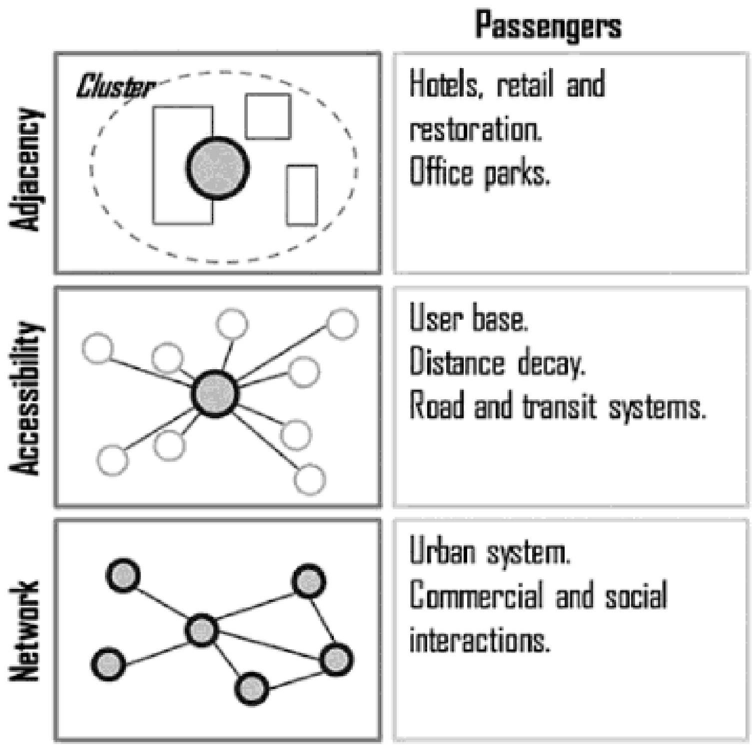

Figure 2-2: *Structuring effects of rail terminals.*

Source: Loo, B. P., & Comtois, C. (Eds.). (2015). Format: Author of the thesis.

Yet, high speed rail systems are permitting the setting of new network effects with increasing interaction levels between cities along the corridors they service, with some terminals such as Brussels becoming hubs and thus reflecting and coordinating a new urban hierarchy.[61]

[61] Loo, B. P., & Comtois, C. (Eds.). (2015). *Sustainable Railway Futures: Issues and Challenges* (1st ed.). Routledge, Abingdon, UK, p.23-25

2.4 Train Stations' Spatial Parameter

2.4.1 Railway tracks, platforms, and sheds

2.4.1.1 Definition of platforms

Platforms are sections that passengers use for boarding or alighting from trains or trams. As the station gets bigger, the number of platforms increases.[62]

2.4.1.2 Types of platforms

Single track lines usually have 1 platform, and double track lines usually have 2 platforms; on outer sides of the tracks (especially on busy lines), or one 2-sided platform between tracks. Access to the platforms, depending on the intensity of traffic, is designed as a grade crossing, in form of an underpass or a footbridge. Also possible is crossing the track when occupied by the train.[63] (**Figure 2-3**) shows the different basic ways (to this day) of crossing the tracks.

Figure 2-3: *Types of crossing of tracks. (L-R) Grade crossing, footbridge, and underpass. Source: Zwolski, J. (2014, October). Format: Author of the thesis.*

[62] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

[63] Zwolski, J. (2014, October). *Pracownia Kolejowa Katedry Mostów i Kolei Wydział Budownictwa Lądowego i Wodnego Politechniki Wrocławskiej.* Retrieved May 2018, from Infrastruktura Transportu Szynowego: http://www.zits.pwr.wroc.pl/zwolski/source/CE12_Stations.pdf

(**Figure 2-4**) shows different types of platform: 1. “bay” platform, 2, 3 and 4 are “through” platforms. Platform accommodating 3 and 4 is an “island” platform.

These types of platforms are not to be confused with the station classification according to their functions discussed before. The review of platform types regards specifically the platforms and their connections only.

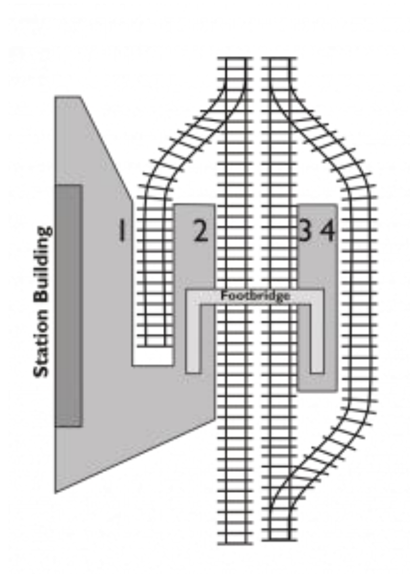

Figure 2-4: *Main types of platforms.*

Source: Railway Platform and Types. *(2015)*

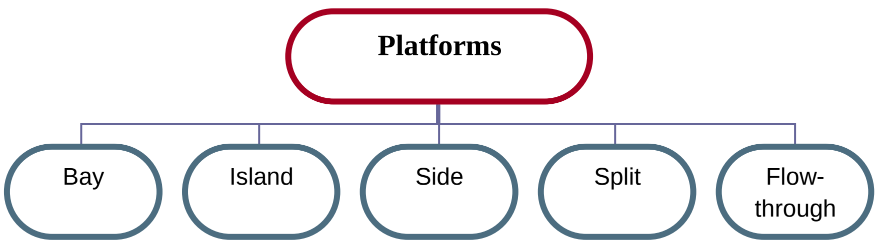

Figure 2-5: *Platform types.*

Source: Railway Platform and Types (2015). Format: Author of the thesis.

A. Bay platform

- The track terminates at it, i.e. a dead-end or siding.

- Trains must reverse in or out. [64]

B. Island platform

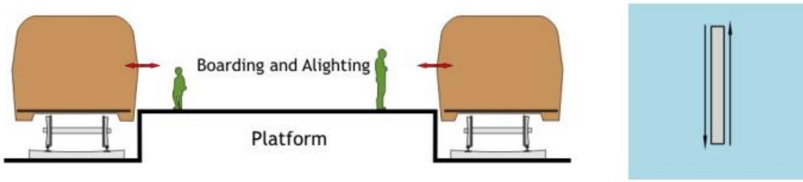

Figure 2-6: *Island platform.*

Source: http://www.railsystem.net/railway-platform-and-types/

Also called “centre platform”

Good at:

1. Popular on twin-track routes and can provide for services in both directions from a single platform requiring only one set of supporting services (toilets, ticket offices, kiosks).
2. Simplifying transfers between the sides within larger stations where local and express services for the same direction of travel can be provided from opposite sides of the same platform.
3. Allow facilities such as escalators, elevators, shops, toilets and waiting rooms to be shared between tracks rather than being duplicated or present only on one side.
4. Prevents overcrowding or deserting of platforms. An island platform prevents this as the same large platform is used for trains travelling in either direction.
5. Reduces the cost of maintenance.
6. Island platform subway stations allow passengers to use any station entrance, and it eliminates both the need for some

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[64] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

signage, and the need to construct a crossover or cross-under between two platforms. [65]

Bad at:

1. If a station is not in the ground level, reaching the platform will require a crossover or cross-under; making the crossing difficult. even able-bodied passengers dislike climbing steps to pass between platforms.

2. In some areas subways (i.e. pedestrian walkways) under the railway line may also pose vandalism and security problems. [66]

C. Side platform

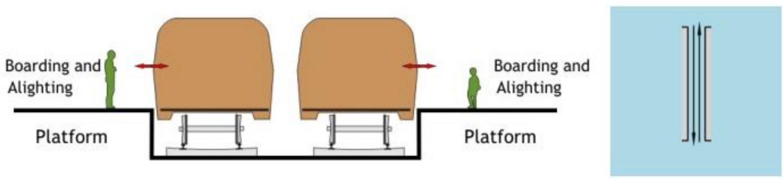

Figure 2-7: *Side platform.*

Source: http://www.railsystem.net/railway-platform-and-types/

Also called "through-platform".

The station is close to a level crossing (grade crossing) the platforms may either be on the same side of the crossing road or alternatively may be staggered in one of two ways. With the "near-side platforms" configuration, each platform appears before the

[65] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

[66] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

intersection and with "far-side platforms" they are positioned after the intersection.

Most stations with two side platforms have an **"Up"** platform for trains heading towards the primary destination of the line, with the other platform being the **"Down"** platform for trains heading the opposite way. Normally, the main facilities of the station are located on the 'Up' platform with the other platform accessed from a footbridge, subway or a track crossing. However, in many cases the station's main buildings are located on whichever side faces the town or village the station serves. [67]

Good at:

1. May result in a wider overall footprint for the station compared to an island platform.
2. In some situations a single side platform can be served by multiple vehicles simultaneously with allowing access mid-way along its length. [68]

Bad at:

Larger stations may have two side platforms with several island platforms in between. [69]

D. Split platform

- Two rails lines cross or run parallel for a time.
- (Origins and effects on layout planning are explained in later chapters). [70]

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[67] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

[68] *Ibid.*

[69] *Ibid.*

[70] *Ibid.*

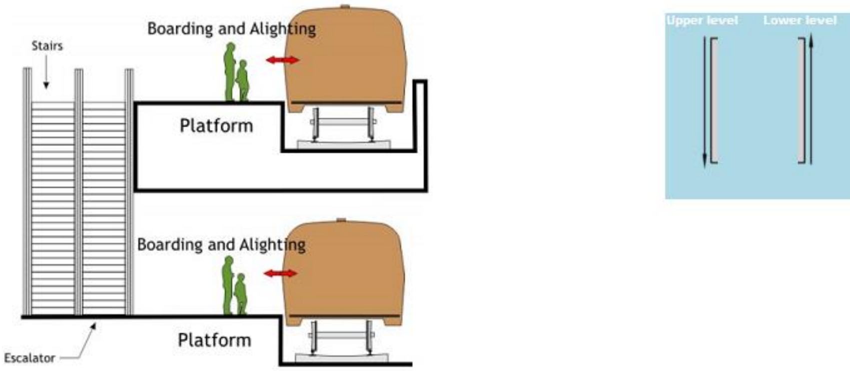

Figure 2-8: *Split platform.*

Source: http://www.railsystem.net/railway-platform-and-types/

Good at:

1. Allows a narrower station plan (or footprint) horizontally.
2. Sometimes used in a hybrid arrangement that allows for convenient cross-platform interchange between trains running in the same general direction. [71]

Bad at:

A narrower plan is at the expense of a deeper (or higher) vertical elevation. [72]

E. Flow-Through Platforms

Often referred to as "Spanish solution" or "Barcelona solution".

[71] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

[72] *Ibid.*

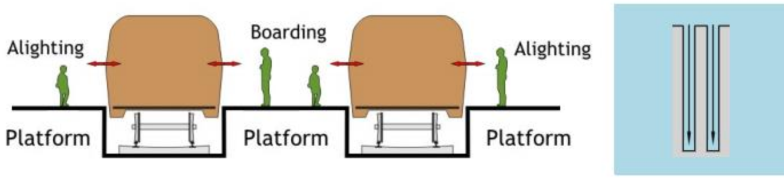

Figure 2-9: *Flow-through platform.*

Source: http://www.railsystem.net/railway-platform-and-types/

Good at:

1. Allow passengers to board and alight the train from dedicated platforms, thereby eliminating conflicting passenger flows (e.g., a high percentage of passengers with bags).
2. Reduce vehicle dwell time at the platform. [73]

Bad at:

High cost and operational considerations. [74]

2.4.1.3 Introducing of train sheds

An efficient part of railroad station architecture; as it depended on the layout of the platforms. The materials remained heavy, and the massive masonry foundations were used until the 20th century when concrete, glass and metal were gaining acceptance.[75]

Train sheds first appeared on the Crown Street Station in Liverpool, England in the 1830's. The shed's main function was to provide cover and protection for the passengers going to and from the

[73] *Railway Platform and Types*. (2015). Retrieved August 2017, from Railsystem.net: http://www.railsystem.net/railway-platform-and-types/

[74] *Ibid.*

[75] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway*. Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 14, 15

station and the trains. A few years later in Lowell, Massachusetts, the train shed appeared in American railway station architecture.[76]

2.4.1.4 Shed coverage and layout arrangement

As railway traffic increased, there was a need to upgrade stations. People needed to be moved more quickly through to their trains. Trains were more frequent and as more departures and arrivals were set in a day, station organization created a problem for designers. The **two-sided** and **twin type** station was the preferred type because of its ability to load, unload, and move the trains quickly. By the 1850's and 60's, the volume of train travellers increased steadily. Convenience was a major factor for the development of the train station. The train shed extended to bring the passengers directly under the cover of the train shed.[77] When money was available, train sheds were built, and became a main feature. The site constraints affect the boundaries of train buildings and sheds; thus articulating the visual impact of the track planning. So, station buildings were placed:

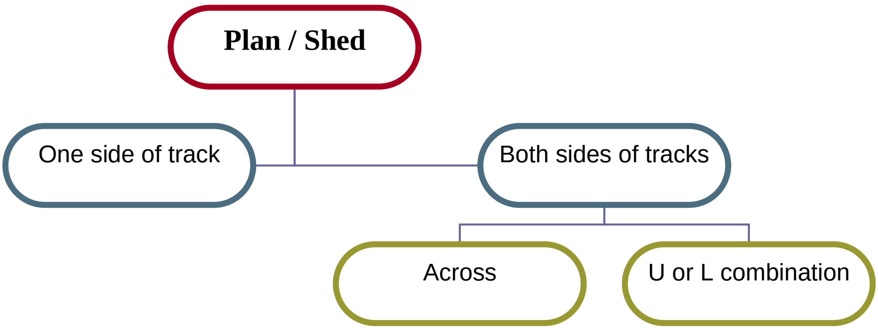

Figure 2-10: Basic planning of station building layout & sheds.

Source: Tsai, M. D. (1991, June). Format: Author of the thesis.

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[76] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway.* Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 9

[77] *Ibid.*, p. 10, 11

A. On one side of the track:

- **Suitable for administrative reasons**;
- Some passengers had to cross them, and face dangers.

B. On both sides of the tracks:

- It was the most common type, in both Europe and the U.S. in the mid 1800's.
- It includes **across them**, or **in combination in U or L-form**.
- Departing passengers from one side and arriving at the other; so passenger services had to be doubled.
- **U-shaped station** could have a connection between the 2 sides, but in **a through station** required raising the cross buildings above the tracks. London's original (& now demolished) **Euston Station (1839)** was the first station of this type (**Figure 2-11**), constructed by architect Philip Hardwick, and engineer Robert Stephenson. The station had separate entrances and amenities for first and second class travellers.

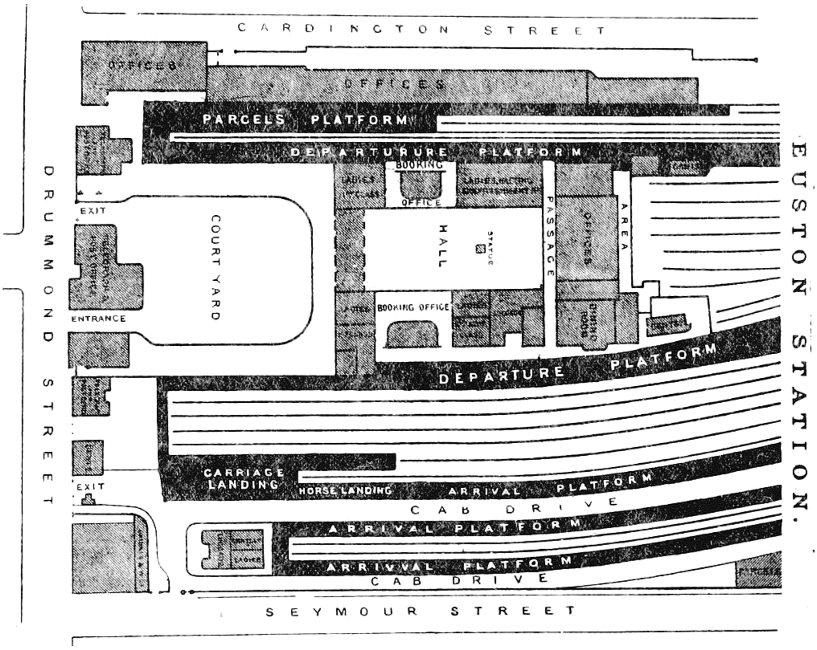

Figure 2-11: *Plan of Euston Railway Station, 1888.*

Source: The District Railway Guide to London (1888).

Similar to France's **Gare de l'Est** (1847-52), there were Lewis & Joseph Cubitt's **King's Cross Station** (1851-52), and Isambard K. Brunel's **Paddington Station** (1852-54), who was a mechanical and civil engineer. The similarities were in their original forms, and the two-sided layout. The increased traffic required leading the passengers to cross from one platform to another in the form of the then-rare two-sided planning.[78]

In 1846, Cesar Daly, editor of the *Revue Générale de l'Architecture*, made an attempt to simplify the different station types into categories. He claimed that there were only four such categories (**Figure 2-12**):

[78] Guedes, P. (Ed.), *Encyclopaedia of Architecture and Technological Change,* Macmillan, London, United Kingdom, , 1979, p.69

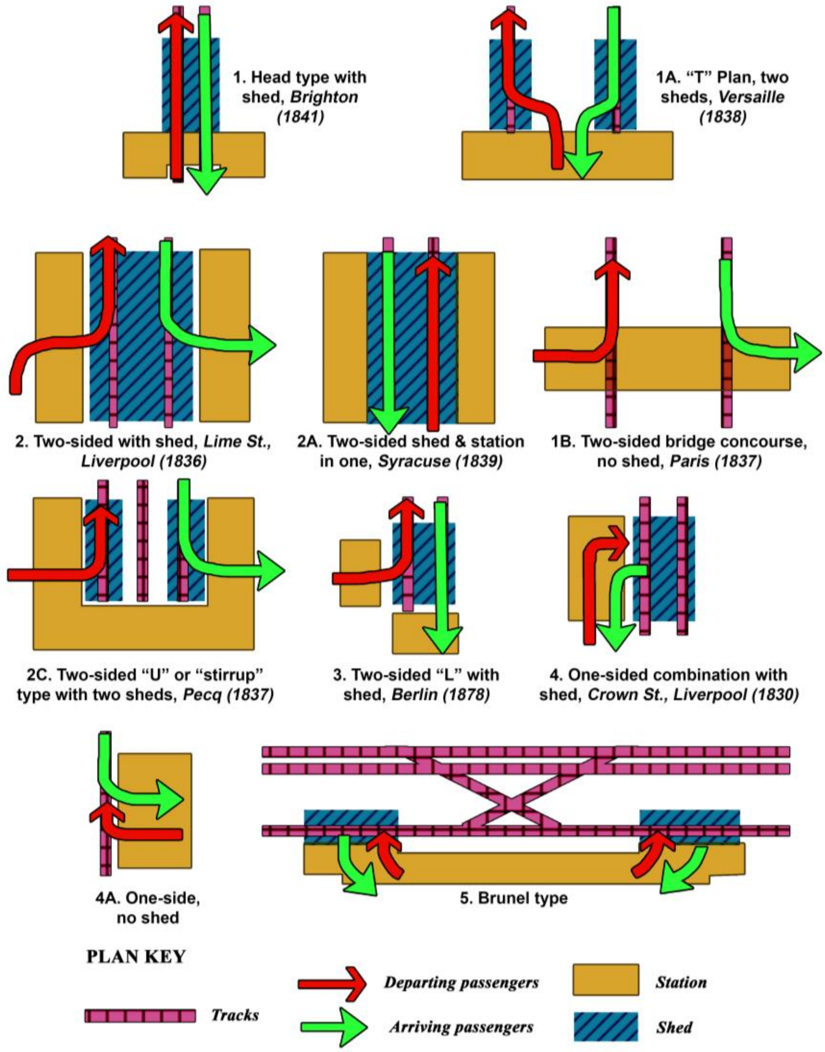

Figure 2-12: *Early Types of Station Plans.*

Source: Tsai, M. D. (1991). Format: Author of the thesis.

1. **Head type:** arrival and departure in a single building across the end of the tracks.

2. **Two-sided or twin type:** with arrival and departure handled on opposite sides of the tracks;

3. **L-type:** with arrival at the end of the tracks and departure at one side or vice versa.

4. **One-sided combination type:** with arrival and departure on one side of the tracks.[79]

5. **Brunel type:** to save passengers from having to cross tracks by switching trains into the station platform; invented by Isambard Brunel. This was only used in smaller train stations that had lower volumes of passengers.[80]

2.4.1.5 Materials of train sheds: as structure, and language

The use of new materials and new methods of fabricating the sheds brought on a new expression. Structural innovations lead to new forms (**Figure 2-13**). Iron truss construction was clearly dominant toward the end of the 19th century. The engineers competed to create the most inventive structures, and were inspired to design increasingly wider and more daring spans. The diversity of the different train-shed types is evident in the examination of the first few decades of the station buildings. Originally constructed of wood, many of the trusses in the early train-sheds deteriorated rapidly because of the exposure to sulphurous train steam. As the material change was taking place, a new problem of expression came about as a result of the evolution of the building type of the railway station.[81]. In 1923, Japan suffered from the damages of the Great Kanto Earthquake; leading to resist aseismic damages by changing construction to reinforced concrete and steel, from wood or stone and brick.[82]

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[79] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway.* Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 10

[80] *Ibid*, p. 10

[81] *Ibid*, p. 11

[82] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 7

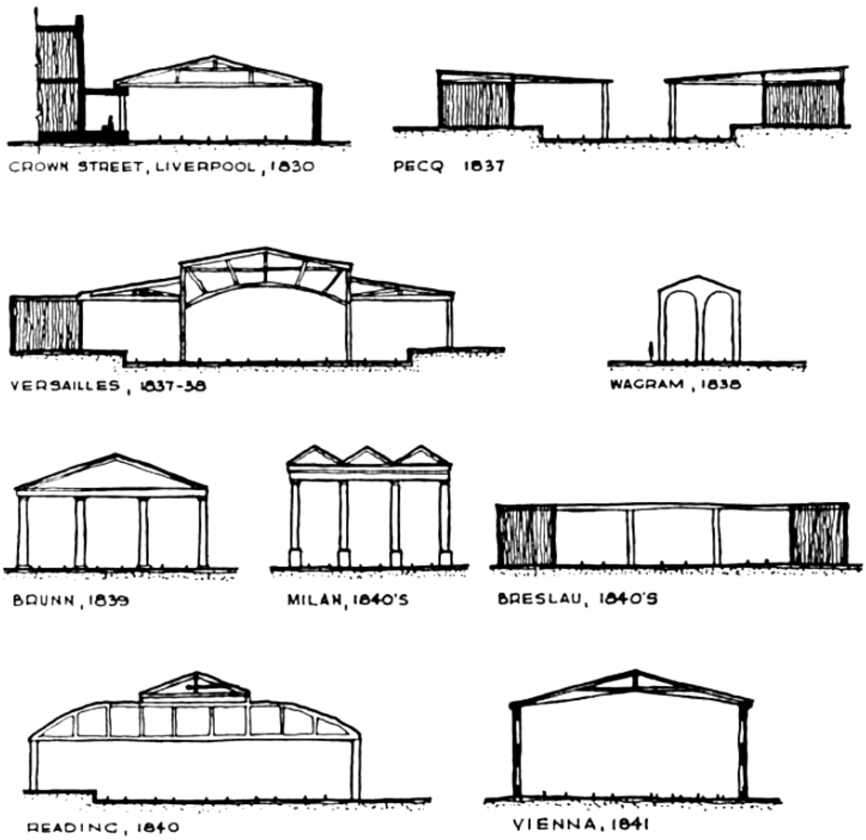

Figure 2-13: *Samples of early types of train shed, with identification.*

Source: Tsai, M. D. (1991).

While iron train sheds were in plain sight; exceptions were present in other stations; such as Gare de l'Est and King's Cross Station. A great semi-circular arch in the centre of the main façade was the representation of train sheds. Train stations were symbolized by great arches and their towers.[83]

[83] Guedes, P. (Ed.), *Encyclopaedia of Architecture and Technological Change*, Macmillan, London, United Kingdom, , 1979, p.69

Paddington Station:

Paddington Station	
Location	London, United Kingdom.
Designer(s)	Isambard Kingdom Brunel (1806-59) (Civil Engineer) Matthew Digby-Wyatt (Architect)
Date	1838 (the temporary station) 1854 (the permanent station)
Construction	wrought iron and glass
Style	Art-Nouveau

Paddington Station is the grand terminus for the Great Western Railway that reflects that of the railway throughout the 19th, 20th and into the 21st century. [84]

Figure 2-14: *Paddington's current state of the façade.*

Source: https://commons.wikimedia.org/wiki/File:2012_at_Paddington_station_-_Olympic_signing.jpg

[84] *Paddington Station, London*. (2012, February). Retrieved August 2016, from NetwworkRail: http://www.networkrail.co.uk/VirtualArchive/paddington-station/

1. Planning & design aspects:

Brunel was deeply influenced by the design and construction of the Crystal Palace for the Great Exhibition of 1851 (**Figure 2-15**), and this can be seen in his use of wrought iron and glass in the three-span roof at Paddington.

Figure 2-15: *Exterior of the Crystal Palace, Hyde Park, London, 1851.*
Source: http://archexpo.net/en/contenu/great-exhibition-crystal-palace-1851#.WWiWz4SGPDc

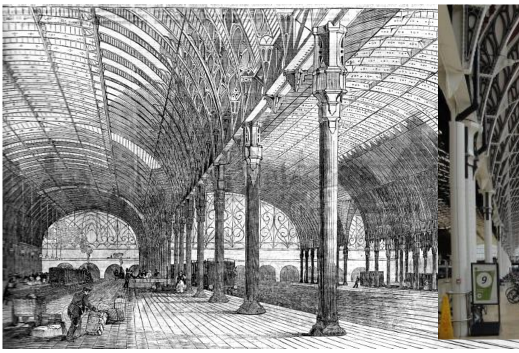

Figure 2-16: *The Great Western Railway Terminus, at Paddington. London.*
Source: The Illustrated London News (8 July 1854): 14.

Figure 2-17: *Paddington's train shed interior.*
Source: http://www.victorianweb.org/technology/railways/80.html

At the time, this was the largest train shed roof in the world with a main span (31.1 m) and two smaller ones to the north (21.3 m) and south (20.7 m). These spans are crossed by two transepts, all overlooked by three oriel windows in the station building on today's platform 1. The main station building, which included offices, the new boardroom for the GWR and a royal waiting room, was constructed along Eastbourne Terrace.[85]

2.4.2 Grand hall / concourse

a : an open space where roads or paths meet

b : an open space or hall (as in a railroad terminal) where crowds gather[86]

Concourses first appeared as a "**salle des pas perdus**" *(=waiting hall)* in the head building; in the Leyonce Reynaud's **Gare du Nord, Paris (1847)**. The design allowed passengers to walk from one platform to the other with no need to cross the tracks. The U-plan contained in its sides departure and arrival amenities, and each of them had the vehicles wait in a large court, which was previously mentioned that using a U-plan was rarely used; despite its importance.[87]

2.4.2.1 Parameters of concourses

Gare de l'Est, Paris:

Gare de l'Est	
Location	Paris, France (Not far from the Gare du Nord, facing the boulevard de Strasbourg).
Designer(s)	François Duquesney (1800-49) (Architect)
Date	1849
Construction	Steel and glass train
Style	Romanesque Revival main body, Neo-Renaissance wings stone façade.

[85] *Paddington Station, London*. (2012, February). Retrieved August 2016, from NetwworkRail: http://www.networkrail.co.uk/VirtualArchive/paddington-station/

[86] *Definition of "Concourse"*. (n.d.). Retrieved November 2017, from Merriam-Webster: https://www.merriam-webster.com/dictionary/concourse

[87] Guedes, P. (Ed.), *Encyclopaedia of Architecture and Technological Change*, Macmillan, London, United Kingdom, , 1979, p.69

The Gare de l'Est *("East station" in English)* is one of the six large SNCF termini in Paris (**Figure 2-18**), was one of the best stations in the world and is one of the largest and the oldest railway stations in Paris.[88]

Figure 2-18: *Exterior of Gare de Paris-Est.*

Source: www.wikipedia.org

Renovations to the station followed in 1885 and 1900. In 1931 it was doubled in size, with the new part of the station built symmetrically with the old part. This transformation changed the surrounding neighbourhood significantly.[89] The Gare de l'Est was conceived on the occasion of its enlargement in 1930, according to very new principles for the time. The movement of travellers was particularly well organized with the separation of travellers at departure and arrival. The most notable was the partially mechanized baggage handling with the installation of treadmill in underground corridors located under the docks. This design is similar to that of airports. While the ground floor is the main

[88] *Gare de l'Est*. (n.d.). Retrieved July 2017, from paris-architecture.info/: http://www.essential-architecture.com/PA/PA-079.htm

[89] *Ibid.*

entrance level, there are also taking the mezzanine and first floor, and a buffet in the first floor[90]

Gare de l'Est influenced the design of many stations later. For example, An American Architect, Bridgens, designed the terminal stations at Yokohama and Shimbashi (**Figure 2-19**).

Figure 2-19: *Shimbashi Station (1872).*
Source: Ando, K. (2010)

The exteriors resembled the Gare de l'Est in Paris; despite the differences in the size. Influenced by Western culture, each of Shimbashi and Yokohama stations had:

- ticket windows
- waiting rooms
- left luggage offices
- toilets

[90] *Une gare moderne*. (2007, June). Retrieved February 2018, from Le Raincy Nono, blog citoyen: http://www.raincy-nono.com/article-1805213.html

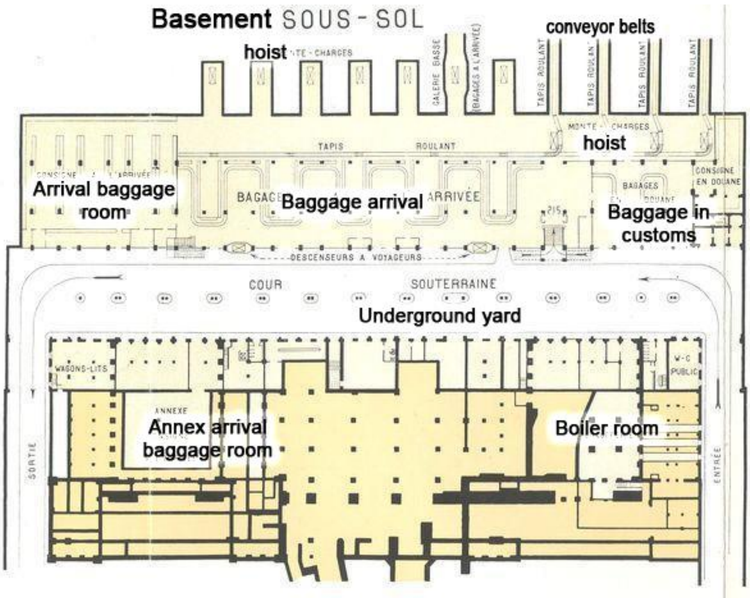

Figure 2-20: Basement floor plan of Gare de l'Est.

Source: http://www.raincy-nono.com/article-1805213.html. Format: Author of the thesis.

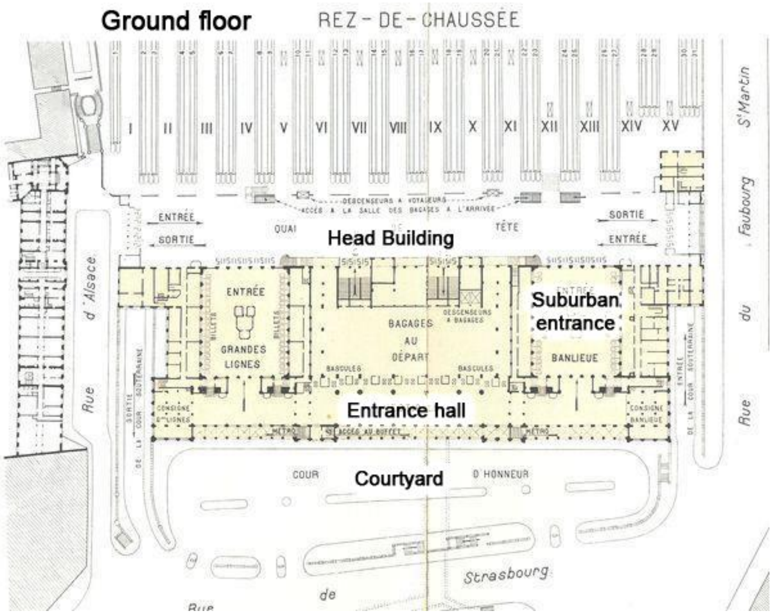

Figure 2-21: Ground floor plan of Gare de l'Est.

Source: http://www.raincy-nono.com/article-6740754.html. Format: Author of the thesis.

Summary of Gare de l'Est's landmark features
Official introduction of concourses in the main hall
Using cast-iron for main structure, and with large spans
Utilising the cast-iron trusses in an appealing arched form, opposed to the standard triangular form; thus creating a visual landmark.
Setting the model for solving high-traffic by turning the two-sided plans into U-plan.

2.4.3 Elevated railways, and multifunctional stations

St. Pancras, London:

Figure 2-22: *The south elevation before the completion of the Midland Grand Hotel, 1868.*

Source: http://stpancras.com/history/a-brief-history-of-st-pancras

St Pancras Station was built by the Midland Railway Company (MRC); the station is noted for its Victorian Gothic Architecture, besides the former Midland Grand Hotel.[91] The train shed at St Pancras station on its completion in 1868 became the largest

[91] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

enclosed space in the world.[92] The designers were: William Henry Barlow (Chief engineer), Roland Mason Ordish (Engineer), and George Gilbert Scott (Architect; hotel + station accommodation).

The train station design is a unique response to its geographic context but also reflects thinking of the day in respect of station design and operation; the platform deck was raised up on a grid of 688 cast-iron columns in order to allow steam engines to pass over the Regent's canal just to the north. The space underneath, now called the Arcade, was designed and used to store beer produced by Burton Brewers, notably Bass and Thomas Salt.[93]

Figure 2-23: *Hydraulic lift used for beer transport to the undercroft.*
Source: A Brief History. *(2016)*

The philosophies of the age were present in configuring the hotel and the station, specifically in the arrangement of entrances, ticketing, and hotel. Brunel used in Paddington the traversal placement of the hotel across the station's head; which was with MRC's business plans to integrate a hotel to the train station[94].

1. The Raised Platform Design

The station faced the gradient problem of continuing the line under the Regents Canal from ground level at Euston Road; for 4 miles to the North out of the station. An engineering solution raised the

[92] RIBA. (n.d.). *The Architeture of Railway Stations*. Retrieved October 2016, from The RIBA Library: architecture.com: https://www.architecture.com/Explore/Stories/TheArchitectureOfRailwayStations.aspx

[93] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

[94] *Ibid.*

platforms, about 3.6 m to 5.1 m higher than the adjoining roads, on a deck.

The elevated platform provided a large space at ground level covers the whole area underneath for commercial purposes: storing beer. In. Constructing an alternative structure was instead of a huge embankment to support the roof and the platforms below it. The station used a hydraulic lift at the shed's north end (**Figure 2-23**) (now in the middle along platforms 7-8).[95]

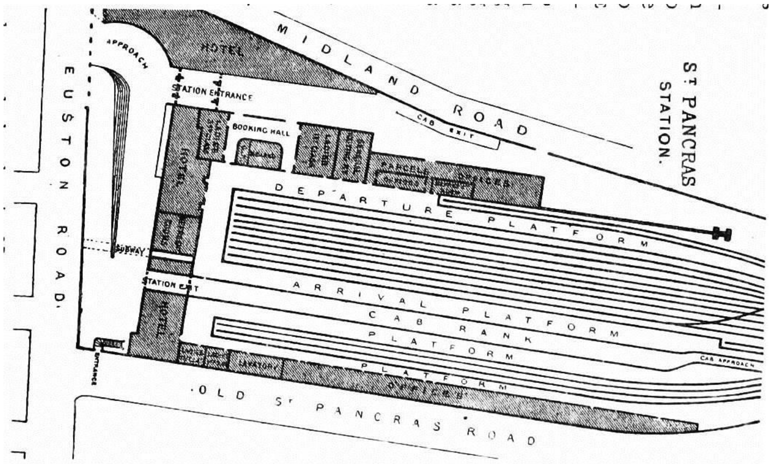

Figure 2-24: *St. Pancras Station, 1888.*

Source: http://www.wikiwand.com/en/St_Pancras_railway_station

Turning to Japan, and during WWI, the steady rate of exports turned many of second-generation and later stations into a mix of Western architecture and Japanese wood architecture. However, later station upgrades removed most of them with only a few of them exist today. The main facilities then were ticketing windows, rooms for passenger waiting, and luggage offices for far travellers. The lifespan of these amenities was estimated to 50 years. [96]

[95] *Station Design*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/station-design

[96] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 28

Example: Tokyo Station, Tokyo

The central station for Japan and was completed in 1914 as (**Figure 2-25**). The station had on the south side an entrance, and on the north side an exit, besides a gate for the Imperial household at its centre. Since then and until now, the train movement towards the station was described as going "up" and "down" for running away. [97]

Figure 2-25: *Virtualization of restored Tokyo Station (opened 1914).*

Source: Ando, K. (2010)

2.4.3.1 Elevated multifunctional stations

Alongside the fact that the main goal of a station is transportation, the passenger transit spaces in Japan became multifunctional spaces that serve numerous purposes. Some writers even deduced that multifunction in stations was a unique matter for Japan. Recently, European stations followed the multifunctional concept that, next to linking other modes, serves as shopping & recreational centres.[98]

The 1900's was the start of constructing electrified and elevated urban railways. The numbers of urban rail commuters highly increased due to

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[97] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 28

[98] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.59.

the age's industrialisation; leading to the need for stations to be compatible with the new railway facilities.[99]

Station buildings were to elevate passengers' convenience with restaurants and shops, at the same time of planning to increase the operators' income. Japan's 1st station building was built in 1920 at Umeda Station, Kansai region was a five-storey high, and floor area of 11,000 m². A **department store** let to the ground floor; **restaurants** on the 1st floor, and other floors were **administrative**.[100]

People pass without obstructions under the tracks using elevated stations that had concourses within them, which were built for separation of road traffic from the rails. Wide outer concourses (outside the ticket gates) were below, so passengers passed through the ticketing to get to the platform. That design allowed unobstructed access and ease in understanding; making it a recurring theme in Japanese under-the-tracks stations, like Nagoya Station in 1937.[101]

Commercial elements, however, were not the only reason for the elevated track concept. Site constraints, limited built-area, and train arrivals and leaving rates; are all factors in reorganizing the station floors.

2.5 Style Parameter of Train Stations

The "Grand Hall" in the British rail station was a symbol for the great entry way to the trains; a meaning that was transformed into a literal great archway in Euston Station, designed by architect Philip Hardwick. Critic William Cubitt said:

[99] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 28

[100] *Ibid.*, p. 28

[101] *Ibid.*, p. 7

"A good station could be built at King's Cross for less than the cost of the ornamental archway at Euston Square."

That classical pediment and column façade express a **theme for the design.**

Figure 2-26: *Original entrance to Euston Station (1896). Source:http://www.ucl.ac.uk/sts/cain/projects/euston_grove/art/euston_arch_1896.gif*

The **theme** of that age was using the literal transformation of the *"gateway"* and *"monumentality"* of the entry into the city. Explaining the different style period of the design, it seems the form of the gateway was simply borrowed from the classical reference, and does not reflect in any way the materials or technology of that time period.[102] It should be noted that its Greek Doric style of an arch was applicable to thee contemporary thought that *"the railroad station was a gateway to the city"*(**Figure 2-26**). [103]

2.5.1 "Monumentality" as a theme for station buildings

The change of typology meant a change in expressing symbolism for a theme. The French claimed that the terminals had a distinctive architecture of its own. To the French, the principal façade was **a monumental clock**, as well as, **a great arch** and pediment expressing the great roof of the train-shed. The English on-the other- hand, located a different function at the head of the tracks as a façade element. This typically was **a hotel** with **a great entry hall**. The transformation of the train station into more than a

[102] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway*. Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 12, 13

[103] *Ibid.*, p. 10

ticketing office has changed its organization of spaces, as well as its structure.[104]

Several features appeared as influences on exterior treatment and form language:

2.5.1.1 The classical style

It dominated station design the world over for 50 years or more. The following two examples are of the **Gothic** style:

- **St. Pancras Station** London (**Figure 2-27**), completed in 1877, was a massive column-free train shed designed by William Henry Barlow and R.M. Ordish.[105] the famous gothic architect George Gilbert Scott (1811-1878) won the competition to design the station's hotel. The design integrated gothic architectural influences from all over Europe to fit the site's particular constraints and opportunities, in an extreme attention to detailing[106]

Figure 2-27: *St Pancras, 1907.*

Source: http://stpancras.com/history/a-brief-history-of-st-pancras

[104] Tsai, M. D. (1991, June). *Taipei Terminal Rail Station: Creating an Urban Gateway.* Massachusetts Institute of Technology, Architecture, MIT Libraries, p. 13, 14

[105] Jones, Will (2006), *New Transport Architecture: Travel Hubs in the 21st Century*, p.202

[106] *Station Design*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/station-design

- **India's Victoria Terminus** Mumbai (completed in 1887), renamed **Chhatrapati Shivaji Terminus** (**Figure 2-28**), and was designed in the Gothic style by Fredrick Stevens.[107]

Figure 2-28: *Chhatrapati Shivaji Terminus, India.*

Source: https://en.wikipedia.org

2.5.1.2 Neo classic

William Symmes Richardson, the project architect for Pennsylvania Station, referenced Rome in describing his station as functional, citing the large roofed ancient buildings as "*the greatest examples in architectural history*" for "*assemblages of people*".[108]

- **Pretoria Station** in South Africa was the work of Englishman Herbert Baker. Even the architectural powerhouse of Italy took its lead on station design from the British, mainly because much of the money invested in railways came from the UK.[109]

[107] Jones, Will (2006), *op. cit.*, p.202

[108] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[109] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.202

- **The original Stazione Leopolda in Florence**, built in the 1860s, takes many cues from the Trijunct Station in Derby (1840) and Nine Elms in London (1838).[110]

Figure 2-29: *Pretoria Station, South Africa.*

Source: https://www.tripadvisor.co.za

Figure 2-30: *Original Stazione Leopolda,Florence, Italy.*

Source: http://www.teladoiofirenze.it

2.5.1.3 Beaux-Art style

Originated in France, and had significant influences in other places. Examples are Union Station, Washington, D.C, and Grand Central Terminal, New York City. [111]

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[110] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.202

[111] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.2

Figure 2-31: *Exterior of Gare du Nord.*

Source: http://www.marilynztomlins.com/wp-content/uploads/gare-du-nord.jpg

One noted example is **Gard du Nord in Paris, France** (**Figure 2-31**)**.** The railway station was designed by Jacques Ignace Hittorff, a German-born French architect. Jacques adopted a Beaux-Arts (neoclassical) style of architecture in the design of the railway station, which has a U-shaped terminus. The façade of the original station was removed and transferred to Lille.

One of the unique features of the railway station is the 23 female statues that adorn the nearly 165-m façade. Each statue represents a particular destination served by the Chemin de Fer du Nord Rail Company *(now part of Société Nationale des Chemins de fer Français)*. The destinations sculpted on the façade include Paris, London, Berlin, Warsaw, Amsterdam, Vienna, Brussels and Frankfurt. Several slabs of stone were used to build the façade, which is supported by a cast iron beam. The interior of the station is 66 m wide and 183 m long, and contains a large central hall and a glass train shed. It is supported by iron pillars manufactured by Alston & Gourley's ironworks based in Glasgow, Scotland.[112]

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[112] *Gare du Nord, Paris, France*. (2017). Retrieved July 2017, from railway-technology.com: http://www.railway-technology.com/projects/garedunord/

2.5.1.4 Monumentality for expressing new and old identities for various regions

The Egyptian case of modernism:

The construction of station buildings was as limited as possible at first; because of the limited need for them at the time, until the increase of transportation movement rates railway lengths and spreading, all of these lead to an increase in the rates of operating, maintenance and management, which means the establishing the stations; consisting of main and secondary stations, in addition to platforms and sheds.[113]

Construction began in 1854 of two main stations: Alexandria (1854), and Cairo (1856), with the construction of smaller stations after them; whether they were wooden kiosks, or simple buildings with platforms included with some of them.[114] The current Cairo Station had a predecessor that was never captured in photographs, only an illustration of it was featured in the railway magazine *(possible sources: Illustrated London News, The Graphic or The Illustrated Sporting and Dramatic News)* (**Figure 2-32**)[115].

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١١٣ بلبع، أ. ف.(١٩٧٧). سكك حديد مصر في ١٢٥ عاما: ١٨٥٢-١٩٧٧. القاهرة: مطابع سكك حديد مصر، ص٧٤

١١٤ بلبع، أ. ف.(١٩٧٧). سكك حديد مصر في ١٢٥ عاما: ١٨٥٢-١٩٧٧. القاهرة: مطابع سكك حديد مصر، ص٧٤

115 Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

Figure 2-32: *Old print of the 1st Cairo Railway Station.*

Source: Seif, O. (2015, October).

Figure 2-33: *Khedive Isma'il (1863-79).*

Source: www.wikipedia.org

Figure 2-34: *Khedive Tawfiq (1879-92).*

Source: www.wikipedia.org

As of the middle of the 19th Century, Egypt began developing a new identity, a distinct identity that is expansive, stemming from history & tradition, but also open & cosmopolitan; forming an identity that is a product of political, cultural and economic changes. **Khedive Isma'il** (**Figure 2-33**), was amazed by Baron Haussmann's bold plan at the Paris Exposition Universelle in 1867, which transformed the city of Paris, that he *"Haussmannized"* Cairo and drastically altered its size, layout, and future development. Isma'il's son, **Tawfiq** (**Figure 2-34**), ruled from 1879 and turned Egypt into the colonial rule; opening the country to the vast British imperial network[116].

Within 20 years, Cairo became a cosmopolitan city tied to the international economic system and using the expertise of migrants & minorities that found Cairo as a new home; reaching the peak architectural life of the city. Hybrid architectural styles emerged that was the product of different styles of the past and various European styles, especially the **Art Dèco** (**Figure 2-35**), **Art Nouveau** (**Figure 2-36**), and **Neo-Baroque** styles. But the one distinguishing invention of the period, and the one adopted as the semi-official style of the country, was the **Neo-Mamluk style.**[117]

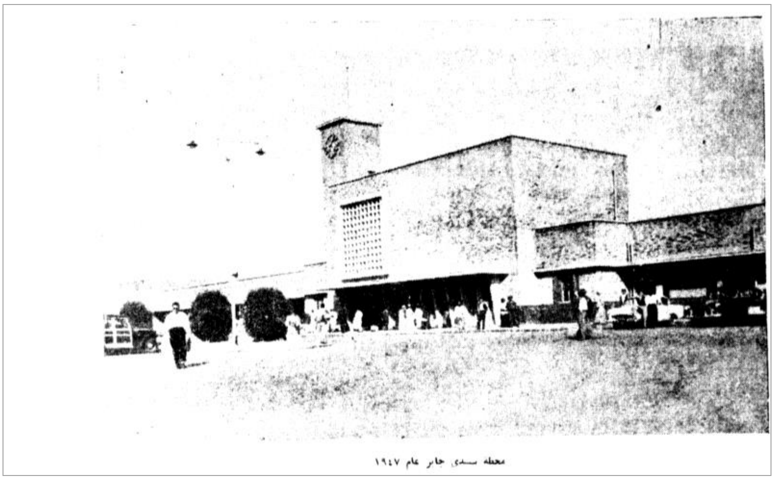


Figure 2-35: *Sidi Gaber Station, Alexandria, 1947.*

Source: بلبع، أ. ف.(١٩٧٧)

[116] The Middle East Institute. (2008). Architecture and Urbanism in the Middle East. *Viewpoints*, 84. Washington, D.C., United States, p.16, http://www.mei.edu/content/architecture-and-urbanism-middle-east

[117] *Ibid.*

Figure 2-36: Ismaileya Railway Station.

Source: Seif, O. (2015, October).

Figure 2-37: Alexandria Station. Alexandria was considered the largest goods station in Egypt.

Source: http://mikes.railhistory.railfan.net/r050.html

The designs for Alexandria Station (**Figure 2-37**) were made by architect Edwin Patsy, and execution supervision was by Henry Ross; Robert Stephenson's first aide, where the building was considered to be close to Mohammad Ali Square in the city centre and close to the governor's palace named **"Al-Qabbary"**, and close to Al-Mahmoudeya Conduit where ships unloaded their shipments of grains, harvests and cottons. The station was built in the English style, and consisted of two floors: the first floor included an inner spacious hallway; equipped with the Egyptian methods for passengers' comfort, and the second floor with offices for engineering, locomotives and tractions.[118]

Station Buildings of Egypt (WWI-)

Key ESR stations were built in many syles, like:

a) **Colonial**; such as: Mallawi Station (**Figure 2-38**), and terminated in 1929 those of Suez (**Figure 2-39**). On the other hand, the earliest Port Sayeed Station (non-extant) was the most modern looking of all Egyptian stations (**Figure 2-40**), with its curved roofing[119].

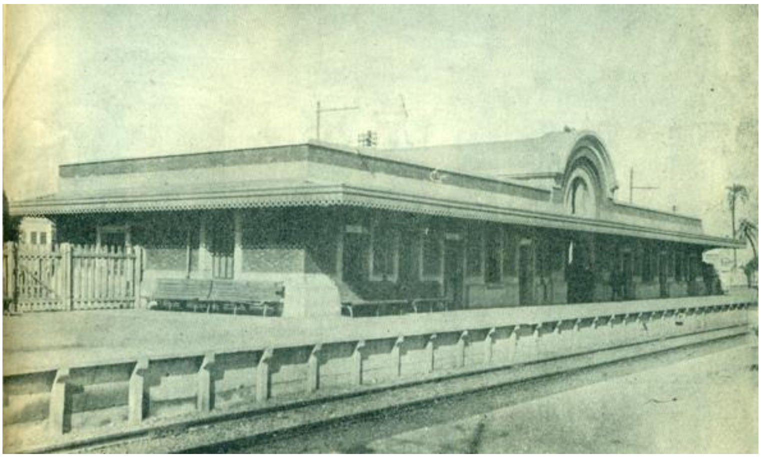


Figure 2-38: *Mallawi Station.*

Source: Seif, O. (2015, October).

[١١٨] حسونة، م. أ. (١٩٧٠). مصر و الطرق الحديدية. القاهرة، مصر، مكتبة مصر العامة، ص١٢٠-١٢١

[119] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

Figure 2-39: *A postcard of Suez Station where a train arriving from Port Tawfiq, 1928.*

Source: Seif, O. (2015, October).

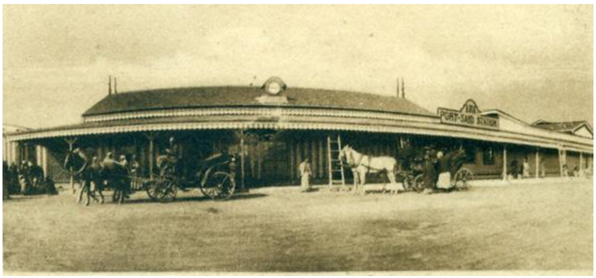


Figure 2-40: *Old Port Sayeed Station.*

Source: Seif, O. (2015, October).

b) **Neo-Mamluk**; such as: Cairo Station (known as *Bab Al-Hadid*, or Ramses Station), designed by British architect Edwin Patsy in 1893[120]. It was taken in consideration with the constructions of stations the environmental and social conditions of the location; which is why, as in Tanta Station (**Figure 2-41**) that was renovated with an Arabian Style to fit the important religious position of the city.[121] One of Cairo's eastern annexes, Pont Limun *(or "Lemon Bridge")*,

[120] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

[121] بلبع، أ. ف.(١٩٧٧). سكك حديد مصر في ١٢٥ عاما: ١٨٥٢-١٩٧٧. القاهرة: مطابع سكك حديد مصر، ص٧٤

used as suburban stations leading to the Matareyya Line (**Figure 2-42**), was pulled down in the early 1980's and replaced by a modern metal clad building dedicated to postal services[122].

Figure 2-41: *Tanta Station.*

Source: Seif, O. (2015, October).

Figure 2-42: *The original Pont Limun annex station.*

Source: Seif, O. (2015, October).

c) **Neo-Pharaonic**; such as: Edfu Station (1928), Kom Ombu Station (1932) (**Figure 2-43**), and Giza Station (**Figure**

[122] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

2-44) (1935)[123]; the latter is still extant, and expectedly: railway stations in neo-Pharonic style are on the touristic path[124].

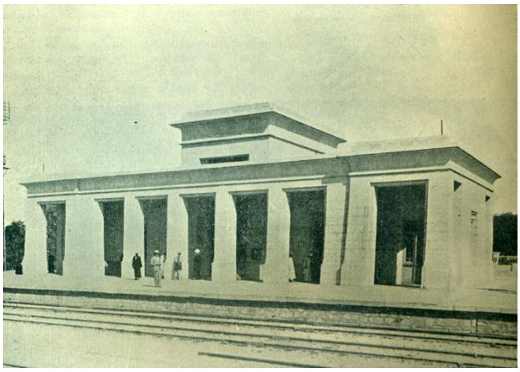


Figure 2-43: *Kom Ombu, completed in 1933.*

Source: Seif, O. (2015, October).

Figure 2-44: *Giza Station.*

Source: Seif, O. (2015, October).

2.6 Station Design Parameters' Criteria

From all the previous discussed examples, it was obvious how the concept of designing a train station was built-up gradually; with the introduction of each new architectural element according to the

١٢٣ بلبع، أ. ف.(١٩٧٧). سكك حديد مصر في ١٢٥ عاما: ١٨٥٢-١٩٧٧. القاهرة: مطابع سكك حديد مصر، ص٧٤

[124] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

requirements of either trains or users. This was explained in the beginning of the chapter, which led to dividing the architectural design process of this era into **4 essential driving parameters**: spatial, urban, technical, and style. The research after it had discussed all examples, when were put to discussion into the 4 parameters, deduced dividing each parameter into several defining criteria.

1. ***Technical parameter***
2. ***Urban parameter***
3. ***Spatial parameter***
4. ***Style parameter***

The presence of each parameter on any station building's design can be seen through the basic design elements of any architectural design: **Function & form**. Each of the function and form guide several categories that are specific to the building elements that were created to form the station building.

(Kido, 2013) used a simple model to demonstrate the categories of function and form for stations. His analysis is about dividing the **function** elements into two branches:

- **Transportation function:** concerns about the accessibility to the building, quality of entrances, quality of platforms, quality of station building, and quality of station hall / concourse.
- **Commercial function:** about shops, and leisure.

The **form** elements are about the aesthetical representation, such as space, composition, light, colour, etc. Also includes the theme for the design.

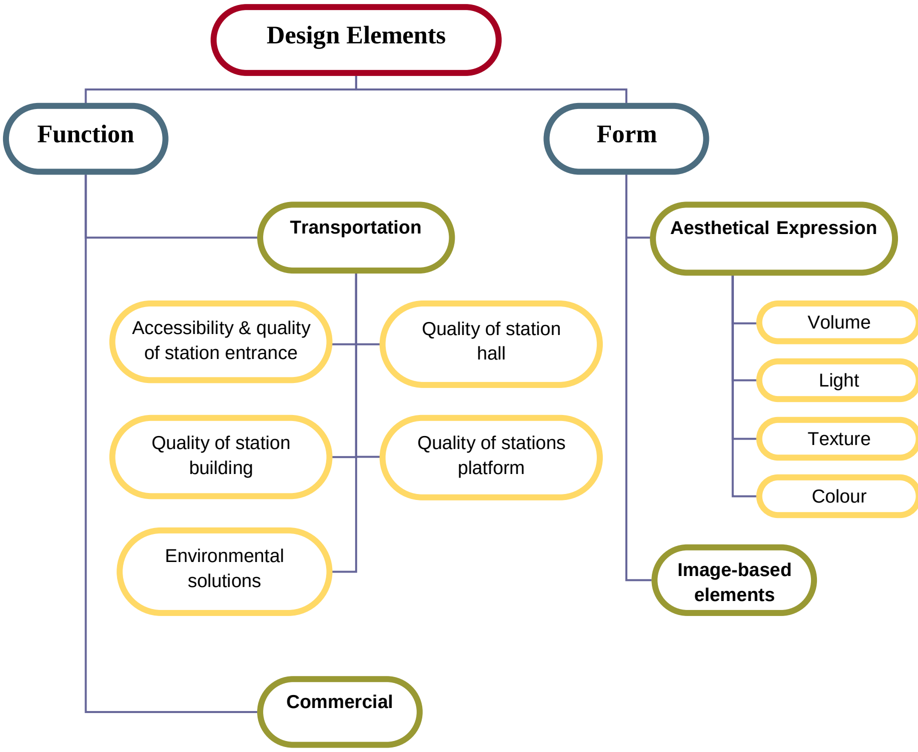


Figure 2-45: *Design elements of railway station spaces.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

However, the analysis of the case studies -starting from the following example- concludes that there are other categories inside the aforementioned categories that affect both function and form; thus a simple revision for the model of analysis is required, which can be applied similarly to show the effects of the 4 main station design parameters.

2.7 Analysis of Projects: Pennsylvania Station, New York

This section is for reviewing and analysing of a project sample that represents several aspects of the time period from the discussed previous points.

The original Pennsylvania (Penn) Station was described as "*an expression the American economy*" (**Figure 2-46**). Construction of the huge steel and stone building ended in 1910 with the area of 4 city blocks. Economic difficulties led to its demolishing in 1963.[125]

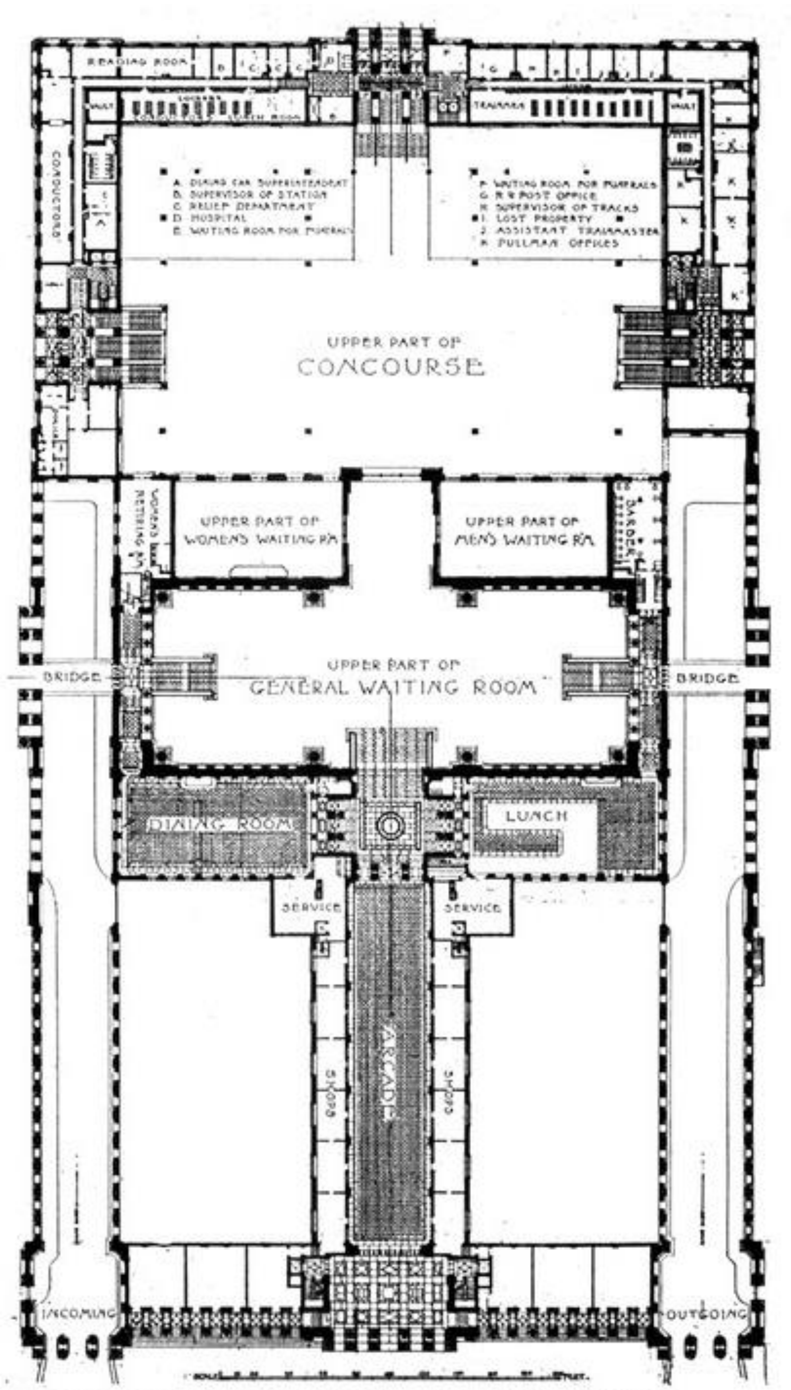
Figure 2-46: *The original Penn Station in aerial view.*

Source: Jones, R. (2014, February).

Penn Station and its yards spanned 113,312 m²; 26 km of rails that converged into 21 tracks serving 11 platforms.[126]

[125] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[126] Roberts, S. (2013, January). *100 Years of Grandeur: The Birth of Grand Central Terminal*. Retrieved October 2016, from The New York Times: http://www.nytimes.com/2013/01/20/nyregion/the-birth-of-grand-central-terminal-100-years-later.html?pagewanted=all



PLAN AT STREET LEVEL, PENNSYLVANIA RAILWAY STATION.

Figure 2-47: *Penn Station's plan at street level.*

Source: Jones, R. (2014, February).

2.7.1 Function elements of Pennsylvania Station

2.7.1.1 Accessibility & quality of station entrance

William Symmes Richardson, McKim's successor, stated that the architects' goal was an efficient system to solve passengers' movement from and into the station (**Figure 2-47**). Each façade had a pedestrian entrance, directly accessing the tracks from two streets: 31st and 33rd Streets, while a third street, 32nd Street, was an arcade of shops extending from 7th Avenue reaching the main waiting area. The carriages had their entry from the south end of the east façade, and going out from the north side. Future connections were regarded to a subway system that was yet to appear; constructing the rail tracks below the street at a sufficient distance for passing under a subway tunnel. [127]

2.7.1.2 Quality of station building

1. Structural challenges:

Being a terminal station, East and West were linked by **a system of tunnels that lead to the island**. Extensive, long-timed engineering solutions led to the embedding of massive columns supporting the train 4.6 m using bedrock, and lining each tunnel with concrete; 60 cm thickness.[128]

2. Relation to surrounding context:

The project required levelling many buildings to provide spaces for the new station, spanning 238 m between Avenues 7 and 8, and 131 m between Streets 31 and 33. The design of the elevations has its own circumstances: because of the limitations of the area horizontally, McKim decided to go for an

[127] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[128] *Ibid.*

innovative solution for a **vertical layout** for separation of programme, in which trains going in and out got stacked in order to avoid congestion. The solution used hundreds of steel columns, 14 m underneath the street, extended from the tracks and carried the main concourse. In 1955, following the annual losses of the station, the station was sold; requiring limiting all of the station underground and demolishing New York City's gateway. [129]

Figure 2-48: *Penn Station's track level & concourse.*

Source: Jones, R. (2014, February).

2.7.1.3 Quality of platforms

Against the traditional design standard that made the platform close to the tracks (about 23 cm high), the movement was eased for passengers by **raising the platforms to the level of the car doors**; which is considered an innovation that was carried to this day.[130]

[129] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[130] *Ibid.*

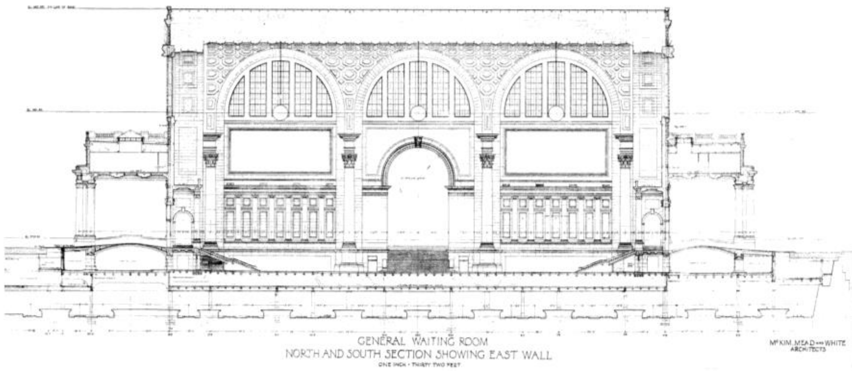


***Figure 2-49**: Penn Station's section of the general waiting room.*

Source: Jones, R. (2014, February).

2.7.1.4 Quality of station hall

With the carried concourse using steel columns, distinctive steel staircase connected the platform below the wide atrium. The ceiling consisted of three barrel vaults of intersecting arches and detailed steel patterns[131].

***Figure 2-50:** The United States Post Office, 1915.*

Source: Jones, R. (2014, February)

***Figure 2-51:** Penn Station's main concourse.*

Source: Jones, R. (2014, February)

[131] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

Amenities:

A variety of amenities were included next to aforementioned two main zones, these at the end of the arcade included:

- Formal dining room for 500 people / a lunch room
- Coffee shop.
- ticket office
- parcel rooms
- baggage check
- separate gentlemen's & ladies' waiting rooms
- lavatories
- facilities for funerals

While the fourth floor was mainly for railroad employees, like:

- Assembly areas
- Lecture halls
- Library
- Billiards room
- Sports areas; a gym and bowling area.
- PRR's own YMCA (*Young Men's Christian Association*)

2.7.1.5 Environmental solutions

In the past, steam locomotives were the common type, but their use in the tunnels could cause asphyxiations for passengers. The solution was the then-new electric trains.[132]

2.7.1.6 Commercial function (Facilities)

Proposing a hotel above the station: McKim argued that a hotel would go away from the main reason for a station to exist. After a long debate, the design ended with cancelling the plans for the hotel, and the station's height became lower than the buildings in its area; at only 3-storeys high.[133]

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[132] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[133] *Ibid*

2.7.2 Form elements of Pennsylvania Station

2.7.2.1 Aesthetical expressions

In a deliberate contrast, the two principal areas: the concourse and tracks were modern steel, while the waiting room and services were neoclassical waiting room and service areas. The four exterior elevations were clad in pink Milford granite and featured little embellishment.[134]

2.7.2.2 Image-based elements

A contrast in styles with the Doric style (exterior) and Neo-classic (interior) is the theme of the design. The contrast in materials was in order to express the function of each space: The utility of the tracks for entering the city, and the symbolism and grandeur welcoming from the latter – taking extensively from Roman culture in the vaults, ornaments, clerestory windows, and proportions (only 20% bigger for the 45 m-height).

2.7.3 Analysis results

The demonstration of the function and form elements of Penn Station in details reflects the characteristics of each station design parameter for the given era. The design elements are collected in (**Table 2-1**) that shows the impact of each design element on one or more station parameter:

[134] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white.

Table 2-1: Impact of design elements on station design parameters.
Source: Author of the thesis.

Design Elements		Description	*Technical*	*Urban*	*Spatial*	*Style*
Function	Accessibility & quality of station entrance	Segregation between carriage & pedestrians' entrance. Using the approach in creating retail without obstructing access.		●		
Function	Quality of station building	**Structural challenges**: Using deep structural elements to support the building and making use of tunnels.	●	●		
Function		**Relationship with surrounding context:** Elevating the plan due to limited building area to avoid congestion.		●		
Function	Environmental solutions	Electric trains instead of steam-power to avoid asphyxiation.	●			
Function	Quality of platforms	Levelling the platforms with carriage doors.			●	
Function	Quality of station hall	**Amenities**: Administrative spaces & user utilities.			●	
Function	Commercial function (Facilities)	Recreational, & cultural spaces; despite cancelling the plans for a hotel.		●	●	
Form	Aesthetical expression	Contrast between materials to enhance function and grandeur.				●
Form	Image-based elements	A contrast in styles with the Doric style (exterior) and Neo-classic (interior). Offering sense of grandeur with vertical elements.				●

The results of the previous study are able to provide a summary for the station design parameters for the age; as in (**Table 2-2**):

Table 2-2: Summary of station design parameters as the driving forces of architectural design elements during pre-WWII.
Source: Author of the thesis.

Technical	• **Structural challenges:** New structural solutions in materials, spans, and load transferring. • **Locomotives:** The strong role of selecting a locomotive in providing requirements to be considered in providing spaces. • **Environmental solutions:** The strong role of selecting a locomotive in providing requirements to be considered in providing spaces, and also sustaining the users' health and structures' lifespan.
Urban	• **Structuring & urban matrix:** Head-type terminals: Outdated, multiplied head-type terminals connect to one another and move away from the city centre, and splitting the urban context from the railway infrastructure. • **Urban context:** Organising the relation between the station with its surrounding urban plan; with the integration with the roads surrounding the station, the urban masses, the problem of space availability for trains' entrance into the city; with ease of access and clearance of approach to the station for all users.
Spatial	• **Hierarchy of spaces:** Establishing available spaces and utilities that witnessed upgrades in style and class to accommodate different types and classes of people; reaching new levels of ease and comfort. Passengers pass through the ticket gate to access the platform. • **Passages & links:** Ease of access and clearance of approach to the station for all users. Safety of users in a volume with machines and crowds, the clearance of passageways and wayfinding. • **Layout organising:** *Horizontal:* On one side of the track: Suitable for administrative reasons, or on both sides of the tracks: It includes across them, or in combination in U or L-form. *Vertical planning* for separation of programme, in which trains going in and out to avoid congestion from horizontal limitations in spaces. • **Facilities:** Adding several new facilities to serve the passengers like hotels, restaurants, and postal services that started to turn the train station into a central hub to the city socially and economically. Commercial facilities and social services can be either integrated to the station building, peripheral to the building, or part of the urban context of the station's surroundings.

Style	• **Aesthetical expression:** The parameter used new and old materials to find new expressions of the age and the fitting style of the city as a "gate" to it. • **Theme:** Historical, cultural, or urban context. Finding new ways to express symbolic messages that form an artistic or a philosophical meaning to the art form of the building externally and internally.

2.8 Conclusion

The research deduced that there are 4 station design parameters: **space, urban design, style, and technology**. Each parameter has its own criteria that add up to form a design paradigm that affects a train station; no matter the volume and location of the station. Using the example of Penn Station, NY as a case study, the research shows that designing a station for that era -despite being a new type of buildings- started to follow some rules for a design paradigm:

1. Technical parameter:

The parameter that requires the use the latest **structural systems** (steel frames) that provide large spans, durability, smoke & fire protection, and proper modular system for arranging and covering all spaces. The parameter also concerns the safety and comfort of users by implementing **environmental solutions** to protect from respiratory problems; using the electrical traction instead of steam for locomotive power.

2. Urban parameter:

The parameter that concerns the relationship with the **urban context, approach, and accessibility**; guiding the relation between the station with its surrounding urban plan; with the integration with the roads surrounding the station, the urban masses, the topography of the site with the mechanical challenges of trains, the problem of space availability for trains' entrance into the city. Structuring effects of rail terminals: Adjacency, accessibility, & networking.

3. Spatial parameter:

The parameter that governs the quality of main and peripheral spaces inside the station buildings; with their adequate volumes, dimensions, and connectivity. **Platforms** started to provide safety of users in a volume with machines and crowds; using problem-solving for track-crossing and boarding/alighting, and the clearance of the platforms. **Station halls** became the main parameter (core) for required spaces, amenities for travellers, administrative areas, and utilities. Halls witnessed upgrades in style and class to accommodate different types and classes of people; reaching new levels of ease and comfort. **Commercial facilities** grew in importance for passengers in providing services during waiting, changing transportation, or serving a local community; like hotels, restaurants, and postal services that started to turn the train station into a central hub to the city socially and economically.

4. Style parameter:

The parameter that can be described as the embodiment of the form design elements. The parameter used new and old materials to find new expressions of the age and the fitting style of the city as a "gate" to it.

Finding new ways to express symbolic messages as a theme that form an artistic or a philosophical meaning to the art form of the building externally and internally.

CHAPTER 3: STANDARDISATION & RENOVATION POST-WWII

3 Topics of Chapter 3

3.1 Introduction

The second Great War had a major impact on civilizations and societies. The War caused about 60 million human losses million, and the destruction of great cities. As for communities, Germany lost about 70% of them, and the Soviet Union lost 1,700 towns and 70,000 villages. North China lost millions of square kilometres in the floods after the Japanese destroyed the trenches. Even with the victorious allies such as the United States and Canada and Australia were mostly unharmed, the European powers such as Britain and France suffered great losses that left them with almost nothing, and Britain and France faced bankruptcy. As for infrastructure and services in Europe and Asia, most of ports, bridges, trenches, were severely damaged. Great cities such as Warsaw, Kiev, Tokyo and Berlin were razed. Even railways almost disappeared, with locomotives, workshops, and factories were ruined.[135]

Following WWII, all the countries that suffered from the war had to reform their damaged infrastructure; including their railway stations, lines, and governing policies. For example: Britain had an error in its vision towards public transport and railways. Railways were nationalised in 1945, but even then, Britain suffered from the belief that public transport must be profitable. Vast areas of the British railway network were erased in the 1960s, forcing many onto the roads – a policy that is only this age, and slowly, being reversed.[136]

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[135] MacMillan, M. (2009, September). *Rebuilding the world after the second world war*. Retrieved February 2018, from The Guardian: https://www.theguardian.com/world/2009/sep/11/second-world-war-rebuilding

[136] Hatherley, O. (2016, December). *"With a good culture war, you can ignore the real reason why British transport architecture is so grim"*. Retrieved January 2017, from Dezeen.com: https://www.dezeen.com/2016/12/08/owen-hatherley-opinion-culture-war-ignore-why-transport-architecture-britain-grim/

3.2 Decline of Railways

After WWII, the development of train stations became significantly slow; as rail travel started to lose competition. In many places, rail passenger service declined; leading to further deterioration of train stations, and even closing of many stations[137]; due to:

1. **Favouring of automobiles**: as their flexibility are needed for short commercial trips and trips to close small towns, leading to high increase in production of cars and trucks. In USA, building Interstate Highway System was to needed to maximize automobiles' use outside the tight urban city planning.

2. **Convenience of air travel:** For example, wartime developments in aeronautics in USA made commercial airlines an attraction in 1950's and 1960's. Airplanes gave Americans access to faster inter-coastal and intercontinental travel.[138]

3.2.1 International style, and demolishing

"Building cannot be separated from the economics that drive construction"[139]

With the railway boom pre-WWII, the station building started with becoming a "gate" to the city, and becoming a "palace" in the city centre; with their huge main halls, effective lighting, and the combination of stonework and metal structural frameworks. With the 1960s and 1970s, the decline of rail travel -in favour of automobiles and planes- almost ended the symbolic image of rail

[137] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.2

[138] Warsing, Ryan R., *"To Polish or Demolish? : The Resurgence and Reimagining of American Rail"* (2014). College of William & Mary Undergraduate Honors Theses. Paper 6.

[139] Hatherley, O. (2016, December). *"With a good culture war, you can ignore the real reason why British transport architecture is so grim"*. Retrieved January 2017, from Dezeen.com: https://www.dezeen.com/2016/12/08/owen-hatherley-opinion-culture-war-ignore-why-transport-architecture-britain-grim/

transport and structures. The few stations built in that period were needed to be built in a crowded cityscape that removed from the stations the distinguished visual landmark property.

"The 'palace' turned into a complex territory, planned like a 'factory' with multitudinous 'pipes' connected to carry their respective traffic. City and station were at best simply juxtaposed".[140]

Using the Atlantic TGV system, it was possible to integrate the railway station as part of the city, while it also acts as a city gate and system gate, exchange pole and urban services pole.[141]

The lack of interest in rail travelling could have been a leading factor for station designers to go for more conservative designs, smaller scope than pre-WWII.[142]

Examples:

- In Rochester, New York, for example, a large New York Central Depot was demolished in 1965 only to be replaced by a single-story, rectangular unit designed to handle the most essential rail traffic. [143]

- In the problem of New York's Penn station: **Overcrowding** by kiosks and shops outside the station and inside concourses. There was also the **lack of legal ways to stop destroying historic buildings**; causing its eventual demolishing in 1966. Because of the protests against the demolition, a decision was made to issue the Landmarks Preservation Commission. It was successful in keeping Grand Central Terminal.

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[140] Maillard, M. (1995). *Reinventing the Railway Station.* Japan Railway & Transport Review.

[141] *Ibid*.

[142] Warsing, Ryan R., *"To Polish or Demolish? : The Resurgence and Reimagining of American Rail"* (2014). College of William & Mary Undergraduate Honors Theses. Paper 6.

[143] *Ibid*.

- New constructions for Euston Station that replaced a neoclassical station which is seldom lamented, except when it comes to the blackened Doric arch at its entrance, demolished in the early 1960s [144] (**Figure 3-1**).

Figure 3-1: *Euston Arch being dismantled, 1961.*

Source: Kerley, P. (2015, September)

In the 1960s, Britain switched from steam engines to diesel locomotives. Smoke coming from steam engines needed buildings with high vaults and strong ventilation. Because diesel engines did not produce smoke, Euston station cancelled the need for high ceiling; turning the building into much lower and dimmer[145] (**Figure 3-2**).

[144] Jones, R. (2014, February). *AD Classics: Pennsylvania Station / McKim, Mead & White*. Retrieved October 2016, from Archdaily: http://www.archdaily.com/475072/ad-classics-pennsylvania-station-mckim-mead-and-white

[145] *Tales From the Terminals: Euston. Part Two (1960s Euston)*. (2012, February). Retrieved June 2018, from View from the Mirror: A Cabbie's London: https://blackcablondon.net/2012/02/26/tales-from-the-terminals-euston-part-two-1960s-euston/

Figure 3-2: *Comparison between the promotional image and modern-day status. Source: Tales From the Terminals: Euston. Part Two (1960s Euston). (2012, February).*

The Euston Arch didn't seem to have a practical use, until the early 1960s. The Arch was demolished, alongside the station's Great Hall. The whole station was replaced by a modern building - *"a more functional and practical"*.[146] The modern building was intended to be similar to an airport terminal; it had wide waiting area, huge departure board, information kiosks, facilities, and long ramps. It is an expression of its time; modern, utilitarian and controversial[147] (**Figure 3-3**).

[146] Kerley, P. (2015, September). *The Beautiful Stations of Rail's Golden Age*. Retrieved August 2018, from BBC News Magazine: https://www.bbc.com/news/magazine-34333684

[147] *Tales From the Terminals: Euston. Part Two (1960s Euston)*. (2012, February). Retrieved June 2018, from View from the Mirror: A Cabbie's London: https://blackcablondon.net/2012/02/26/tales-from-the-terminals-euston-part-two-1960s-euston/

Figure 3-3: Euston Station, 1968.

Source: Kerley, P. (2015, September).

Unlike the intended design, the problems of the design continued to this day. The station has a cluttered concourse, a new mezzanine level cuts the space across one side of the room, and retail outlets, benches, and the information desk are crowding the pedestrian walkways[148] (**Figure 3-4**).

Figure 3-4: Euston's cluttered passenger concourse.

Source: Waite, J. (2018, January).

[148] Waite, J. (2018, January). *This 1960s Brochure Brags About Bulldozing The Old Euston Station*. Retrieved June 2018, from Londonist: https://londonist.com/london/transport/this-brochure-brags-about-bulldozing-euston-station

3.3 A New Look at Railways

However, around the late 1970's, railway's appeal to the society appeared once again; due to many reasons:

1. Railway transport is the fastest and cheapest land transport mode that connects the cities into their centres.[149]
2. Fixed wages compared to the increasing cost of fuel and insurance; led commuters to go for a cheaper transport mode.[150]
3. Regardless of the wages and class of commuters, urban congestion increased forcing commuter to prefer other modes of public transportation to automobiles.[151]

3.3.1 Technical parameter of the era

Following Japan's WWII defeat in 1945, the Japanese government started the plans to reconstruct dilapidated stations; starting with the government and with reorganising its railways under **JNR** for only running of the railways. As stations formed the town "face", JNR faced important challenges:

- Priority of key facilities, like tracks
- Strong demand from the community for renovations
- Small budget for station restoration
- The demand for high-pace for reconstruction.

3.3.1.1 Development of HSR

Starting from 1964, JNR started to face gradual losses as passenger numbers continued dropping; due to excessive lengths of railways and vast distribution of lines and other ownership policies on rural areas

[149] Maillard, M. (1995). *Reinventing the Railway Station.* Japan Railway & Transport Review.

[150] Warsing, Ryan R., *"To Polish or Demolish? : The Resurgence and Reimagining of American Rail"* (2014). College of William & Mary Undergraduate Honors Theses. Paper 6.

[151] *Ibid.*

with low population; thus decreasing the income for renovating stations.[152] Summarising the development of high speed rail systems around the world into two major phases[153] (**Figure 3-5**):

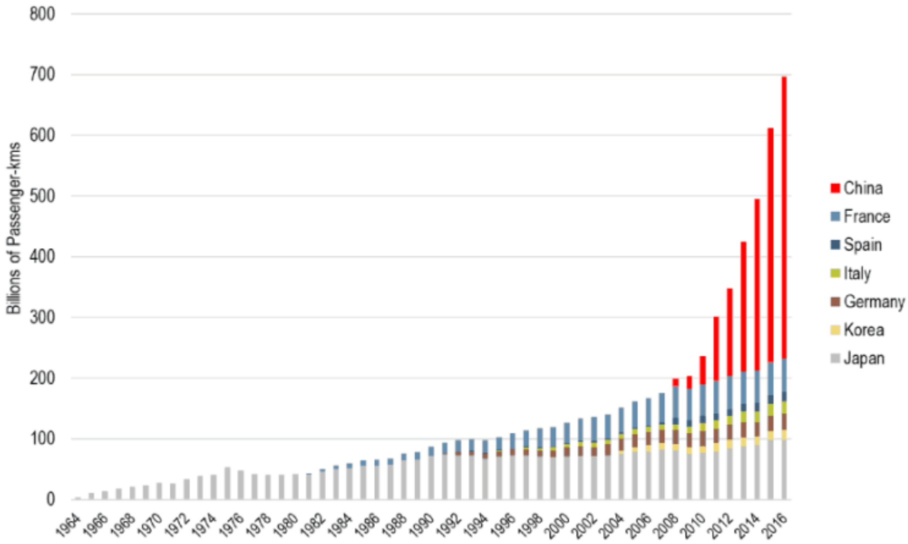

Figure 3-5: *Development of High Speed Train Traffic, 1964-2016.*

Source: Rodrigue, J.-P. et al. (2017).

Phase 1: Development of twin cities corridors:

Developing most of HSR systems was initially for connecting the most important cities within 300 to 500 km. Japan's 1st development was the Tokyo – Osaka corridor in 1964. HSR services started in Europe in 1991: two corridors between Paris and Lyon and Paris and Dijon. Asia had the 1st lines for South Korea (2004), Taiwan (2007), and China (2009).

[152] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 29

[153] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

Phase 2: Interconnection:

Developing additional HSR segments, and their growing interconnection; with some risks. By the 1990s the usage of HSR in Japan peaked, it also faced low returns because HSR was servicing lower density areas. For Europe, interconnection was more successful in Europe; such as Italy, Germany, Belgium and the Netherlands. China had the system uniquely developed and interconnected fast, so the Chinese HSR crossed the first phase.[154]

Train design is currently evolving again, with the advancement of magnetic levitation technology and Maglev trains in both Japan and Germany. The Japanese MLX01 is capable of reaching speeds of 550 kilometres per hour and the first Maglev route now runs between Pudong Shanghai International Airport and the city's financial district.[155]

Figure 3-6: *Pudong International Airport, Shanghai, and a maglev train coming out.*

Source: https://en.wikivoyage.org/wiki/Shanghai_Pudong_International_Airport

[154] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018. https://transportgeography.org/?page_id=1975

[155] Jones, Will (2006), New Transport Architecture: Travel Hubs in the 21st Century, p.203

3.3.1.2 Intermodality: Redefining a concept

The definition of the intermodal concept defines the **transportation facilities for the 21st century** can be:

"The concept of transporting passengers and freight on two or more different modes in such a way that all parts of transportation process, including the exchange of information, are efficiently connected and coordinated".[156]

This goes against the traditional **transmodality**; which is *"the movements of passengers or freight within the same mode of transport"*. Its function is to keep the flow within the network, even if complete transmodality is rare due to the regular need for changing transportation modes (harbour to station to airport).[157]

As of the *Renaissance Era* of train stations, Europe, for example, is witnessing a full-scale revival of interest in railways. The important reasons are:

1. High speed links; for HTS, TGV, …etc.
2. Mass transit's importance in energy conservation and environmental planning.

Station design is in evolution. **The intermodal concept** is being applied to railway stations for including an interchange between suburbs, intercity, or across borders, using various transportation types like buses, air services, metros, taxi, private cars, etc.; making the train an extension of, for example, the plane & not an alternative.[158]

Intermodality for railway transport affected the categorization of terminal stations; which, in turn, affected the urban value and functions

[156] Muller, G. (1999). *Intermodal Freight Transportation* (4 ed.). United States: Eno Transportation Foundation, Inc./Intermodal Association of North America.

[157] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

[158] Cerver, F. A. (1997). *Architecture of Stations and Terminals.* USA: Hearst Books International, p.71

of train stations. In other words: mixing the technical parameter with a desired urban and spatial parameter.

3.3.1.3 Categories & typology of terminal stations

Rail terminals can be categorised into: **passenger and freight**; according to the markets they service, and their locations. A third type, **shunting**, is considered as an intermediary form; since they do not deal with passengers or cargo. The research will view only the passengers' facilities.

1. Passenger terminals

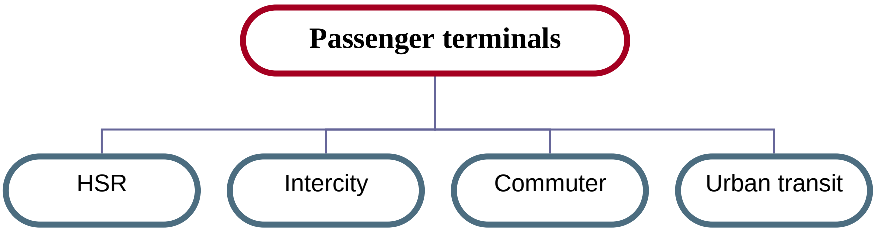

Figure 3-7: *Types of passengers terminals.*

Source: Loo, B. P., & Comtois, C. (Eds.). (2015). Format: Author of the thesis.

Passenger terminals have a whole hierarchy of rail stations depending on their size and the passenger traffic they handle. Railways have new opportunities with the growth of air transport, with the airport becoming a hub for intercity, commuter and urban transit, even turning a high speed rail station is part of the airport terminal complex.[159]

- **High speed rail stations (HSR):** the most recent type of rail terminal of them. Requires either:

  1. The adaptation of existing central stations to provide spurs connected to the high speed rail network.

[159] Loo, B. P., & Comtois, C. (Eds.). (2015). *Sustainable Railway Futures: Issues and Challenges* (1st ed.). Routledge, Abingdon, UK, p.26

2. The construction of new dedicated terminals in suburban areas to attract urban development.

- **Intercity terminal:** The standard passenger terminal; making it a central station and an urban landmark; having helped in defining urban centrality.
- **Commuter rail:** due to the short waiting time, these metropolitan stations have simpler design and function.
- **Urban transit systems:** mainly subway and light rail, and depending on density levels are shaping urban dynamics through their network structure.

2. Shunting (switching) terminals

Passenger car shunting: important but less frequent and often takes place at maintenance yards or at yards near central stations *(coach yards)*.

3.3.2 Style parameter

The era following WWII witnessed a decline in the expressive architectural language; in favour of more functionality practicality, and budget constraints. These factors to standardization of visual elements, against building conservation, and lack of comprehending an aesthetical value for the age; represented in the late modernism.

3.3.3 Spatial parameter

Japan started building stations creating a free passage gradually between the station sides and connecting both sides of the station. This was by constructing the station building over the tracks, or under the tracks. Despite its inception in the 1950's, the introduction of HSR and the pass-through terminals have an evident effect on this spatial development. It should be noted that this concept is upgrade of the elevated platforms concept introduced pre-WWII. Penn Station Terminal is an example.

3.3.3.1 Diversification of station upgrade methods

A. Over-the-tracks stations

In Japan, JNR focused more in the beginning on ground level-type stations, first appeared in Japan in 1954, but expanded to the space above tracks in 1962. Simply enough, accessing the platform was through the ticketing area. This mechanism led Japan's stations lean towards being on one side of the tracks. So, users had to cross the tracks one side to the other to reach the station. For renovating the stations and avoid the crossing problems, the solution was to **make a passage between the 2 sides by constructing the stations over the tracks**. Many stations thereafter were built in three simultaneous steps[160] (**Figure 3-8**):

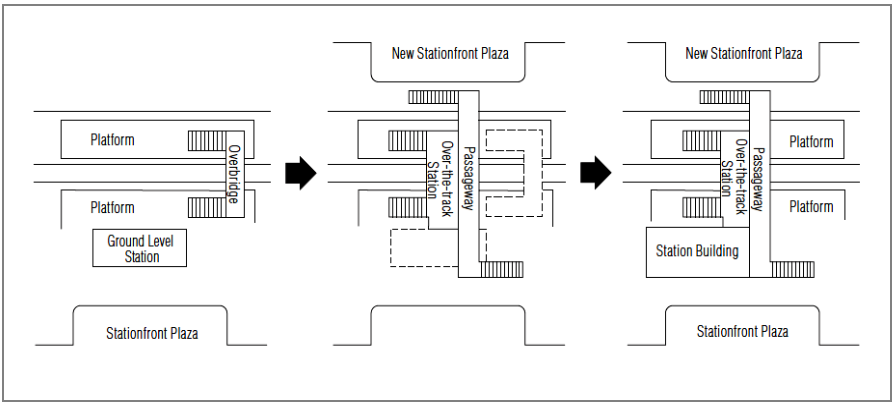

Figure 3-8: *Over-the-track station evolution & free passageway.*

Source: Ando, K. (2010)

1. *Passage construction:*

With the station splitting the community area, it was important to create above the tracks a free passage.

2. *Over - the - track construction:*

A result of having the existing station prevents making a free passage.

160 Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 29

3. *Station building construction:*

A new station built in the place of the original ground floor station.

B. Under - the - tracks Stations

Because they divide the city, urban railways showed in many cases inconvenience; often requiring elevating the tracks at road for the increasing of the efficiency of cross-tack transportation in urban areas with high densities. The problem appeared in the high cost of elevating the tracks and a distribution of responsibilities & operations between JNR asked the Ministry of Transport affected the designs; from 1940s to 1969. Part of the urban planning was the implementation of projects. Many new under-the tracks stations existed by using elevations to this day. [161] An example of following the design view is a **Shinkansen station:**

1. Elevated tracks are the basis for the Shinkansen network; making under-the-track the majority of stations.
2. Public funding build Shinkansen,
3. Stations' boundaries need to be within the viaduct walls, and using the minimum area of land to operate railways.
4. The result is the difficulty in the individual building of Shinkansen stations. The new Shinkansen stations, on the other hand, do have:
    - Distinctive entrances.
    - Public facilities that aid in the publicity for local tourism and linked to the station after founding the station plaza by the local government.[162]

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[161] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 29

[162] *Ibid.*, p. 34

3.3.4 Urban parameter: the station, and the city

It is considered that large structures and nodes of traffic are attractions for large numbers of people. Therefore, a train station (terminal) is considered an important mark in the local fabric; due to its connection to services and facilities. Such importance as:

1. Centre point of a city.
2. Accessibility for users.
3. Fast intermodality.
4. Gives a visual look to the city.

In the last few decades, on the other hand, as the population started moving towards suburbs from centres of cities and towns (e.g. the Japanese case), the role of the train grew to become: **A link between the residential periphery and the commercial and financial centre.** Since the majority of users of the line make the journey daily, the station is considered the most important focal point of the neighbourhood.[163] For similarity of development amongst urban cities, Europe is a good example. As for function, they have old train stations; distinguishable structures that are both an old part of the infrastructure and enriching the heritage of its city. The problems, however, with these old structures are (**Figure 3-9**)[164]:

[163] Cerver, F. A. (1997). *Architecture of Stations and Terminals.* USA: Hearst Books International, p.71

[164] Stevanović, K. N., & Stevanović, M. V. (September , 2014). *New Directions in the Design of Railways Stations*. Građevinar, volume 66, issue 8, p. 740.

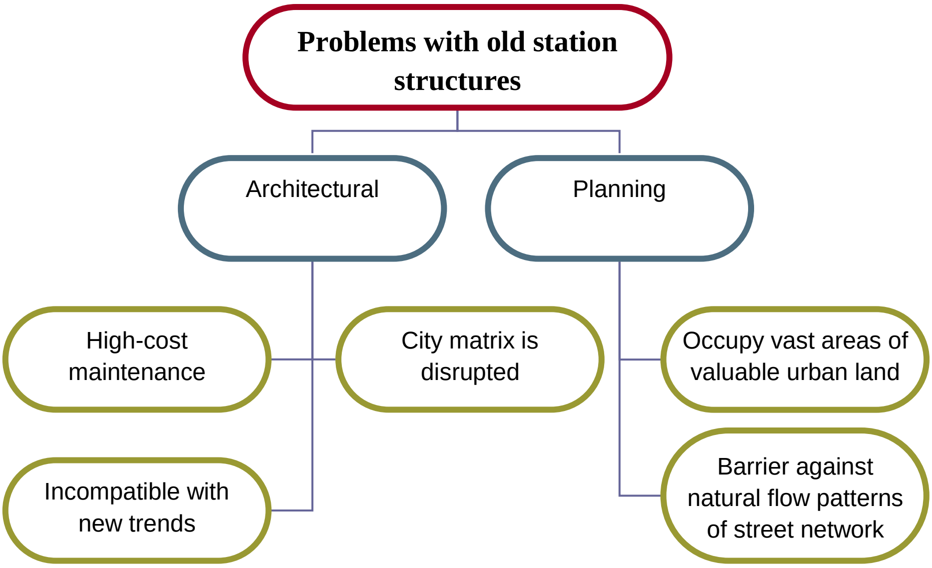

Figure 3-9: *The classification of the problems of maintaining heritage station structures. Source: Stevanović, K. N., & Stevanović, M. V. (September, 2014). Format: Author of the thesis.*

3.3.4.1 Trains, and interaction with the urban matrix and planning

The problems of planning are because of constructing the railways horizontally; a result to the **head–type**. A **pass-through** idea provides much-higher interaction regarding urban matrices. (**Figure 3-10**) explains the steps of the relationship development between the urban fabric and its station; as follows:[165]

1. *Urban matrix boundary*
2. *City centre*
3. *Original head-type line*
4. *New outer connection*
5. *New tangential connection*

[165] Stevanović, K. N., & Stevanović, M. V. (September , 2014). *New Directions in the Design of Railways Stations*. Građevinar, volume 66, issue 8, p. 740.

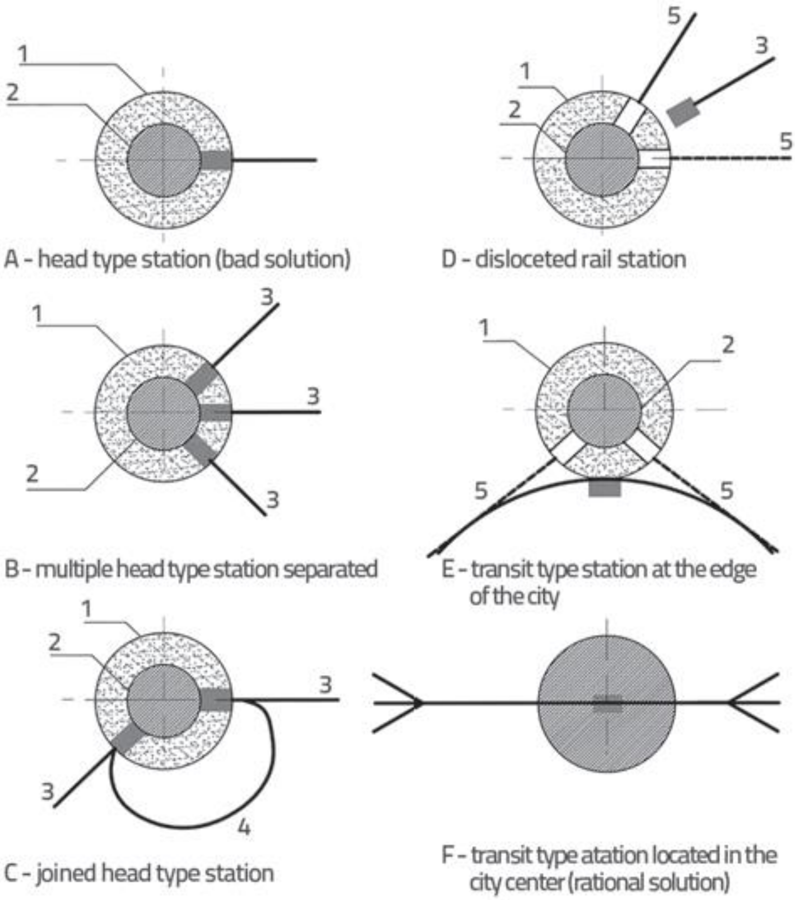

Figure 3-10: Development of relations between the station and the city.

Source: Stevanović, K. N., & Stevanović, M. V. (2014).

3.3.4.2 Development of pass-through concept to train stations

The final design product for designing a train station is defined by the interrelationships between its 3 main spaces: **Station entrance (square), station building, and platforms**. The final design product serves a relationship between architectural and urban design of the whole area, and one should look at **pass-through**, and **head-types.**[166]. See (**Table 3-1**) for comparison.

A. Head-type terminals

- Considered an obsolete term for treating construction, traffic, planning, and architectural design.
- From the late 1800's, many head-type terminals are connected to each other, getting farther from the centres of the city.
- Led to the formation of transit stations at the borders of a city. In turn: **the transit-type terminus** at the city centre.[167]

B. Pass-through station

- Used for connecting several railway lines in the same network (**Figure 3-11**).
- A station's sub-type is determined from site properties, and from natural and man-made elements in the surrounding area.
- A pass-through terminus started with having the station building separated from the platforms, which meant that accessibility to the platforms was either by a gangway or an underpass.
- The concept gradually changed, and connected the station building to the platforms becoming a single huge complex, and also gave a unity in the architectural treatment of the facades (**Figure 3-12**);[168] with the vertical arrangement of the plan produces more benefits to the function and the city.

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[166] Stevanović, K. N., & Stevanović, M. V. (September, 2014). *New Directions in the Design of Railways Stations*. Građevinar, volume 66, issue 8, p. 741.

[167] Stevanović, K. N., & Stevanović, M. V. (September, 2014). *New Directions in the Design of Railways Stations*. Građevinar, volume 66, issue 8, p. 741.

[168] *Ibid.*, p. 741, 742.

Table 3-1: *Comparison between head-type and pass-through station types.*

Source: Stevanović, K. N., & Stevanović, M. V. (September, 2014). Format: Author of the thesis.

	Head-Type Station	Pass-Through Station
Advantages	• Greater spaciousness. • Located away from the city centre. • A rich value of heritage.	• Line merging causes lower line number with overall traffic control. • Merging introduces various interregional lines / other lines into the urban area • Configuration and splitting of rail networks and types (passenger/freight) when integrated to the city transportation system • Better accessibility to the stations (station or pass-through). **Vertical pass-through train stations:** • Easier traffic approach with the numerous station squares, levels, and entrances. • Unity in architectural appearance and functionality. • Area of urban occupancy: relatively small. • Transition is faster and easier in intermodality.
Disadvantages	• Splitting the urban context from the railway infrastructure. • Very limited throughput capability of rail traffic in comparison. • Input-output type: operating requires a greater number of tracks for mandate long manoeuvres. • Larger area of urban land for manoeuvres.	• Long distance from the station square to platforms, and narrow dark-corridors or passageways exposed to external influences. • Requires more skilful planning.

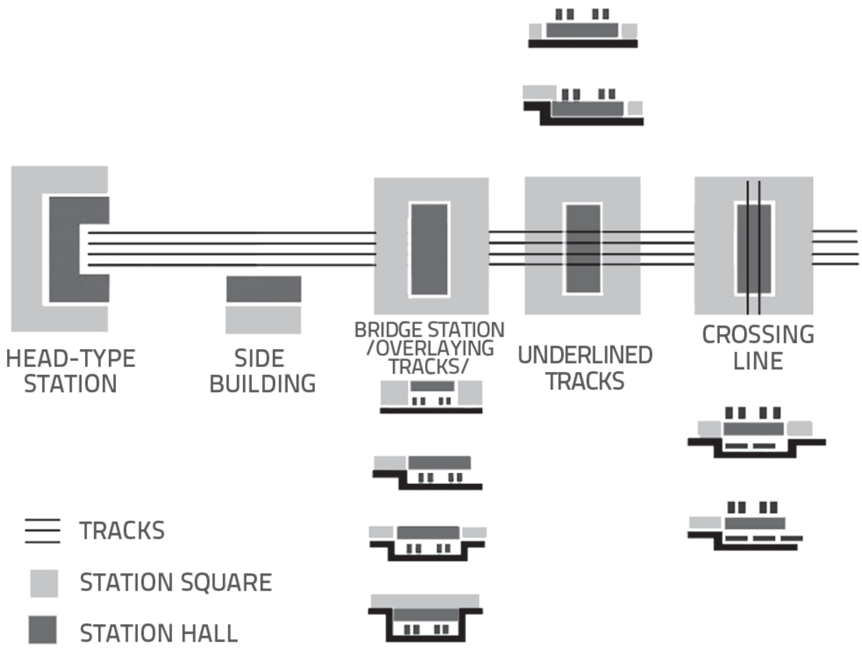

Figure 3-11: Head-type and pass-through stations' zoning.
Source: Stevanović, K. N., & Stevanović, M. V. (2014).

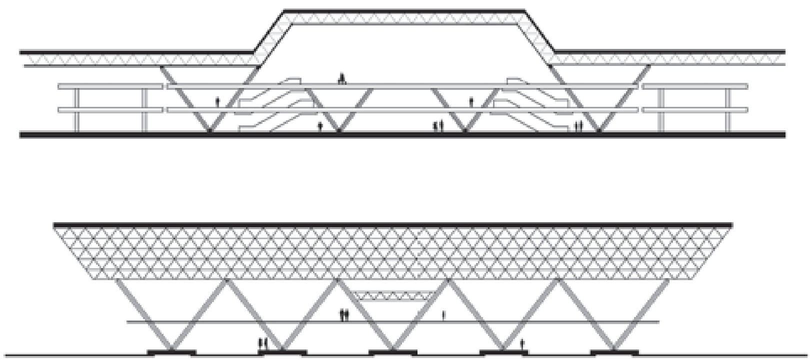

Figure 3-12: Section through a pass-through type station, provides a unified vertical content

Source: Stevanović, K. N., & Stevanović, M. V. (2014).

3.4 Conclusion

The chapter explains the changes that faced the railways after WWII; with the decline of railway services in favour of air and road modes. This led to:

1. Standardisation of train station design, and abandoning the monumental approach for exterior design.
2. Shutting down of several stations.

The chapter demonstrates the problems with previous urban solution for a station's location, the effect of High-Speed Trains on a station's location, and comparing the old solution with the developed urban concept.

Table 3-2: *Summary of station design parameters as the driving forces of architectural design elements during post-WWII.*

Source: Author of the thesis.

Technical	• **Structural challenges:** Standard structural solutions • **Locomotives:** Following the war, a decline in railway progress, relying more on motor roads. High-Speed Trains by Japan in 1963 changed typology of terminal & platform design; leading to several changes to urban and spatial to the design paradigm. • **Environmental solutions:** Choosing either the newly-presented electrical trains sustains the users' health and structures' lifespan.
Urban	• **Structuring & urban matrix:** - *Interaction with the urban matrix and planning:* <u>Pass-through stations</u>: Integrating vertical plans of the entire complex vertically for content; which add functionality to the city. • **Urban context:** The decline of rail travel harmed the symbolic image of rail transport and structures. The few stations built in that period were needed to be built in a crowded cityscape that removed from the stations the distinguished visual landmark property; leading to more conservative designs, smaller scope than pre-WWII.
Spatial	• **Hierarchy of spaces:** - Poor expression. Minimum functionality, standardization against expression.

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- Hierarchy and clarity became complex overtime.
- Design accommodation to existing elements only & leaving the new; making the centre not serving a useful purpose.
Passages & links:
- Development of dimensions and routes started with new train technology.
- Weak distinguishing of passages and classification.
Layout organising:
Vertical planning becomes more important. The continuation of the strategy of vertical planning efficiently; for technical, and civil functions, and also for land use, inclusivity of functions, and even creating landmarks. Structure also started to play a role in aesthetics with rhythm, straight or organic motion, etc.
- Over-the-tracks stations: creating a free passage between the station sides. Many stations thereafter were built in three simultaneous steps: Passage construction, Over-the-track construction, station building construction.
- Under-the-tracks Stations: Projects were implemented as part of urban planning, and even today, elevation is used to create many new under-the tracks stations e.g. Shinkansen station.
Facilities: Cluttered; even blocking main entrances.

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<td>Style</td>
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Aesthetical expression: Weak. Modern elements and demolishing of old elements in favour of more utilitarian and ease.
Theme: The decline of rail travel harmed the symbolic image of rail transport and structures. The few stations built in that period were needed to be built in a crowded cityscape that removed from the stations the distinguished visual landmark property; leading to more conservative designs, smaller scope than pre-WWII.

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1. Technical parameter:

Following WWII, there was a decline in railway progress, relying more on motor roads. High Speed Trains by Japan in 1963 changed typology of terminal & platform design.

2. Urban parameter:

Outside the building witnessed poor organization of activities, consumption of spaces, and therefore complexity of functions at the end of the era

However, it should be stated the new arrangement and planning of the station; especially as a result of HSR:

<u>Interaction with the urban matrix and planning:</u>

- Head-type terminals: Outdated, multiplied head-type terminals connect to one another and move away from the city centre.
- Pass-through stations: Integrating vertical plans of the entire complex vertically for content; which add functionality to the city.

3. Spatial parameter:

Japan introduced 2 types of stations:

- Over-the-tracks stations: creating a free passage between the station sides. Many stations thereafter were built in three simultaneous steps: Passage construction, Over-the-track construction, station building construction.
- Under-the-tracks Stations: Projects were implemented as part of urban planning, and even today, elevation is used to create many new under-the tracks stations e.g. Shinkansen station.

4. Style parameter:

The era following WWII witnessed a decline in the expressive architectural language; in favour of more functionality practicality, and budget constraints. These factors to standardization of visual elements, against building conservation, and lack of comprehending an aesthetical value for the age; represented in the late modernism.

CHAPTER 4:
UPDATING STATION PRINCIPLES FOR A NEW AGE

4 Topics of Chapter 4

4.1 Introduction

The chapter continues with the changes that faced the railways after WWII. Starting from the late 70's, the technological advancements of trains, and the development of the urban role of the stations led to a new defining stage: The Renaissance of stations. Within this stage, the developers of stations realised the importance of old monumental stations for their cultural value, and acquiring the means, technologies and legislations to upgrade said stations and also construct new major stations.

4.2 Design Direction in Europe (1980s-)

After decades of ignoring rail travel in favour of automobiles, railways returned to have a central role in urban life with the increase in passenger numbers; leading to the rise of the importance of economy and culture from stations. People needed train stations with high-quality, beauty, and flexibility in their location within the city.[169] Train stations must have every facility in an order for their main functions: ticketing, waiting, boarding, and alighting - and also the commercial functions. The contemporary age produced all-new facilities and newly developed stations.[170]

Train stations are designed to serve people; as a reliable and a comfortable service. There are several factors that "*stations for people*" need to find a solution for. Railway operators knew that today's railway stations needs to achieve the requirements of trains and users.[171]

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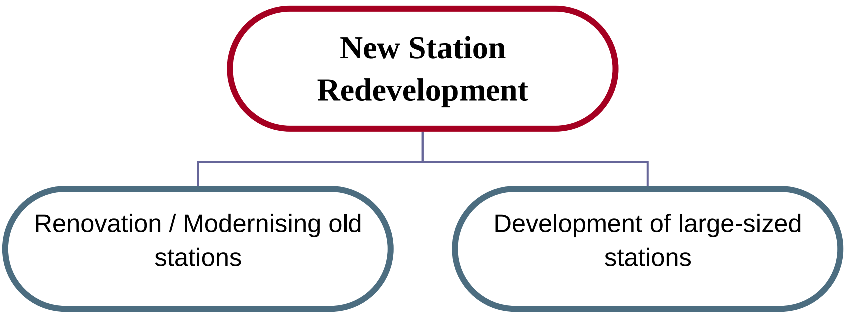
[169] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Stations in the City – How are Transport Hubs Evolving to Meet Local Needs?* Retrieved July 2018, from ARUP: https://www.arup.com/perspectives/cities-and-stations

[170] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.58

[171] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Op. cit.*

So, investment programmes emerged to expand and modernise many stations across Europe and North America. Arnhem Central Station is one example: dating back to 1845, the station has been completely redeveloped to better meet today's travel needs. It was opened late 2015. In other regions, the focus is more often on the construction of new public transport systems, like Shenzhen Metro's new Line 4 - 15 stations built with provision for development above.[172]

From the previous chapter, the emergence of high-speed trains (HST) had a critical role in the redevelopment of the station design(s); which led to a *"renaissance"* in many forms[173]:



4.2.1 Importance of station developments *(station renaissance)*

1. Providing places in transit for simple trips as a priority without distractions. Some rail and metro stations, such as Cityringen *(City Circle Line)* in Copenhagen[174]

[172] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Stations in the City – How are Transport Hubs Evolving to Meet Local Needs?* Retrieved July 2018, from ARUP: https://www.arup.com/perspectives/cities-and-stations

[173] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design*. Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.58

[174] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Op. cit.*

2. Creating new destinations that have dynamic, multifunctional spaces where people can do much more than set out or arrive on a journey. New spaces include libraries, medical centres, theatres, shops, and eateries. This requires greater flexibility – as seen in Canary Wharf's new Crossrail station, where the commercial space can be completely redesigned to meet tenant needs – this in turn needs careful planning and design[175] (**Figure 4-1**).

3. Adapting of HST by modernising old stations; with renovating can become integrated with existing buildings, innovation in structure with function. The prominent train stations within the urban fabric, should have visually-attractive qualities. So, the buildings often satisfy the requirements of both architectural alongside structural needs.[176] Rail and metro stations are powerful catalysts for regeneration. Stations today express strongly symbolism of the place, so they should smoothly integrate with their cities' identities.[177]

4. Response to the redesigning the urban plan of cities and the introduction of high-speed trains network. Such stations have become big architectural achievements. Current **intermodal stations**, often similar to airports, must respond to different requirements than before. They provide:

   - Access to different transportation modes.
   - Part of a new urban and commercial centre with administrative, shopping and leisure services.[178]

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[175] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Stations in the City – How are Transport Hubs Evolving to Meet Local Needs?* Retrieved July 2018, from ARUP: https://www.arup.com/perspectives/cities-and-stations

[176] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.53

[177] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Op. cit.*

[178] Kido, E. M. (2013). *Op. cit.*, p.53

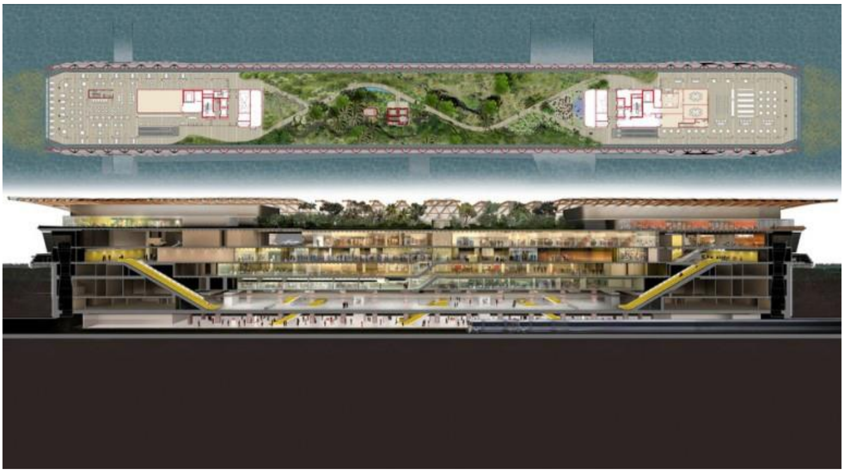

Figure 4-1: *Cross section at Canary Wharf Station.*

Source: Canary Wharf Station. *(n.d.).*

4.2.2 The revival direction of stations

Brought attention to the station's quality

Brought attention to station users.

The trend has influenced the development of new generation of stations in Europe and Japan that included **totally new infrastructure, as well as redeveloping existing, and extended** by renewing buildings in a better quality; that attracts the attention of the users. The station turned into a source of friendly environment for people alongside providing technological solutions and commercial centres. [179] Important examples of the renaissance of stations in Britain are **St Pancras** and **King's Cross** (the latter to be discussed in further chapters), London's two hugely contrasting northern terminals, and were rebuilt by Network Rail. In 1966 proposals to demolish both King's Cross and St Pancras were put forward by British Rail. However, following the public response from figures such as architectural historian Niklaus Pevsner and

[179] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.54

poet John Betjeman, the station was listed **Grade I** in November 1967.[180]

4.2.3 Station redevelopment programmes in Europe

Train operators found out that stations should include several activities alongside the rail transport services. The aim of the rail operators was "*to promote a new image of railway travel, of station and of the rail operators themselves"*. The redevelopment of buildings, and inclusion of HST & LRT are part of the environmental and urban concerns. Among the European countries to adapt the new policies and technologies are:[181]

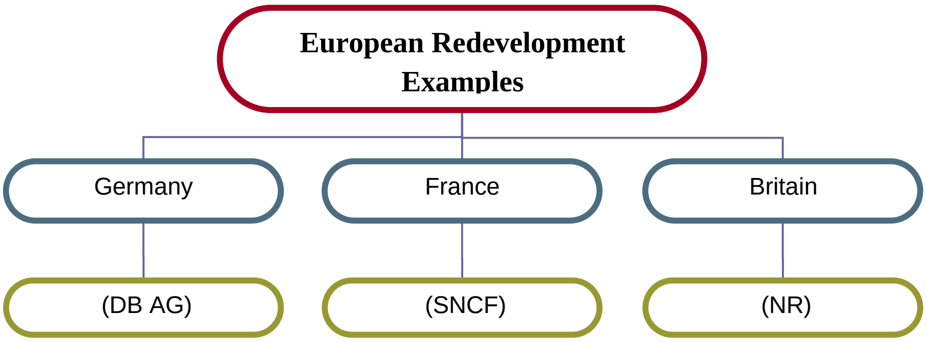

Figure 4-2: *Diagram of important examples of European station renaissance, and their respective train operators.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

4.2.3.1 Deutsche Bahn and station redevelopment in Germany

Based on DB comprehensive station development programme: "Emergency Programme" (2002), which assumes that: "*each station*

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[180] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

[181] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.54

is a 'visiting card' of the city and responsible for conveying their identity". The programme started with:

- Quality
- Economy
- Brand products

The "Emergency programme": was mainly related to:

- **Platform modifications** for HST; inserting new corporate design (in graphics, platform furniture)
- **Building new stations** for HST & airports.
- **Renovating and enhancing the image** of stations and its spaces; hence creating the **corporate design.**

Corporate design:

Uses aesthetic features, overall unity and diversity of elements by solving the problem of non-consistent design approaches of different railway companies by designing a dependable railway product as a coherent design for all rail sections. The concept also called a "forum station"; public function and an attraction.[182]

DB AG programme produced the following stations:

Table 4-1: *Renaissance stations of Germany.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

Renovation	Construction
• Leipzig Hauptbahnhof (1997) • Dresden Hauptbahnhof (2006) • Osnabruck Hauptbahnhof (2012).	• Berlin Hauptbahnhof (2006) • Koln/BonnFlughafen Bahnhof (2003)* • Montabaur Bahnhof (2002)*

** On the new ICE line – New Cologne–Rhine/Main line*

[182] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.55

4.2.3.2 French Railways & redevelopment for France

Table 4-2: *Redevelopment stations of France.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

Renovation	Construction
• Gare d'Austerlitz (1989) • Gare de Lyon (1994) • Gare du Nord (2001) • Gare de'l Est (2007) • Gare Bruxelles-Schuman (2014 u.c.)	• Lyon Gare de Saint-Exupéry TGV (1994) • Gare Lille-Europe (1994) • Gare Meuse TGV Voie Sacrée (2007) • Gare de Besancon TGV (2011)

French railways went through replacement and renewal in the infrastructure and operating system. SNCF runs France's national rail services, and its TGV.[183] The French aims for policies include:

- Strengthened corporate design.
- Vigorous station renewal.
- Introduction of new amenity type.
- Integration of city need to the main rail service; such as commercial functions.
- Introducing **certification for stations**, which consists of 45 element concerning function and image.

Stations in France were met with policies for modernization that is continuous to this day. Renewal of station requires careful studies on historical architecture while new train stations followed the airport theme in its zoning and lightness of structures. TGV is the main reason for the station renaissance in France.[184]

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[183] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design*. Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.55, 56

[184] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design*. Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.55, 56

4.2.3.3 Network Rail and redevelopment in the United Kingdom

Like Germany, and to improve the network and appeal to users, Britain went through trials of nationalizing and privatisations until 2002, NR has the ownership and management of station buildings, but not the operations.[185]

In the majority of cases, new stations are funded by a partnership, such as local authority, train operator and developer. Government support may be available for such an approach through specific funds. Seventy five railway stations have opened since 1st January 2000 across the UK National Rail network, with a total of 2,563 railway stations are open on the UK national rail network.[186]

To achieve the new product of station that achieve the trust, efficiency, comfort, and experience - while preserving the history part of the buildings, NR has promoted new railway station's goals, such as:

1. **Quality** (improvement and renewal)
2. **Operation** (balanced services)
3. **Access** (provision of interchanges, barriers-free)

Several guideline policies were issued for renovating and redevelopment of station, "Station 2000" and construction of new stations.[187]

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[185] *Ibid*., p.56

[186] *New Stations*. (2017). Retrieved July 2017, from www.railfuture.org.uk: http://www.railfuture.org.uk/New+stations

[187] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.56

Table 4-3: *Redevelopment stations of Britain.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

Renovation	Construction
• St Pancras (2007)	• Cambridge North (2017)
• King's Cross (2012)	• Oxford Parkway (2015)
• Waterloo International (1994)	• Leeds (2015)*
• Paddington (1998)	
• London Bridge (2018)	

**Newly-rebuilt. Original opening: 1938.*

4.3 Conclusion

Beginning from the late 70's, the technological advancements of trains, and the development of the urban role of the stations, have led to a new defining stage: The Renaissance of Stations. Within this stage, station developers realised the importance of old monumental stations for their cultural value, and acquiring the means, technologies and legislations to upgrade said stations and also construct new major stations. It was not long afterwards that European countries started developing its regulations and ideas for setting the criteria for conservation, station renovations for new functions, technologies, and constructing new stations for new needs.

CHAPTER 5:
INTERMODALITY & STATION COMPLEXITY

5 Topics of Chapter 5

5.1	**Intermodal Concept**
	5.1.1 Station intermodal types
5.2	**Aspects of Intermodal Station Design**
	5.2.1 Major physical and functional elements of station building
5.3	**Design Complexity & Purpose Confusion**
	5.3.1 Main stations' spaces, and the required application of rules
	5.3.2 The causes and effects of the increase of spaces and practical considerations of spaces
	5.3.3 Design elements in expressing physical elements of a station
5.4	**Function as a Design Element**
	5.4.1 Transportation function
	5.5.2 Commercial & cultural functions
5.5	**Form as a Design Element**
	5.5.1 Aesthetical expression
	5.5.2 Image - based elements / Landmarks
5.6	**New Design Elements in Reshaping Train Station Parameters**
5.7	**Conclusion**

5.1 Intermodal Concept

Since the late 1980's, the renaissance of railway stations turned their buildings into symbols of economic power and landmarks of their environments. With the developed concepts of pass-through stations, the stations could be placed **under** or **above the ground level**, or even at where lines from the city and other regions **intersect** (**Figure 5-1**).

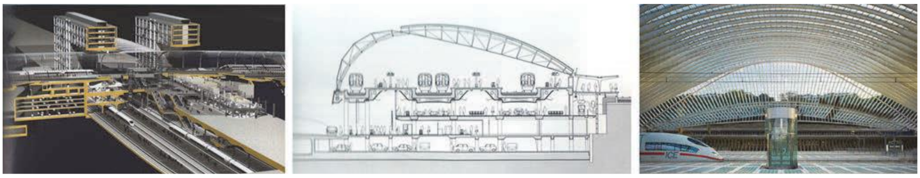


Figure 5-1: *Modern termini and their placements (L-R): Berlin Hauptbahnhof, Waterloo Station, Liège Station.*

Source: Stevanović, K. N., & Stevanović, M. V. (2014).

Apart from the already accepted vertical concept as was explained before, these stations should meet **several other functional needs**, such as:

1. Efficiency and adapting the current forms in transportation mode change.
2. Better **orientation**.
3. Safety of users of the station.
4. Adequate **daylighting** to light all storeys below.
5. A new form and visual language to give a covered area with required facilities.
6. Adding a new landmark to its urban fabric.[188]

[188] Stevanović, K. N., & Stevanović, M. V. (September, 2014). *New Directions in the Design of Railways Stations*. Građevinar, volume 66, issue 8, p. 742.

5.1.1 Station intermodal types

The new concept of transportation via railways went towards integration, whether it is an intercity or across borders. In terms of railway stations, each transportation mode is an extension of the other. The intermodal concept generated different types of stations in (**Figure 5-2**).

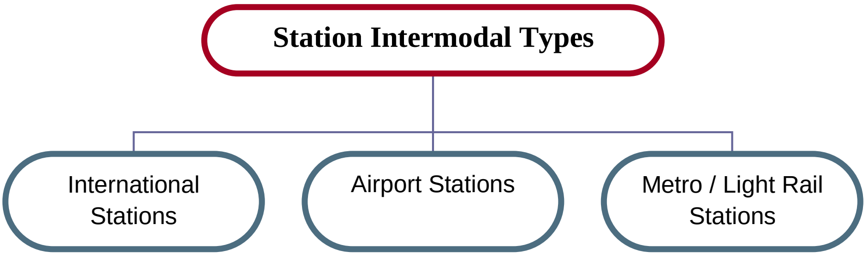


Figure 5-2: *Distinctive building patterns for railway stations using intermodal concept.*

Source: Kandee, S. (2004). Format: Author of the thesis.

5.1.1.1 International train stations

Airports had a significant effect on train stations' facilities and their designs; such as: ticketing, passport checking, security checkpoints, and segregation between arrivals and departures.

Example: Waterloo International, London

Figure 5-3: *Bird-eye view of Waterloo Station, London.*

Source: www.wikipedia.org

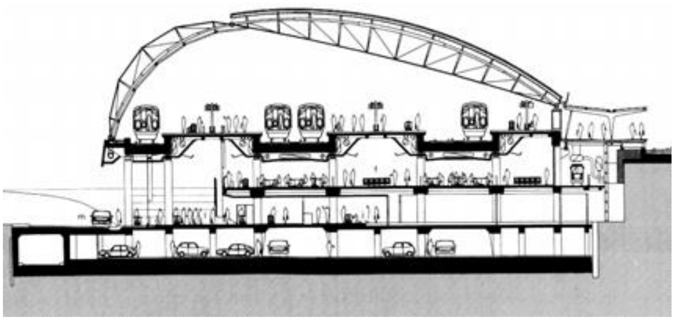


Figure 5-4: *Cross section of Waterloo International's levels of separate departures from arrivals.*
Source: Kandee, S. (2004)

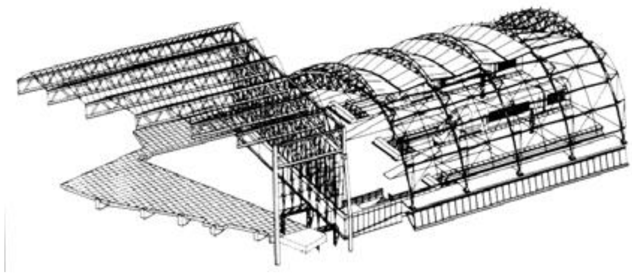


Figure 5-5: *Waterloo International. View of 3rd floor platform and its roof.*
Source: Kandee, S. (2004)

Waterloo International Terminus adapting of airport language serves both the function and form aesthetics. It has an addition to its old structure a massive 396 m-long shed added to the old structure that helps in giving separate levels for departures and arrivals, with the platform on the 3rd floor, with services below, and entrance to concourse is on the ground floor [189] (**Figure 5-4** & **Figure 5-5**).

5.1.1.2 Airport train stations

The concept aims to connect inner cities to the designated airports using railways; requiring building train facilities at airports. The designer should provide the required extra spaces for baggage,

[189] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.3

security, etc., and also require segregation, clarity and security for links between the station and airports.[190]

Example: Copenhagen Station, Denmark

Serving about 15% of the airport users, the triangular Terminal 3 is an addition to the airport, with the station itself at the triangle's point (**Figure 5-6**).

Figure 5-6: *T3 and its station, Copenhagen Airport.*

Source: Kandee, S. (2004).

5.1.1.3 Metro or light rail stations

Light rail is considered a flexible and cost-effective in installation and maintenance. These reasons make light rail become favourably compared to buses and trams, and becoming a part of the city areas.

Example: Bangkok Mass Transit System (BTS)

One famous engineering solution with which the station is elevated above the ground and entrance, with the supporting is on a row of single columns carrying a cantilever on both sides. (**Figure 5-7**).

[190] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.4

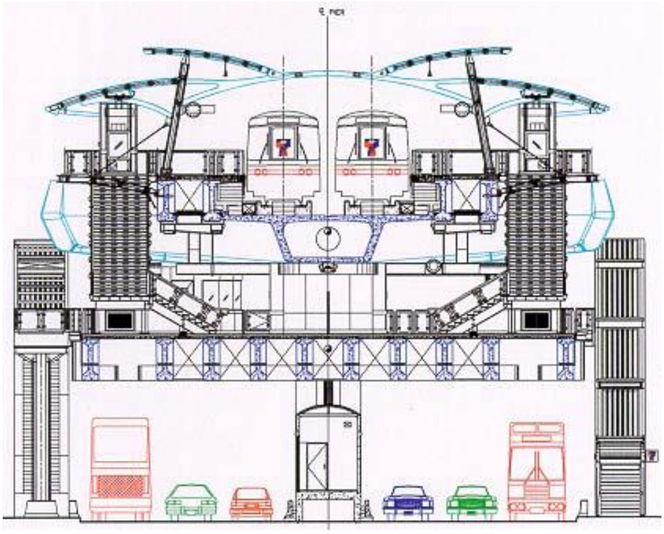


Figure 5-7: Cross section of a BTS station.

Source: Kandee, S. (2004)

5.2 Aspects of Intermodal Station Design

5.2.1 Major physical and functional elements of station building

In the early days, trains were for long-distance transportation, so the waiting rooms and left luggage offices were the most important spaces for passengers. However, the floor plan changed from waiting to fluid medium due to the increase in commuters, thus changing the functions due to changes in[191]:

- Customer character
- Equipment advances
- Railway company policy
- Social demands

[191] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 30, 31

Today's stations tends to express their design concept differently from their past. Nowadays, stations are often designed in a way that makes the utmost benefit from existing buildings that are already a part of the urban design; as designers pay thorough attention to solve problems with interior planning of spaces. Most stations typically have **four main functional areas**. (**Figure 5-8**) shows the four functional areas and their interrelationships[192].

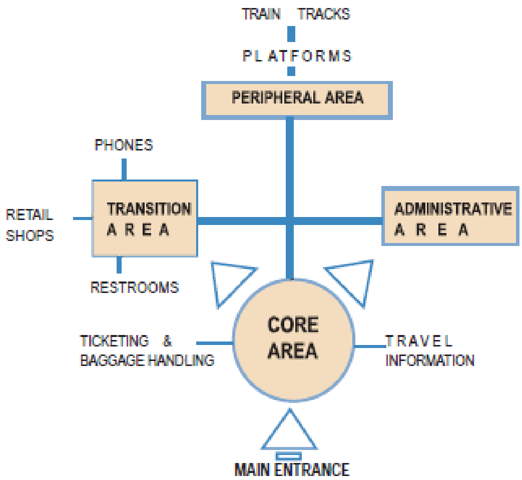


Figure 5-8: *Flow diagram of functional element.*

Source: Kandee, S. (2004).

Those four areas represent the major physical and functional elements, along with their relationships to each other, which can be essential for establishing an intermodal station.

The goals of this inter-relationship; as a collective, general value can be summarized as[193]:

1. **Linking physically together** to achieve good functional flows among them, & smooth connections in and out of the stations.

2. **The efficient space capacity** for the increasing rate of users.

3. **Routes** for pedestrians and vehicles should be clear, and safe, with their widths reflecting: **a) functions within the building**, and **b) movement scale.**

[192] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.4

[193] *Ibid.*, p.6

4. **Emphasizing hierarchies in function.** A passenger's trip inside a station from the entrance to the platform should be free of obstructions. For this reason, there was the need to physically expand the main circulation areas; usually the entrance hall, main hall, and concourse. (**Table 5-1**) explains the comparison between the four areas according to their definition, activities, area requirements, and users.

Table 5-1: *Functional standards of main areas in railway stations.*

Source: Kandee, S. (2004).

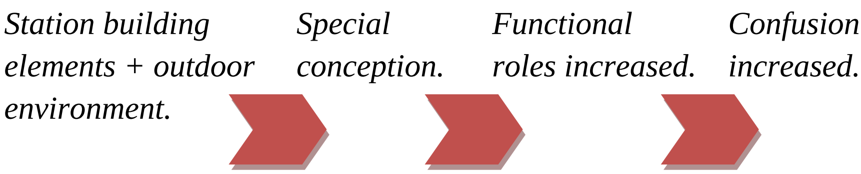
	Core	Transit	Peripheral	Administrative
Definition	- Centre of closely related areas. - Processing passengers.	- Connect transit facilities in core areas to transportation modes. - Usually include secondary, but often-essential facilities.	- Support circulation outside the main buildings.	- Control both traffic & station management. - Only in some station types for complex arrangements to large number of passengers.
Activities	**Departing** - Checking train schedule. - Ticketing. - Baggage handling - Fare collection. - Gate check-in. - Waiting. **Arriving** - Meeting & greeting. - Reclaiming baggage	**Departing, Arriving, Working & Visiting** - Using public facilities. - Walking to vehicles or waiting around before boarding - Shopping or eating.	**Departing, Arriving, Working** - Boarding. - Loading & unloading. Maintenance.	**Working & controlling traffic System** - Working. - Controlling traffic systems & functions in the stations.

	Core	Transit	Peripheral	Administrative
Area requirements	**Main Hall** - Information. - Ticket office. - Ticket machine. - Ticket counters with baggage check-in. **Departure hall** - Automated fare collectors or staff. - Seating. **Arriving Hall** - Meeting point or seating. - Baggage reclaim.	**Public service facilities** i.e., restroom, public & lockers. **Amenities** i.e., shops, restaurants, & snack bars.	**Platforms** - Tracks. - Workshops / vehicle service areas. - Traffic signal.	**Offices** - Isolated from / inserted among other facilities, i.e., Management office. - Traffic Controlling office.
Users	**Main Hall** - Passengers & guests. - Staff. **Arrival Hall** - Passengers - Greeters. - Staff.	**All users** -Passengers & their guest. -Staff. -Visitors.	- Passengers. - Staff.	- Staff. - Visitors.
Comments	- Ticket sales depend on type & size of stations. - All functions may take place in one open space, i.e., main lobby, ticket hall, etc. or separate areas, but connecting. - An arrival hall is normally the same area as a departure hall.	- Public facilities are necessary for any type of station. - The variety of amenities depends on the type, size, & concept of stations.	- Numbers of platforms and train tracks derive from numbers of passengers a terminal can handle. - Maintenance services are provided only at large terminals.	- Locations of administrative office may be isolated from others or inserted among facilities in every area, but they have to be able to control all systems.

5.3 Design Complexity & Purpose Confusion

The importance of railway stations is with various functions –aside from accessing to trains- like a place for meeting, shopping, and urban landmarks. The functional type of the station is the factor that affects the landscape; considering many types of stations, like: Central city terminals, airport, light rail, etc.[194]

With station designing became expansive in space in volume and types, and as a result, in activities. Space functionality became more complex; an issue that turned the space from the inside into a disorienting experience; as the "red line" that separates the travel spaces from the other public ones became more blurred[195].



As a modern interpretation as an intermodal knot, the complexity of a railway station should be both a system of space sequences, and includes reference points marking out the course. Easy access and simultaneous perception of various levels of the station result in comfort and fluidity for users.[196]

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[194] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design, p.59.*

[195] Smith, M., Juul-Sorensen, N., & Worsfold, T. (2017). *Stations in the City – How are Transport Hubs Evolving to Meet Local Needs?* Retrieved July 2018, from ARUP: https://www.arup.com/perspectives/cities-and-stations

[196] Maillard, M. (1995). *Reinventing the Railway Station.* Japan Railway & Transport Review.

Figure 5-9: *The basics of flow direction for passengers.*

Source: Fourie, C. J. (2014).

5.3.1 Main stations' spaces, and the required application of rules

From the previous 4 main elements of stations *(core, transit, peripheral, and administrative)*, the following is the collection of the practical considerations in designing the area requirements of stations:

1. ***External circulation:*** The architectural design value of a station is articulated by the architecturally-distinctive entrances, clear and separate walkways, clarity and ease in reaching desired destination inside the station.

2. ***Ticket offices:*** In this contemporary age, ticket reservations can be done online, but there is a need of regular ticketing spaces; which can affect the circulation process.[197] These spaces should provide ease, space, and comfort to the users[198].

3. ***Commercial spaces:*** organised in their designated spaces, and non-obstructing to the walkways outside their areas.[199]

4. ***Waiting rooms:*** for the passengers to get some rest before travelling. Contains amenities such as travelling information, communication means, comfortable furnishing, etc. [200]

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[197] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 30, 31

[198] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design, p.59.*

[199] *Ibid.*

5. ***Platform shelters:*** serves both as an eye-catching element, but the glazing provides protection from the weather[201].

6. ***Toilets:*** well ventilated and lit. [202]

7. ***Barrier-free access:*** linking elements (stairs, lifts, ramps, etc.) should have an appropriate finishing, handicapped-friendly elements, safety, and clarity.

8. ***Information signs:*** Even with the presence of online guides, audible and visual information should be present, near entrances and main spaces; to avoid confusion, time-loss, and congestions;[203] especially with the presence of crowds, advertisements, and noises.[204]

5.3.2 The causes and effects of the increase of spaces and practical considerations of spaces

Table 5-2: *Result & reasons for a disorienting experience in a station.*

Source: Kandee, S. (2004). Format: Author of the thesis.

Cause	Overcrowding of shops, booths, displays, etc.	- Consumption of spaces. - Poor organization of activities.	Design accommodation to existing elements only & leaving the new.
Effect	Increased confusion among users.	Complexity of functions.	The centre not serving a useful purpose.

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[200] *Ibid.*

[201] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.59.

[202] *Ibid.*

[203] *Ibid.*

[204] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 31

The centre will lose its usefulness if the station building's design accommodates only existing elements without considering the new ones. With the internal circulation reinforcing the functional priorities (**Figure 5-10**) should distinguish main and secondary passageways using narrower ones, the traditional main functions with their normal requirements, such as: ticket halls, waiting areas, platforms, and trains should not be the only aspects to express the functionality of a station, but there should be **other supporting aspects** added to meet the various needs of travellers and public during the transit. (**Figure 5-11**) explains the required circulation inside a station by passengers, and (**Table 5-3**) explains the supplementary aspects of stations' spaces[205].

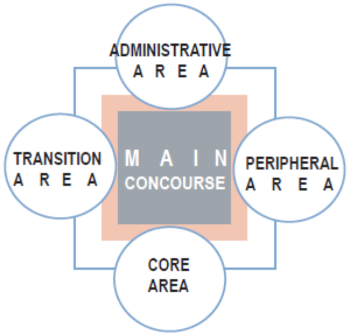


Figure 5-10: *The interrelationships that should form an intermodal station.*

Source: Kandee, S. (2004).

[205] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.6-8

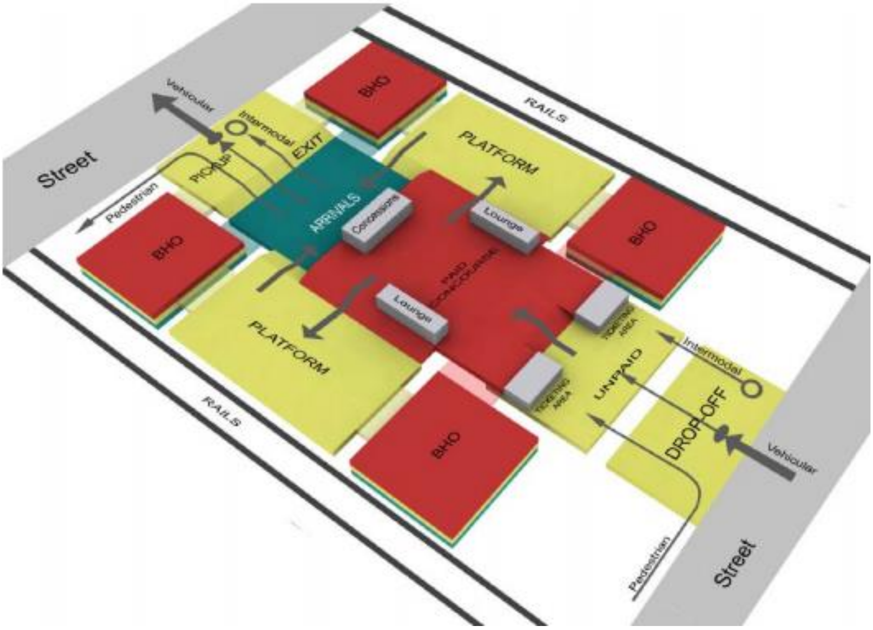


Figure 5-11: *Design for passengers' circulation inside a station.*

Source: Ministry of Railways (Railway Board). (2009).

Table 5-3: *Supplementary aspects in a station.*

Source: Kandee, S. (2004). Format: Author of the thesis.

Internal circulation	**Structure & light**	**Access for disabled people**
Reinforcing the priorities with assisting functional routes to help distinguish major and minor spaces.	The structural expression and light penetration through it strengthens the space definition and helps in navigation	People with disabilities, children, and seniors.
Advertising and public arts	**Travel information**	**Commercial developments**
Lighting up the stations. Could help identify the stations, give them images, serving as backgrounds or focal points.	Should be visible, provided in appropriate forms, providing efficiency in space circulation.	Like airport terminals, use waiting time for leisure and profit.

5.3.3 Design elements in expressing physical elements of a station

From the development of stations buildings' design theory, the research should re-examine the basic 2 design elements (function and form). Due to the advancement in main aspects of design, required supplementary aspects of designing, and the new interrelationships that govern all areas, both function and form had their categories upgraded and increased to include said changes; compared to pre-WWII era (**Figure 5-12**).

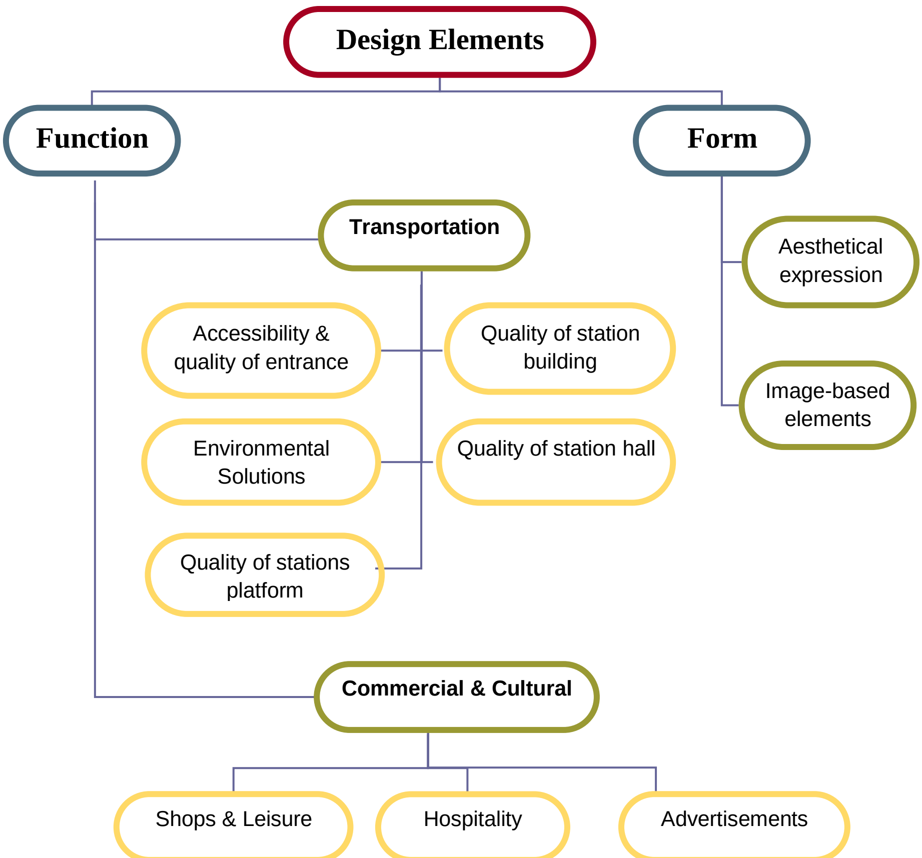
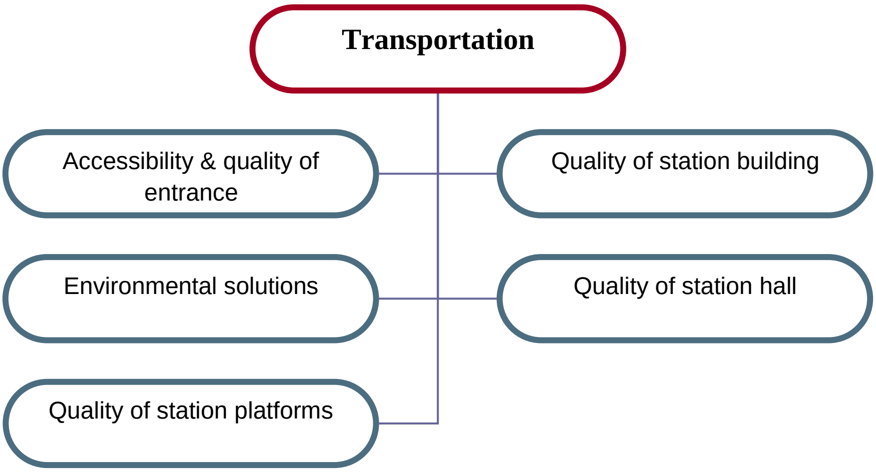


Figure 5-12: *Design elements of railway station spaces.*

Source: Kido, E. M. (2013). Format: Author of the thesis.

5.4 Function as a Design Element

5.4.1 Transportation function



5.4.1.1 Accessibility & quality of entrance

Accessibility should be present for all users; therefore, universal design is very important. Universal design should include aesthetic values, like: colourful glass elevators, interesting forms of ramps, etc. as glass gives a modern look. Today, stations have barrier-free circulation through **escalators**, **lifts**, helping **signs** and various verbal announcements.

Figure 5-13: *Station Amersfoort Vathorst, Netherlands.*

Source: Station Vathorst Amersfoort *(2013)*

In Europe, the most important notes on entrances include:

- Clear entrance.
- Name & logo are visible.
- Clear & visible design, even when it is standardized sometimes.
- Providing total concept of the function, i.e. subway lines.

In addition, entrances should be exposed and have harmony with its surroundings in the case of elevated stations. In case of subways, since there are no buildings for them, entrances become more important. Whether it is an existing station or not, there can be ways to find a solution for making any entrance distinguishing. Here are some examples[206]:

1. Some underground train stations' entrances **show the operator's logo** (**Figure 5-14**).
2. Others have an articulate design express for the underground lines **an overall concept of the subway lines** (**Figure 5-15**).
3. Some show **interesting design and subway operator's logo** (**Figure 5-16**).
4. Some are architecturally remarkable and **express the urban fabric as a landmark** (**Figure 5-17**).

In general, station entrance has important roles functionally, which can be summarized as follows:

1. The main plaza is a direct entry for vehicles and pedestrians; with protection from weather conditions.
2. Not limited to the concourse and the façade, the entrance is a visual representation to the whole building
3. Ease, clarity, and better orientation can be brought using glass walls. Entrances can be bigger for form quality.

[206] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.61.

Figure 5-14: *Bank Station in Princes St., London.*
Source: http://www.alamy.com

Figure 5-15: *Paris Métro entrance by Hector Guimard.*
Source: https://en.wikipedia.org

Figure 5-16: *Omotensandō Station, Tokyo.*
Source: https://en.wikipedia.org

Figure 5-17: *Metro Bilbao, Spain.*
Source: www.fosterandpartners.com

5.4.1.2 Quality of station building

Main station parameters include: **indoor environment** (discussed earlier), and **outdoor environment**, like: plaza and main street in front of station buildings (or entrance for subways). Train stations (especially termini) are a representation of the urban context and corporation. An original station -with being a transportation pivot- can become important, a local landmark, a gateway, and a meeting point for the locals. Modern railway stations often resemble airport terminals. There are few points to be considered[207]:

1. Train stations have no separation between departing and arriving routes.

[207] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.60.

2. A station can represent an important urban mark in comparison to airports; especially with small stations that can serve the local communities with its visual identity and facilities, while the large stations are considered "*gateways*".[208]

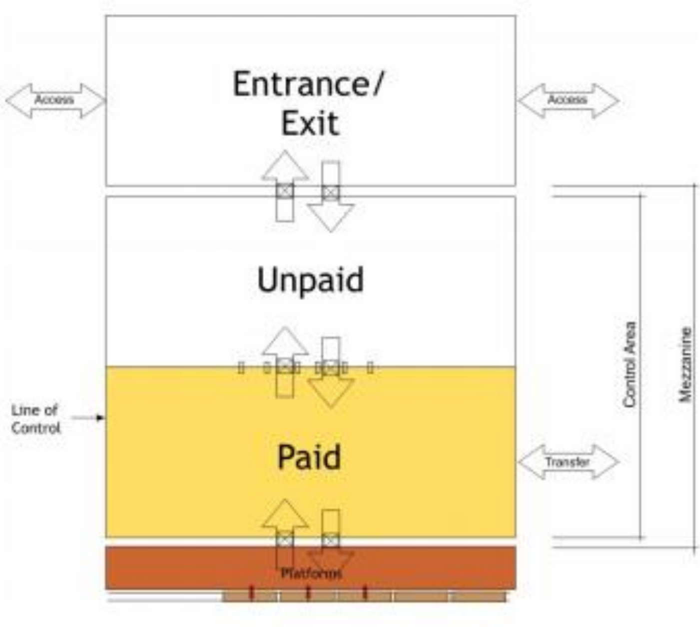


Figure 5-18: *Typical control area between entrances.*

Source: Ministry of Railways (Railway Board). (2009).

3. The designer is expected to ensure that journeys are easy and less confusing. The station design has to take into account that the journey extends out of a station, i.e. the **approach** and **departure from the station** affect the travel experience. The site can have one or more transportation modes; such as: buses, taxis, personal vehicles, planes, and even bicycles.[209]

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[208] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.61.

[209] Wilson, T., & Yariv, B. (2015). *Station Design Principles for Network Rail.* Network Rail, Document no. BLDG-SP80-002

Figure 5-19: *St Pancras International, England; by Norman Foster. Source: Kido, E. M. (2013).*

Figure 5-20: *Sloterdijk Station, Netherland;by H. Reijndersof, Holland Railconsul. Source: http://www.simplyamsterdam.nl*

This brings back the pertinent issue of modern multi-functional stations. Sometimes the complexity and diversity of functions make it difficult to distinguish **station building** from **attached functions**. The visual codes, however, may be less rigid and there is a movement for intermodality and multi-functionality transportation nodes. It is also important to save the clarity of function of modernized or modern station building. Renovation of European stations confirmed the distinguishing **(Figure 5-19**) & (**Figure 5-20**).

The clarity of the form and the visual representation of the buildings are related to the size of the station. In Japan's case for example: with only few buildings of historical value survived earthquakes and WWII by the 1960's, there was a need for more stations fast. The smaller stations especially had clearer elevations, but with a more standardised style; a corporate standard, or for integration with the surroundings (**Figure 5-21**). However, medium-sized and large stations had a more complex elevation treatment, weak clarity, and full of advertisements[210] (**Figure 5-22**).

[210] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.61.

Figure 5-21: *Masuda Station, Japan.*
Source: https://en.wikipedia.org/

Figure 5-22: *Shinjuku Station, Japan.*
Source: https://www.shinjukustation.com

5.4.1.3 Environmental solutions

Sustainability study for train station help -not only with environmental behaviour- but with the economic and social effects:

- Decrease consumption of energy.
- Using suitable daylighting for more efficient production and comfort.
- Treatment of ventilation; especially with fire prevention.
- Acoustic treatment for users' guidance and comfort[211].

With nearly 80% of the noise is from a train comes from wheel/rail, Charles De Gaulle Airport Interchange Module (TGV CDG2) planned an innovative concept to reduce the startle effect of a fast moving (230 km/hr) through train; by generating an artificial noise from sound traps near the track that gradually increases as a high speed train approaches the station, and decreasing platforms' noise levels down to about 60 Db levels. Also, developing a magnetic braking system noise and wearing on the wheels. [212]

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[211] Wilson, T., & Yariv, B. (2015). *Station Design Principles for Network Rail.* Network Rail, Document no. BLDG-SP80-002

[212] Bakry, O. (2008). An Approach to Sustainable Design of Intermodal Stations in Greater Cairo Region. Cairo: Ain Shams University, Faculty of Engineering, p.114-115

5.4.1.4 Quality of station hall

The circulation design can depend on: **locomotive types, rate of users at the busiest times, barrier-free accessibility, etc.** Placing commercial activities and other amenities at circulation routes can hinder the users' flow, safety, and ease.[213] Thus, **barrier-free needs** themselves can act against the basic objective[214].

1. All spaces (transit, peripheral, etc.) should be located with ease and without hindering.

2. Suitable dimensions for visibility and orientation.

3. Clear and easy definitions of the progression through all the elements for travellers. A natural flow in a specific order for functions: through facilities and timetables, ticket-selling facilities, etc.

4. Ease of movement, comfort and speed are important for circulation through the station.

5. Using furniture and other services to separate main areas of high-rate passing from other areas of a slower rate.

6. Sustaining the flow of passengers through station concourses and other public spaces and comfort in waiting areas by adding furniture, amenities and separation from main passengers flow area[215].

Those are general notes for the quality function to clarify circulation. Station halls and concourses are the areas where there is a lot of activity; they include **circulations areas**, **ticket sales,** and **retail space**, with post office at large stations. For the sake of

[213] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.61.

[214] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 30, 31

[215] Kido, E. M. (2013). Op. cit., p.61.

clarifying the desired flow of users, one should separate -figuratively- the commercial function in definitions from the main area of circulation; which are the hall and concourses.

In summary: Ticketing should be of main importance in layout, while retail or leisure activities should be the secondary; like locating them at the ends of the building, or other levels.[216]

5.4.1.5 Quality of stations platform

In talking about station types regarding rail tracks and platforms, there are two types: **termini** and **pass-throughs**.

Handling traffic on platforms particularly important at the underground stations that are confined spaces where passengers can enter or leave the stations easily even at busiest times. In deep underground, linking corridors can cut the connection between dynamic users' flow and static spaces. Platforms are related to train

length, and the width by the users' ratio (for example, 1 passenger : 1 m² in Britain); and the wider the platform, the better for flow[217], while in India, the preferred minimum clear width is 2.64 m includes safety spaces, buffer spaces, and clear spaces[218].

Figure 5-23: *Franklyn Roosevelt Station.*

Source: Kido, E. M. (2013).

[216] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.62.

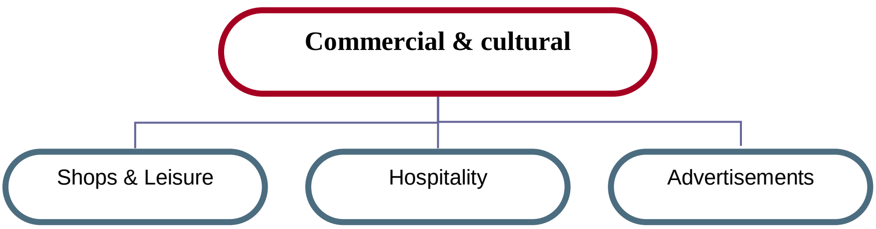
[217] *Ibid*., p.63.

[218] Ministry of Railways (Railway Board). (2009). *Manual for Standards and Specifications for Railway Stations.* Retrieved 2019: http://www.indianrailways.gov.in/railwayboard/uploads/directorate/land_amen/downloads/Manual%20for%20WCS%20%28Vol%201-%20Main%20Report%29.pdf

It is important to make platform an element for harmony with other areas; for better value to the whole station (**Figure 5-24**). Transparent glazed walls are very preferable to link the sight with the exterior view, while underground stations can benefit from arranging advertisements and other signs; giving a better visual experience, and without adding confusion. Examples are in the London Underground and Paris Métro. [219]

Figure 5-24: *Gare de Saint-Exupéry Lyon, 1994, arch. S. Calatrava.*
Source: Kido, E. M. (2013).

5.4.2 Commercial & cultural functions



Whether it is a passenger waiting or a regular consumer, commercial activities affect positively the economic conditions of the station and the image of the industry; on the condition that commercial activities do not affect negatively the speed and efficiency of catching the transportation.

[219] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.63.

Choosing the required commercial activity is linked with the station's location. King's Cross, Waterloo, and Birmingham New Street are examples for the need of these activities in the city centres. Smaller stations can have its commercial spaces out of the building[220] (e.g. Japan's case with downsizing).

Revitalization by downsizing

Downsizing is an idea that started in 1983 that became the solutions for stations that serve the community as a centre to its urban context, without carrying the burden of operational costs. To solve this, the local authorities build the commercial facilities adjacent to the station; focusing on stations with less than 5,000 passengers/day.[221] Features of add-ons to the downsized stations included:

- Tourist info offices
- shops selling local products
- Event facilities: public halls, meeting places,… etc.
- Citizens' services: libraries, galleries, …etc.
- Hot-spring baths
- Agricultural cooperatives
- Food & gift shops

1. **Hotto-Yuda Station** (**Figure 5-25**) serving Kitakami Line. The station has hot-baths that gained 500,000 customers in 4 years, with the passenger rate is less than 200/day.

[220] Wilson, T., & Yariv, B. (2015). *Station Design Principles for Network Rail.* Network Rail, Document no. BLDG-SP80-002

[221] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 29

2. **Etchu Funahashi Station** (**Figure 5-26**) serving the Toyama Chiho Railway Line. The village library attached to it loans books at the highest rate in Japan.[222]

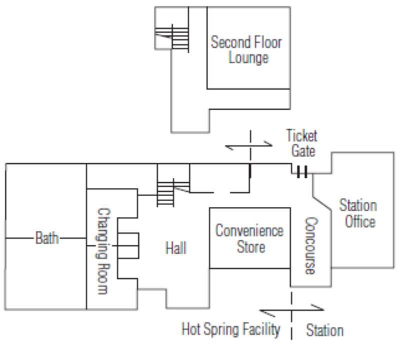


Figure 5-25: Hotto-Yuda Station floor plan at opening.
Source: Ando, K. (2010)

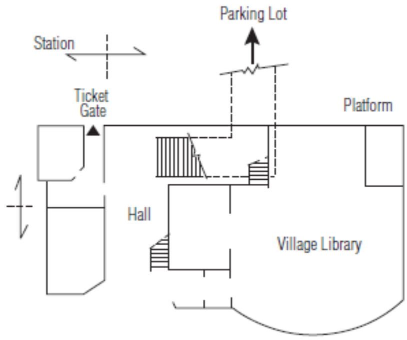


Figure 5-26: Etchu-Funahashi Station floor plan.
Source: Ando, K. (2010)

5.4.2.1 Shops & Leisure

Large train stations in many countries (such as USA, Japan, and UK) started to act as "*shopping districts*"; particularly for tourists. This happens by collecting several functions inside the station, like: banks, coffee shops, postal services, hotels, cinemas, etc.[223]

Example: Milano Centrale, Italy:

The station consists of 5 levels: underground, ground, mezzanine, platform, and upper level. The front building is considered a shopping mall (**Figure 5-27**) & (**Figure 5-28**) distributed mainly on

[222] *Ibid.*, p. 30

[223] Kandee, S. (2004). *Intermodal Concept in Railway Station Design.* BU Academic Review, volume 3, issue 1, p.7

the first 3 levels and includes many varieties such as: bistro, restaurants, fashion clothing, toys, appliances, etc.[224]

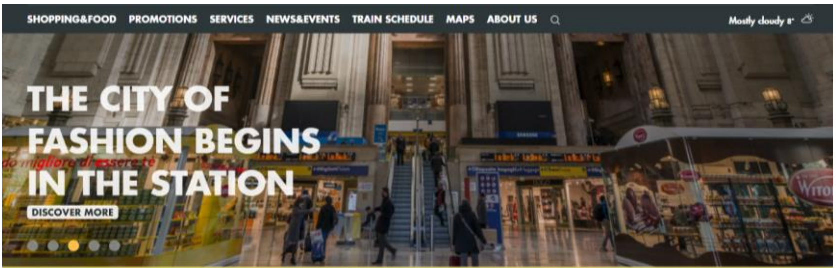


Figure 5-27: *The shopping mall inside Milano Centrale, Italy.*

Source: http://www.milanocentrale.it/en/

Figure 5-28: *Ground floor plan of Milano Centrale.*

Source: http://www.milanocentrale.it/en/

[224] *Milano Station - Shopping Gallery*. (2016). Retrieved December 2017, from Milano Centrale: http://www.milanocentrale.it/en/

5.4.2.2 Hospitality

Train stations tend to have a direct link to hospitality facilities for travellers; in adjacency or accessibility in the urban structuring. Similar to airports, many large stations tend to have hotels within their grounds; for both travellers and other types of guests.

Figure 5-29: Nagoya Station's twin towers.

Source: Muza-chan. (2012).

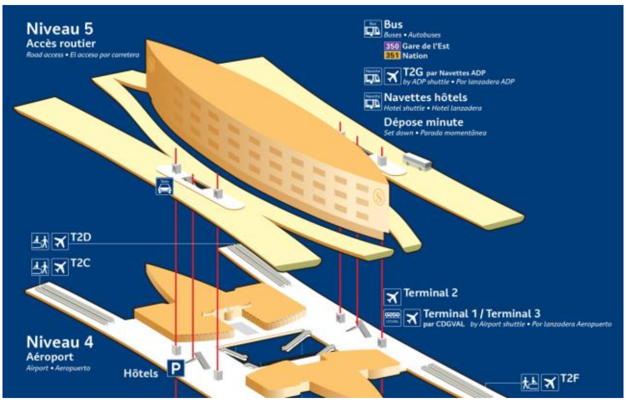


Figure 5-30: *Diagram of train station levels and location in T2, CDG Airport.*

Source: TGV & RER Stations. *(2018).*

Nagoya Station's two towers has in its 1st tower is a 53-storey **Hotel Tower**: Nagoya Marriott Associa Hotel; separated from the station by a 30-second walkway, and takes 4,100 m² of space. The other is 51-floor **Office Tower**, 60,000 m² of space for rent. Both towers share a common base 15 floors high, plus six more floors underground. The station towers also contain gardens, spas, cafes, bars, restaurants, and department stores (**Figure 5-29**). [225]

Charles De Gaulle Airport Interchange Module (TGV CDG2) has its Sheraton Hotel on top of the TGV station of the airport; and linked to TGV platforms (**Figure 5-30**).[226]

5.4.2.3 Advertisements

Advertisements for commercial purposes include posters, billboards, large screens, and are a source of revenue for railway operators in many countries; such as Japan and European countries. Advertisements also serve the purpose of aesthetics for public areas, and give a station's façade a distinctive image. The design of ads can reference either <u>cultural and healthy systems for life, etc. or a part of the context surrounding the station.</u> **For the exterior design**, designers and operators should be careful with the placement and number of advertisements on a façade, especially a historical station; as to carefully handle the visual treatment of the architectural language[227].

Figure 5-31: *Advertisements covering the façade of Shibuya Station, Tokyo.*

Source: http://www.japanvisitor.com/

[225] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

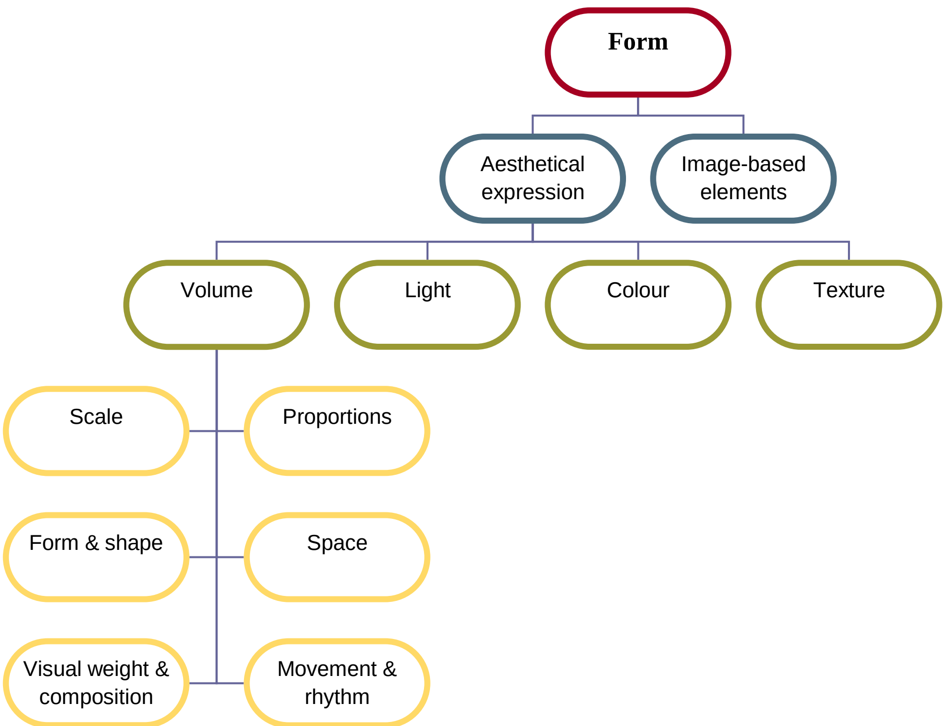
[226] *Paris-Charles De Gaulle International Airport. Interchange Module and High Speed Train Station.* (n.d.). Retrieved May 2017, from ADP Ingéniere: http://www.adp-i.com/en/paris-charles-de-gaulle-international-airport-interchange-module-and-high-speed-train-station

[227] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.63, 64.

Ads can become a substitute for thoroughly solving the facades' language, or lack of them. Example is Japan since the 1970's; a country that accepts the owners' rights for a product, with the abundance of ads around the urban fabric [228] (**Figure 5-31**).

For the interior design, there is the function concern regarding the cluttering of ads and screens in the path of passengers in corridors, lifts, and entryways. A careful attention should be on the barrier-free accessibility, and time-saving[229].

5.5 Form as a Design Element



[228] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.63, 64.

[229] *Ibid*

Train station buildings are considered an image or a gateway to its urban fabric. They carry a cultural and social representation of the city or town's background, and showcased with aesthetical values.

The parameters of a station are complex. So, the designer should sustain the function elements while adding elegance and balance to the form[230]:

- Between inside and outside of the station: interior design, facades, corporate identity, and urban context
- Between architectural design, structural design, mechanical requirements, and transportation requirements.

Theme

It is the wholesome category in the style parameter; as an expression using all form elements, special arrangement, and urban characteristics. In the past, with the concept of stations was new, themes were about expressing the philosophy of welcoming the travellers to a new urban entity, and using artistic movements for that; starting with the classicism in order and features, and evolving with the special and technological progress of station building.

Later, train station renaissance overcame the problems with standardised styles using the station renaissance, and the special arrangements of the station spaces became more adaptable to other styles; whether they are for a new building, or part of a renovated building.

[230] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.63, 64.

Figure 5-32: *Bermingham New Street Station, UK.*

Source: Mairs, J. (2016).

Figure 5-33: *The old Bermingham New Street.*

Source: https://en.wikipedia.org

The theme can express a futuristic style; even contrasting with old concepts. The **Bermingham New Street Station** (**Figure 5-32**) was opened in 2015 with a futuristic, dynamic theme that expresses the dynamics of railways' nature using perception distorting and forms of motion and replaced a demolished, classical station (**Figure 5-33**)[231]. **University of Naples subway station** (**Figure 5-34**) has a

[231] Mairs, J. (2016). *AZPML's Birmingham New Street Station renovation revealed in new images.* Retrieved 2019, from Dezeen.com: https://www.dezeen.com/2016/01/19/azpml-architects-birmingham-new-street-station-renovation-photographs/

morphological theme; in which design forms descending to the platforms to represent as a "*metaphorical shift from the conscious brain to the spiritual mind*"[232]

Figure 5-34: *University of Naples subway station, Italy.*
Source: Etherington, R. (2011).

Figure 5-35: *Beijing Station, China.*
Source: https://en.wikipedia.org

The theme can be a traditional style; a pure vernacular, or a blend with another concept. **Beijing Station** has a style that merges traditional Chinese style with socialist classicism (**Figure 5-35**)[233].

5.5.1 Aesthetical expression

5.5.1.1 Volume

Regards the aesthetical values, adequate spaces, and ease for maintenance[234].

1. Scale

It gives the emotional response for the users within the containment of the space.

[232] Etherington, R. (2011). *University of Naples Metro Station by Karim Rashid.* Retrieved 2019, from Dezeen.com: https://www.dezeen.com/2011/04/01/university-of-naples-metro-station-by-karim-rashid/

[233] *Beijing railway station.* (n.d.). Retrieved 2019, from Wikipedia.org: https://en.wikipedia.org/wiki/Beijing_railway_station

[234] Wilson, T., & Yariv, B. (2015). *Station Design Principles for Network Rail.* Network Rail, Document no. BLDG-SP80-002

Large stations have spacious spaces, but the designer should maintain the elements regarding the human scale to avoid anxiety.

Large European railway terminals, like London's St Pancras, Paddington or Victoria were designed with large scale to both provide a space for functions and adding an expression of grandeur. St Pancras, with its gothic architecture; was like churches. On the other hand, **smaller stations** are closer to the human scale, and can use lighting to add more space. [235]

Figure 5-36: The St Pancras Station Booking Office in 1900, showing the original roof. Source: http://stpancras.com/history/a-brief-history-of-st-pancras

In order to convert the station for use by modern international trains, St. Pancras Station (**Figure 5-36**) had to be doubled in length and an additional 6 new platforms were needed to serve both international and domestic trains at the same time. To preserve Scott and Barlow's original design a wholly separate extension was constructed in concrete, glass and steel. The renewal took from 2004-2007 in an intensive conservation work.[236]

Figure 5-37: Penn Station's interior design; showing the cladding and ceiling level. Source: Jones, R. (2014, February).

[235] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.65.

2. Proportions

As the geometry is based on natural laws, several aesthetic interpretations were realized over time. Proportion is a result of scale and shape. Whether it is the favoured proportions (**Figure 5-37**); such as the ancient **Golden Ratio** (1.6:1), or in modern times, based on the definition of "beautiful" structures; such as **"modulor"** system by Le Corbusier[237].

3. Form and shape

2-D shapes and 3-D forms are affected by distances, angles, colours, and texture. (**Figure 5-38**) & (**Figure 5-39**) explain the arrangement of simpler elements to create complex forms, and basic elements in form generating.

[236] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

[237] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

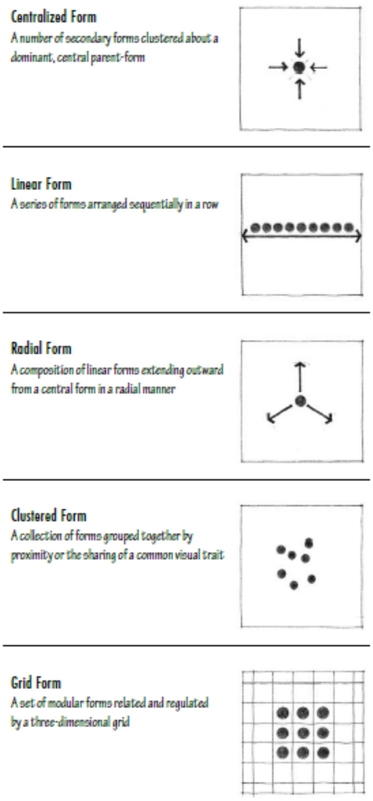


Figure 5-38: Creating complex elements using arrangement.

Source: Ching, F. D. (2007). Architecture: Form, Space, and Order.

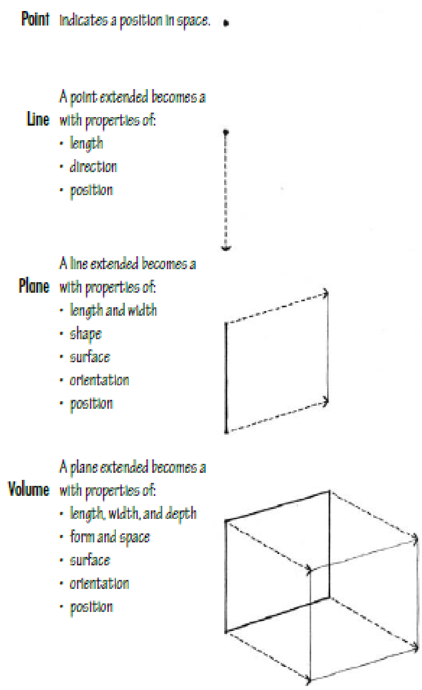


Figure 5-39: Building elements of form.

Source: Ching, F. D. (2007). Architecture: Form, Space, and Order.

Example: Kyoto Station, Japan

Despite the enormous space in the central main hall, there is a distinct definition from a distance in colours, masses, linear elements, and texture that help the users to find their way through, even in rush hours (**Figure 5-40**).

Figure 5-40: *Central hall of Kyoto Station.*

Source: https://www.kyotostation.com/kyoto-station-building-facilities/

4. Space

Station buildings cover particular space and offer both direction and stops. Careful design and choices for materials can affect the safety and comfort of users. For example, glass walls and lifts increase the connection visually to the outside, decreases confinement feeling; as a part of a universal design. [238]

Example: Rotterdam Central Station, Netherlands

While the grand entrance offers a strong expression of international, metropolitan character (**Figure 5-41**), daylighting through the transparent panels, voids, and ceiling materials offer a warm, inviting feeling to the passengers and guiding the passengers through the station easily and comfortably.[239]

[238] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

[239] *Rotterdam Central Station / Benthem Crouwel Architects + MVSA Architects + West 8*. (2015, January). Retrieved February 2018, from ArchDaily: https://www.archdaily.com/588218/rotterdam-central-station-benthem-crouwel-architects-mvsa-meyer-en-van-schooten-architecten-and-west-8

Figure 5-41: *Grand entrance of Rotterdam Central Station.*
Source: https://www.archdaily.com

Figure 5-42: *Roof glass plates vary light transmittance level by utilizing different solar cells patterns.*
Source: https://www.archdaily.com

Figure 5-43: *Warmth of large space using wood and a complex glass chandelier.*
Source: https://www.archdaily.com

5. Visual weight & composition

Often referred to the lightness of structures; affecting areas and volumes with the respect to the balance, composition with their relation with light, texture, and colours. Composition is a very important factor of railway stations, because it also guarantees solving out functional issues. New shell structures can show the harmonic integration of lightweight and lighting. [240]

[240] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

Example: The World Trade Centre Transportation Hub, New York, USA.

Figure 5-44: *Exterior of World Trade Centre Transportation Hub.*
Source: https://cdn.vox-cdn.com/uploads/chorus_image/image/48354127/2008_4_calatrava.0.jpg

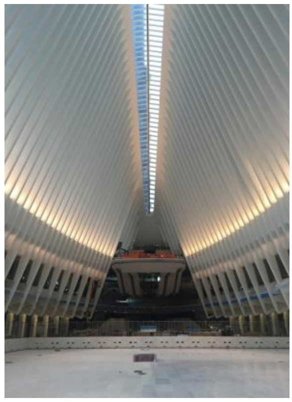


Figure 5-45: *Interior of World Trade Centre Transportation Hub.*
Source: www.dezeen.com

The World Trade Centre Transportation Hub, designed by Spanish architect **Santiago Calatrava**, opened in March 2017 (**Figure 5-44**).

The building has a skeletal appearance, with white walls that resemble ribs to evoke a bird in flight. The original scheme called for an operable roof, so that the pavilion's two "wings" could move up and down, the motion was cancelled due to costs.

Calatrava sought the need for a needed public space to enjoy by New Yorkers in the Occulus (**Figure 5-45**), with its sculptural form and natural lighting to provide *"dignity and beauty to the building's lower levels and pedestrian walkways"* [241]

[241] McKnight, J. (2016, February). *Santiago Calatrava's World Trade Centre transit terminal to quietly open next week*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2016/02/25/santiago-calatrava-world-trade-centre-transit-terminal-hub-to-open-lower-manhattan/

6. Movement and rhythm

Figure 5-46: *Madinah Haramain Station, Saudi Arabia.*

Source: https://www.compositestoday.com/2014/06/pct-completes-roof-installation-at-the-amazing-Haramain-railway-station/

The sight and brain cause the impression of the movement; from columns, arrangement of vertical and horizontal elements. All of these can help in affecting the users' flow inside a space (**Figure 5-46**), controlling crowds, articulating entrances and offering distinguishing sense to certain volumes. [242]

5.5.1.2 Light

Light's role (natural or artificial) is important in defining or exploring a form. Brightness, its intensity, its source angle, and even darkness can give different interpretations for colours and textures, and enhancing the visual expression of interior and exterior spaces[243]. Lighting also reveals all necessary information and help in circulating a space; highlighting signs, and guiding passengers to their destinations within the station safely and fast[244].

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[242] *A Brief History*. (2016). Retrieved October 2016, from St Pancras International: http://stpancras.com/history/a-brief-history-of-st-pancras

[243] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.66.

[244] *Ibid.*

Example: The original station of Atocha Station, Madrid

Figure 5-47: *Atocha Station, Madrid, Spain.*

Source: http://time.com/3816411/beautiful-train-stations/

People access the new 1992 terminal through it, buy tickets, and wait for their trains (**Figure 5-47**). Locals converted the original adjacent station into a concourse with -besides a nightclub and several cafés- a beautiful tropical garden of palm trees reaching toward the steel and glass roof in the centre.[245]

5.5.1.3 Texture

Values for surfaces can be articulated by texture variations. Smoothness, roughness, and their intensities can create patterns, which affect the visual weight of objects (**Figure 5-48**) [246].

[245] Matthews, L. (2015, April). *The World's Most Beautiful Train Stations*. Retrieved December 2017, from Time Magazine: http://time.com/3816411/beautiful-train-stations/

[246] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.66.

5.5.1.4 Colour

Perceiving colours is related to the surface area, colour palettes, and lighting. The result is the value of the visual weight. The warmth and coldness can affect the appearance of an object as light or heavy respectively, i.e. the spaciousness of a hall and feeling of safety.

(**Figure 5-49**). Colours are also used to **express the design concept**. Adding colours to light can be used for aesthetic and functional reasons, to **emphasise a particular functional elements**, **brand** or to **lead to a direction**[247]. For the people vision problems, the surfaces must have low reflectivity, and its colours are highly contrasted with other vertical elements[248].

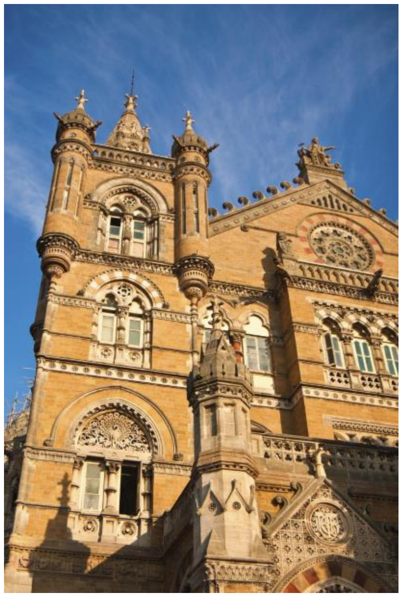

Figure 5-48: *Chhatrapati Shivaji Terminus, Mumbai, India.*

Source: http://time.com/3816411/beautiful-train-stations/

Figure 5-49: *Kazansky station business class lounge, Russia.*

Source: https://kremlintour.com/travel-tips/moscow-train-stations-guide

[247] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.66.

[248] Wilson, T., & Yariv, B. (2015). *Station Design Principles for Network Rail.* Network Rail, Document no. BLDG-SP80-002

5.5.2 Image - based elements / Landmarks

A method for linking a visual element to a place using symbolism or other visual means that links the mind to a fixed idea.

- They might express the image of the city (**Figure 5-50**).
- Expressing the operators' logo. The logos themselves should have an artistic graphical quality (**Figure 5-51**).
- Relating to a local historical, cultural, or a social idea[249] (**Figure 5-52**).

Figure 5-50: *Entrance to Kanazawa Station, Japan.*

Source: http://time.com/3816411/beautiful-train-stations/

Figure 5-51: *Berlin Hauptbahnhof with a glass facade showing the connecting lines of the station.*

Source: Shamsian, J. (2016, July).

[249] Kido, E. M. (2013). Stations for People: Recent Developments in Railway Station Design, p.66.

Figure 5-52: *Michael Bond, author of "Paddington Bear" book series, next to the titular character's statue inside Paddington Station, London, UK.*
Source: Tyzack, A. (2017, June).

5.6 New Design Elements in Reshaping Train Station Parameters

The previous discussion was about the function and form elements as products of the new design paradigms of train stations of today; following the development of transport modes, integration of several social activities; the adapting of the train station to the new circumstances of urban constraints (planning, society, economy)- whether the train station is a new building in a new urban space, a new building in a pre-defined space, or an updated original building.

As discussed before, the research assumed that the design paradigm of any given station is guided by 4 distinct parameters:

1. Technical
2. Urban
3. Spatial
4. Style

With the advancement in technology and the development of new aesthetics expressions for the architectural product, the research notices the problem of the interference of the design parameters with each other; blurring the lines between each parameter, and losing the "purity" of each parameter that distinguished each one; i.e. losing the ability to adequately analyse the differences and changes among each station design.

For example: **Public art** -an obvious aesthetic design element- is considered by operators and lawmakers (and in turn: the artists) as a **function** design element that is controlled by guidelines for revenue and barrier-free spaces. **Commercial functions** were upgraded from being peripherals to become integral parts of a station. Other qualities like **environmental solutions** (which in the past were part of the technical parameter) had become diluted in various design aspects, such as: quality of station building and platforms are related to the thermal comfort and adequate lighting; lighting itself is an aesthetic value adding to the users' experience and delight, and finally: the sustainability and energy saving; all of those should be found, not just in the machination, but in the materials, open spaces, voids in solids, and even structure.

From all the previously discussed examples, it was shown that how the concept of designing a train station was built up gradually; with the introduction of each new architectural element according to the requirements of either trains or users. This was explained in the beginning of the chapter, which led to dividing the architectural design process of this era into **4 essential driving parameters**: spatial, urban, technical, and style.

As previously stated: the research observes the 3 important eras in railway history:

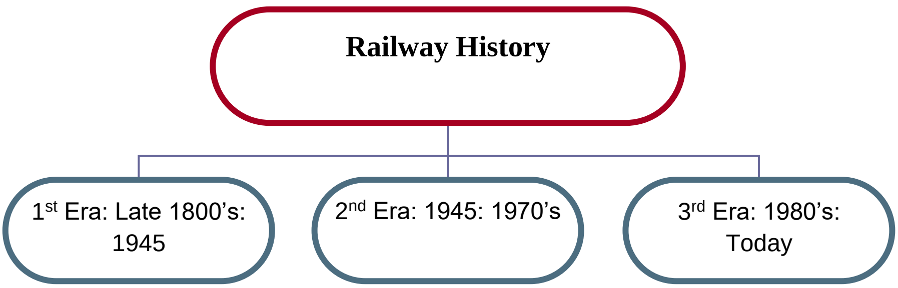

Figure 5-53: *Milestones of railway history.*

Source: Author of the thesis.

Table 5-4: *Comparative analysis between the design elements in each design parameter during the 3 eras of rail transportation.*
Source: Author of the thesis.

	1st Era: Late 1800's-1945	2nd Era: 1945-1970's	3rd Era: 1980's-Today
Function Elements			
Accessibility & quality of entrances	Ease of access and clearance of approach to the station for all users. Entrances: Providing shed and passage for horse and cars. Usually borrowed from classical elements to express a "gateway expression" to the city itself.	Overcrowding of shops, booths, displays, etc. Increased confusion among users. Entrances had poor expression. Minimum functionality, standardization against expression.	Implementing universal design is very important which should include aesthetic values in form & materials, like: colourful glass elevators, interesting forms of ramps, etc. Barrier-free access through escalators, elevators, signs for visually impaired & various verbal announcements. Entrances should have: • Roofs providing water and protection; their structure gives station distinctive image, • Emphasizing the company logo. • Articulate design reflecting total concept of the subway lines. • Show interesting design of operator's logo. Distinguished as urban landmarks that strongly identify particular city.

	1st Era: Late 1800's-1945	2nd Era: 1945-1970's	3rd Era: 1980's-Today
Quality of station building	The parameter that guides the relation between the station with its surrounding urban plan; with the integration with the roads surrounding the station, the urban masses, the problem of space availability for trains' entrance into the city.	• Consumption of spaces. • Poor organization of activities. • Complexity of functions.	People in wheelchairs, blind / partially sighted people, deaf / poor hearing, people with learning disabilities, people with heavy luggage, people with children, & the elderly. Journeys should be designed for less confusion. No separation between arrival and departure levels. While big terminal or airport station have the form of urban gateways, smaller stations are suitable to become a community need with adding a design value and identity for railway station and its functions.
Environmental solutions	New structural solutions in materials, spans, and load transferring. The strong role of selecting a locomotive in providing requirements to be considered in providing spaces, and also sustaining the users' health and structures' lifespan.	Switching from steam to diesel locomotives; which is safer for users' health and buildings' safety.	Providing comfort & efficiency through lighting without glaring, suitable air conditioning, and noise control. Choice of materials and technology in energy saving and recycling.

	1st Era: Late 1800's-1945	2nd Era: 1945-1970's	3rd Era: 1980's-Today
Quality of platforms	Safety of users in a volume with machines and crowds, the clearance of passageways and wayfinding.	• Development of dimensions and routes started with new train technology. • Hierarchy and clarity became complex overtime.	Design implements new locomotives; as numbers of platforms, dimensions, and train tracks derive from numbers of passengers a terminal can handle. Maintenance services are provided only at large terminals.
Quality of station hall	Establishing available spaces and utilities that witnessed upgrades in style and class to accommodate different types and classes of people; reaching new levels of ease and comfort. The principal façade was either a monumental clock or/and a great arch expressing the great roof of the train-shed locating different function at the head of the tracks as a façade element e.g. hotel with great entry hall. Changing the train station into more than a ticketing office has changed its organization of spaces, as well as its structure.	Weak distinguishing of passages and classification. Design accommodation to existing elements only & leaving the new; making the centre not serving a useful purpose.	People in wheelchairs, blind / partially sighted people, deaf / poor hearing, people with learning disabilities, people with heavy luggage, people with children, & the elderly. Station halls are designed as open spaces, and include buffer areas for security and crowd control. To eliminate confusions and delays, amenities and shops are organized to help in determining routes, clear information methods, and even aesthetical treatments.

	1st Era: Late 1800's-1945	2nd Era: 1945-1970's	3rd Era: 1980's-Today
Commercial & cultural	Adding several new facilities to serve the passengers like hotels, restaurants, and postal services that started to turn the train station into a central hub to the city socially and economically.	Cluttered; even blocking main entrances.	Commercial facilities and social services can be either integrated to the station building, peripheral to the building, or part of the urban context of the station's surroundings. Advertisements and public art add revenue be associated with the context of the station environment, also a reference to healthy lifestyle products, or culture, etc.
Form Elements			
Aesthetical expression	The parameter used new and old materials to find new expressions of the age and the fitting style of the city as a "gate" to it.	Weak. Modern elements and demolishing of old elements in favour of more utilitarian and ease.	Advertisement and public art started in lighting up the stations and identify the stations, give them images, serving as backgrounds or focal points. The structural expression (rhythm, proportion. Movement, etc.) with light penetration through it strengthens the space definition and helps in navigation.

	1st Era: Late 1800's-1945	2nd Era: 1945-1970's	3rd Era: 1980's-Today
Image-based elements	Finding new ways to express symbolic messages that form an artistic or a philosophical meaning to the art form of the building externally and internally. Usually borrowed from classical elements or modern aspects from the late 19th century.	None. Standardization preferred.	New volumes (added to old stations, or overall brand new stations) are added with the visual goals of any or all of the following: • express the image of the city • Representing company logo. • As landmarks, if they are visible and their image-based elements are strongly related to their urban, historical, cultural, and social context.

5.7 Conclusion

The first part of the chapter further explains the concept of intermodality: as for its passenger stations' types, according to the location of the station within the city, and the type of travellers requiring railways, Translating the supporting aspects into the overall two categories of basic architectural design: Function and form.

The second part of the chapter discusses the effects of increasing the size and services of stations; a matter that led to the complexity of functions and confusion among users; leading to:

- An uneasy experience of travellers and visitors.
- Wasting time needed to conserve for the basic function of stations: travelling in time.

The solution to the problem of complexity can be found in:

- Classifying the main and secondary spaces within a station and the required application of rules.

- Analysing the causes and effects of the increase of spaces and practical considerations of spaces, caused by the created supporting aspects of train stations as a result of complexity; such as: internal circulation, access for the disabled, advertising, information, etc.

- The form and aesthetics of a station building -aside of providing an identity of the designer and the location- should also serve the functional aspect of a station; as a quality and as a quantity. This is shown in several “functional” elements; such as: public art, choice of materials, advertising, colours, lighting, clarity, etc.

The third part is a comparison between the 3 eras of train stations: The rise of railways, the decline, and the renaissance. The comparison views the changes within design elements as functions and forms during the 3 time periods. The comparison concludes that:

- <u>Style</u> has a more controlling value on the overall architectural product of train stations by deciding a theme; which is now not limited to only a classical representation of an art movement, but serves a function purpose in enhancing the spatial and urban parameters using the advancements in technical parameters.

- <u>Technical parameter</u> development is the first element that started the station redevelopment and redefining the spatial and urban requirements; with the introducing of High speed trains. Technical parameter’s scope is broadened; as it includes more structural achievements, construction solutions, space-guidance, services, materials, and environmental solutions. Environmental solutions became integral to train stations in sustainability and comfort, and includes a variety of methods in dealing with lighting, air conditioning, waste control, etc.

- <u>Spatial parameter</u> became more focused on maintaining space and route hierarchies, enhancing the boundaries of each concourse, and maintaining clarity of corridors and essential spaces, while providing elements of international styles in clarity of materials, and using construction elements in user guidance and averting confusion; as opposed to the staggering of kiosks, shops, and services on the corridors.

- Urban parameter became more effective in the design of the station building’s urban weight, unity & linking with surrounding spaces, & cultural expression. An important design paradigm affects the design elements of a station is the urban structuring of train stations: adjacency to services, accessibility to other services and facilities inside the station, and a part of a large transportation network; i.e. producing intermodal stations like airport stations, international stations, and light rail.

CHAPTER 6: CASE STUDIES & COMPARATIVE ANALYSIS

6 Topics of Chapter 6

6.1	**Introduction**
6.2	**Method of Reviewing**
6.3	**About the Case Study Samples** *6.3.1 King's Cross Station, United Kingdom* *6.3.2 The Haramain Stations, Saudi Arabia* *6.3.3 Berlin Hauptbahnhof, Germany* *6.3.4 Nagoya Station, Japan* *6.3.5 Kenitra Station, Morocco*
6.4	**Function Elements of Train Stations** *6.4.1 Accessibility and quality of station entrance* *6.4.2 Quality of station building* *6.4.3 Environmental solutions* *6.4.4 Quality of platforms* *6.4.5 Quality of station halls* *6.4.6 Commercial & cultural functions*
6.5	**Form Design Elements** *6.5.1 Aesthetical expression* *6.5.2 Image-based elements*
6.6	**Effects of the Design Elements on the Station Design Parameters**
6.7	**Conclusion**

6.1 Introduction

The chapter is an analytical review of existing examples of train stations. The choice of samples depends on developing old stations and newly-built stations; with each lies within a different urban context. The goal of the chapter is to review the development of design parameters and their function and form elements. The chapter also looks for any common results between renovation of old buildings and construction of new ones.

The previous chapter indicated the design changes with train station, and the limitations and possibilities between renovating a station, or constructing a new complex. This chapter is a comparative analysis between several stations from different backgrounds; for the purpose of obtaining enough results that should provide conclusions for the assumptions about the design parameters of the renaissance era: how each parameters was affected, the extents of these changes, and the interrelationship between each parameters with the other.

6.2 Method of Reviewing

The method is to categorise the elements for comparison to study the effect of each station on the form and function elements of the station: quality of platforms, accessibility, etc.; which will show its results on the 4 station design parameters, and whether the effect of a category has an effect on a single or multiple station parameter.

6.3 About the Case Study Samples

The research conducts a comparative analysis between 5 different stations with different backgrounds:

6.3.1 King's Cross Station, United Kingdom

King's Cross	
Location	King's Cross, London, UK.
Designer(s)	• Lewis Cubitt (Original design) • John McAslan + Partners (Architects; Renovations) • Arup, London (Structural engineering design; Renovations)
Date	1852
Construction	Steel, masonry
Style	Italianate (Original) Postmodern (Upgrades)[250]

Figure 6-1: *King's Cross station post- restoration.*

Source: https://en.wikipedia.org

As other countries, the updates were mainly for HST. The British Government renewed 14 historical stations for urban reviving. The plans included adding new facilities, commercial activities, and other amenities to the station, while maintaining the main goal of

[250] *The History of London King's Cross Station*. (n.d.). Retrieved July 2017, from www.networkrail.co.uk: https://www.networkrail.co.uk/who-we-are/our-history/iconic-infrastructure/the-history-of-london-kings-cross-station/

updating the transportation modes for a more reliable and environmentally-friendly methods.[251]

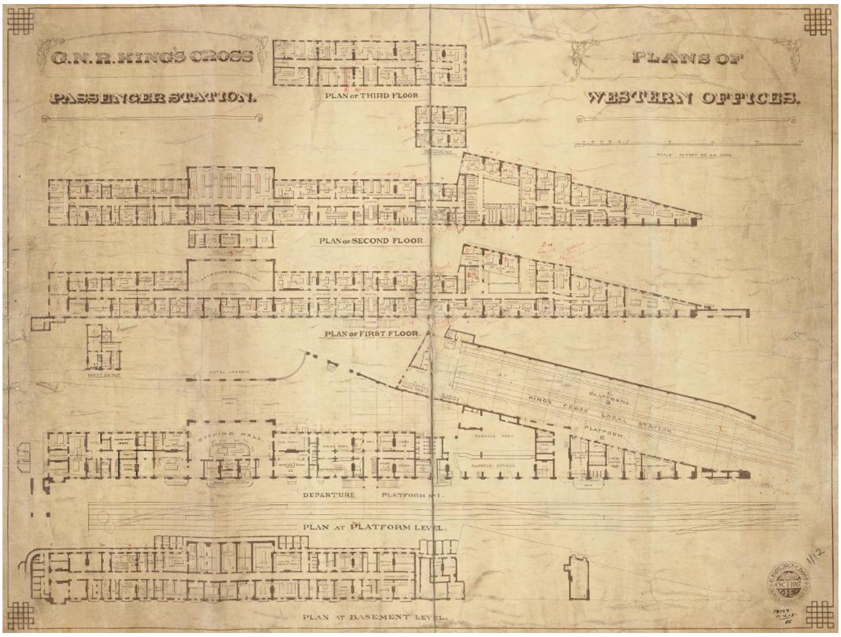

***Figure 6-2:** Old King's Cross plans of western offices.*

Source: The History of London King's Cross Station. (n.d.)

6.3.1.1 Planning & design aspects

From the east, a cab pathway could be reached, and from the west a passenger could find facilities, ticketing, administrative offices and the Great Northern Railway boardroomThe station had a total [252] . of 8 platforms:

[251] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design.* Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.57

[252] *The History of London King's Cross Station*. (n.d.). Retrieved July 2017, from www.networkrail.co.uk: https://www.networkrail.co.uk/who-we-are/our-history/iconic-infrastructure/the-history-of-london-kings-cross-station/

	Group #1	Group #2
Count	2	6
Purpose	passengers	storage & movement of locomotives and carriages
Location	west side: departures east side: arrivals	middle

6.3.1.2 Decline

The problems continued to face the station in the 20th century, two glimpses of the decline are:

- From 1866 until 1977, suburban trains passed through the station using eastern platforms (York Road), going to the south, and going through the suburban platforms was to the west. York Road and suburban platforms were shut down in 1977.

- When King's Cross opened, and for trading with passengers mainly, the front of the station was crowded with a large number of huts and kiosks. In the early 1970s the officials cleared all kiosks, and opened a one-floor travel centre, ticketing, and concourse opposite to Cubitt's elevation. However, the effect was too weak to solve overcrowding blocking passenger facilities.[253]

Since 1900, the railways and in turn, the railway stations, went through decline, a changed matter with new investment and renovation projects in more recent years.[254]

253 *The History of London King's Cross Station*. (n.d.). Retrieved July 2017, from www.networkrail.co.uk: https://www.networkrail.co.uk/who-we-are/our-history/iconic-infrastructure/the-history-of-london-kings-cross-station/

254 RIBA. (n.d.). *The Architeture of Railway Stations*. Retrieved October 2016, from The RIBA Library: architecture.com: https://www.architecture.com/Explore/Stories/TheArchitectureOfRailwayStations.aspx

6.3.1.3 Renovating King's Cross

"Of all the historic train stations in London, King's Cross (1852) may perhaps be said to have the most beautiful, possibly even the purest design of them all". [255]

From 2002, investments for the transport infrastructure for and around the station were estimated as £2.5 billion. In 2009, London Underground at both St. Pancras and King's Cross had new and improved access. The upgrading of King's Cross Station for Network Rail used 3 different methods:

1. **Re - use** — The train shed & range buildings
2. **Restoration** — Grade I-listed façade
3. **New building** — A new, highly expressive Western Concourse

The station is a link to local, national, and international travel; with different types of modes[256]:

1. **International rail**
   Eurostar direct to Paris, Brussels, & Lille.
2. **National rail**
   2 major rail termini (Kings Cross & St Pancras), & only 500 metres to a third (Euston).
3. **Underground**
   6 tube lines; the biggest interchange on London Underground to this day.
4. **Air**
   London's five international airports within the hour.
5. **Bus**
   14 bus routes.
6. **Bike**
   Available over 400 public bike spaces.
7. **Car driving**
   The Handyside Car Park is open daily.

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[255] Brensing, C. (2012, April). *Renovation and extension of King's Cross Station in London*. Retrieved July 2017, from detail-online.com: http://www.detail-online.com/article/renovation-and-extension-of-king s-cross-station-in-london-16288/

[256] *Getting To & Around*. (2018). Retrieved August 2018, from King's Cross: https://www.kingscross.co.uk/transport

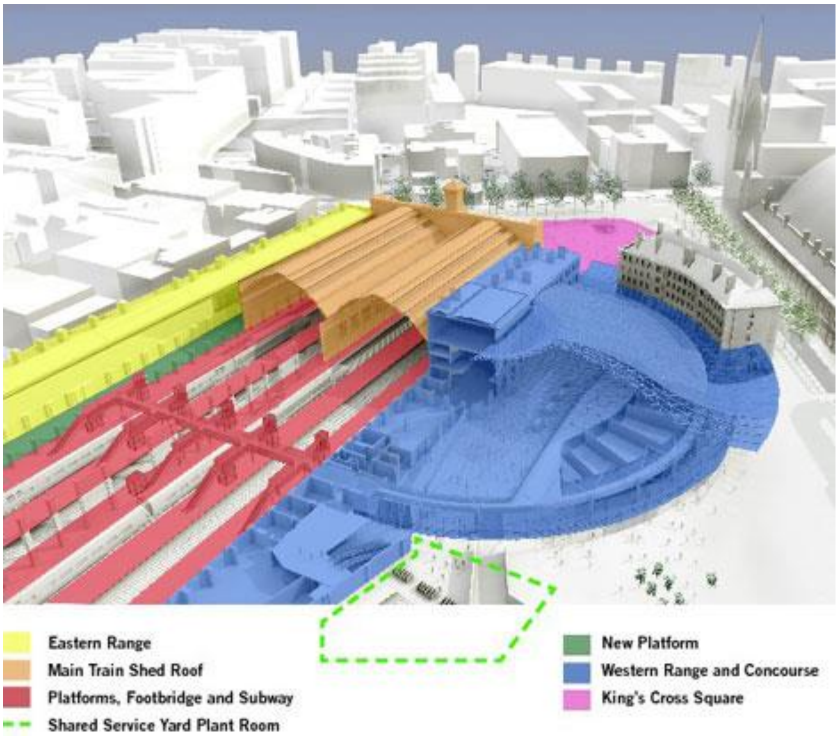

Figure 6-3: *King's Cross, highlighting zones after renovations.*

Source: Frearson, A. (2012, March)

The centrepiece of the £547,000,000 renewals is the new diagrid-structured, semi-circular vaulted concourse at west of the original station (**Figure 6-4**). The new station entrance is 20 m high, 52 m in span, and a diameter of 130 m in diameter; a total of approximately 1,000 tons and an area of 7,500 m².[257]

[257] Brensing, C. (2012, April). *Renovation and extension of King's Cross Station in London*. Retrieved July 2017, from detail-online.com: http://www.detail-online.com/article/renovation-and-extension-of-kings-cross-station-in-london-16288/

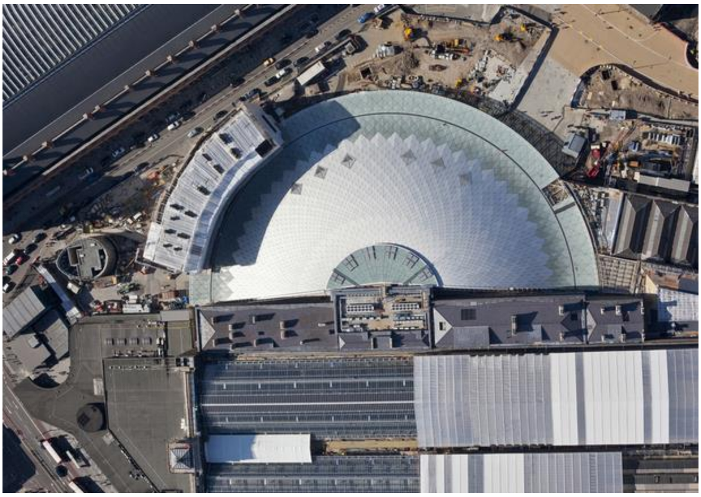

Figure 6-4: *The semi-circular roof above King Cross station's new station entrance.*

Source: Brensing, C. (2012, April).

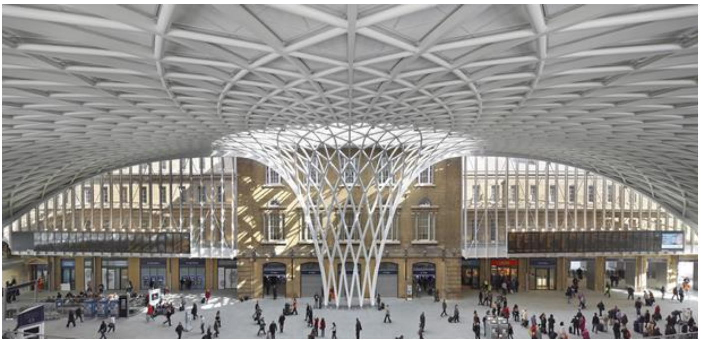

Figure 6-5: *Radiating tree-form of west concourse, King's Cross.*

Source: Brensing, C. (2012, April).

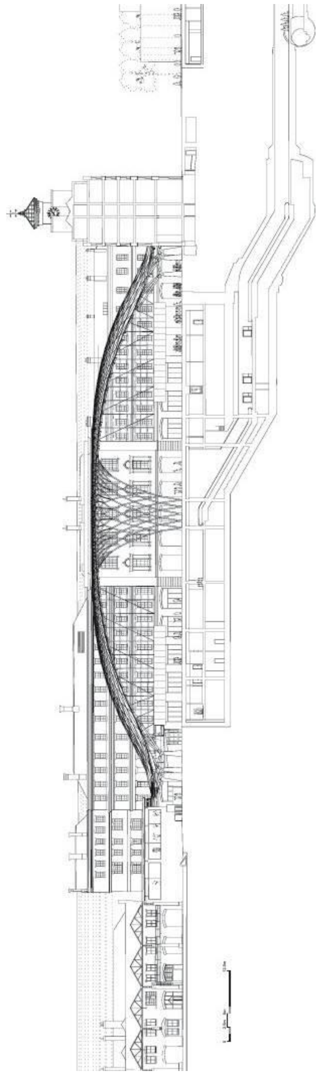

Figure 6-6: *Section looking east showing interface with northern line tube station, King's Cross. Source: http://www.archdaily.com*

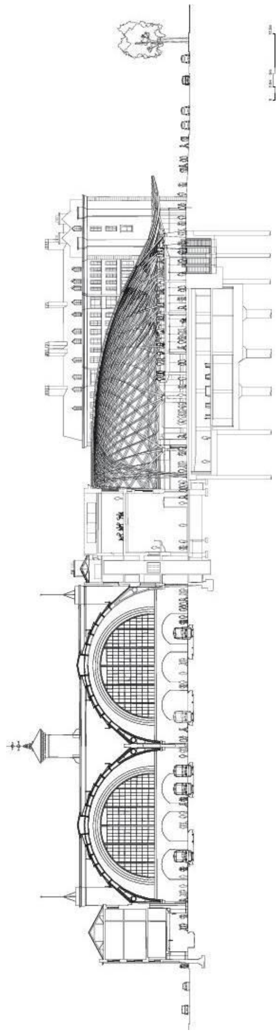

Figure 6-7: *Section looking south, King's Cross Source: http://www.archdaily.com.*

6.3.2 The Haramain Stations, Saudi Arabia

Figure 6-8: Exterior of Makkah Station.

Source: Welch, A. (2016, January).

The Haramain High Speed Rail (HHSR) is a major infrastructure project for the Kingdom of Saudi Arabia for the planned longest electric speed train in the Middle East of 450 km-long rail line, and at speed of 300 km/hr; connecting 4 cities[258] (**Figure 6-9**):

1. Makkah
2. Madinah
3. Jeddah*
4. The developing King Abdullah Economic City (KAEC) in Rabigh

**A 5th station went under further studies to link King Abd-Al-Aziz International Airport (KAIA) with Jeddah & KAEC stations.*

[258] *King Salman to inaugurate Haramain high-speed train line on Tuesday*. (September 2018). Retrieved June 2019, from Travel Wire News: https://travelwirenews.com/king-salman-to-inaugurate-Haramain-high-speed-train-line-on-tuesday-1102440/

The designs of Haramain (*The Two Holy Mosques*) Stations are the collaboration of Foster + Partners and Buro Happold, along with local architect Dar Al Riyadh. The stations should provide a vital new service for the millions of pilgrims travelling between the Holy Cities of Makkah and Madinah.[259]

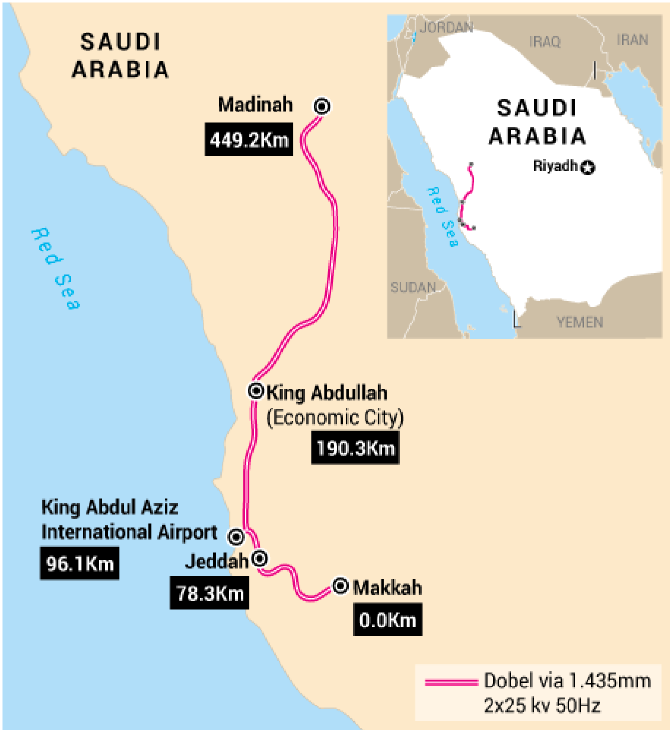

Figure 6-9: *The Haramain High Speed Rail line.*

Source: Travel Wire News (September 2018).

Altogether, the stations are planned to initially accommodate an anticipated 60 million passengers - approximately six times the number of passengers that take the Eurostar from St Pancras each

[259] Welch, A. (2016, January). *Haramain High-speed Railway Saudi Arabia*. Retrieved 2019, from E-Architect: https://www.e-architect.co.uk/saudiarabia/Haramain-high-speed-railway-stations

year. This is expected to increase to 135 million passengers by 2042.[260]

6.3.3 Berlin Hauptbahnhof, Germany

Berlin Hauptbahnhof	
Location	Tiergarten District, Berlin, Germany
Designer(s)	• Meinhard von Gerkan (architect) • Jürgen Hillmer (architect) • Schlaich bergermann und partner; IVZ/Emch+Berger (Structural engineers)
Date	2006
Construction	Concrete, steel, filigree glass.
Style	Postmodern

Berlin's new Central Station is Europe's largest train station for long-distance, regional, and local transport. It is built on its historical site in the Tiergarten District, west of Humboldthafen. At this station the new underground north-south link of the InterCityExpress service connects with the west-east line running on a curved railway track. Additionally, suburban railway tracks in both directions, as well as an underground line from north to south arrive at this station. The north-south track runs 15 m below ground level in a tunnel, which also passes below the River Spree and the Tiergarten. (**Figure 6-10**).

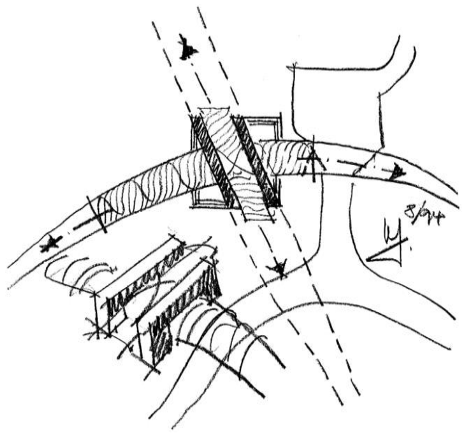

Figure 6-10: *Berlin Central Station's concept. Source: GMP Projects: Berlin Central Station. (2016).*

[260] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

Construction lasted 10 years have meant that some conflicts between the German rail company Deutsche Bahn and the architect, in deciding to first shorten the time of execution of the work by modifying the project. It shortened the cover of the station at 100 m and the lower floors that serve as the underground heat exchanger to be covered; causing no daylight arrived as planned in the initial project.[261]

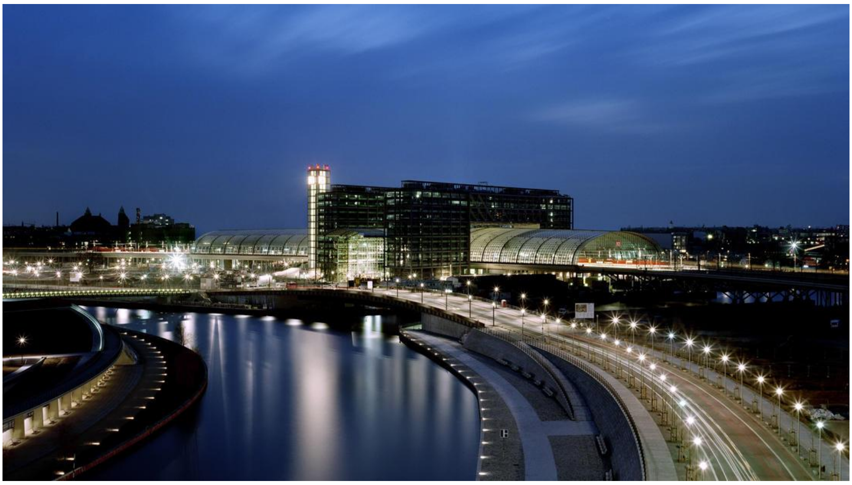

Figure 6-11: *Berlin Central Station; night shot.*

Source: Berlin Central Station. (n.d.).

The designers sought to emphasise the importance of the New Berlin Hauptbahnhof - Lehrter Bahnhof crossing point in an increasingly integrated Europe, to highlight, in turn, the existing track of a railway routes within an urban context through architectural means[262]. The lobby of the station is framed by two curved structures 14-m high trying to highlight the scale of the place, the importance of the station as a crossing point between Europe and link the east and west[263].

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[261] Berlin Central Station. (n.d.). Retrieved 2017, from WikiArquitectura.com: https://en.wikiarquitectura.com/building/berlin-central-station/

[262] *Ibid.*

[263] *Ibid.*

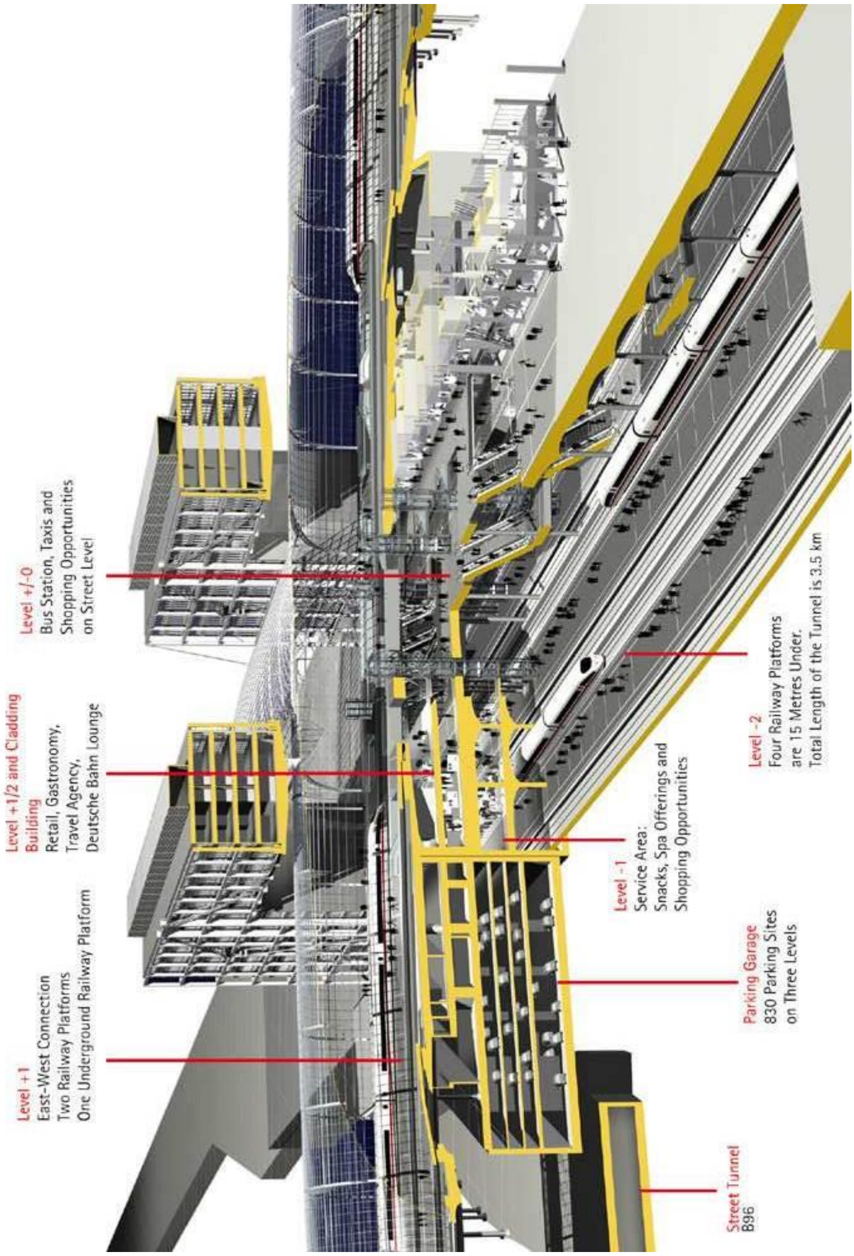

Figure 6-12: *Traffic of Berlin Central Station.*
Source: GMP Projects: Berlin Central Station. (2016).

Figure 6-13: *Lowering the constructed bridge above the main shed, Berlin Central Station.*

Source: Berlin Central Station. (n.d.)

Figure 6-14: *Daylighting in Berlin Central Station.*

Source: GMP Projects: Berlin Central Station. (2016).

To cope with the volume of vehicles, the station has two parking areas that can hold a total of 1,500 cars; with 200 of these inside the hotel car park[264].

[264] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

Gross floor area: 175,000 m² / 5 levels. The traffic of the train station is organised on **three levels**[265] (**Figure 6-12**).

- ***Level -2:*** Long-distance and regional lines from north to south; U5 underground line.
- ***Level -1:*** Service area, spa, snacks, shopping.
- ***Level ±0:*** Local public transport; individual transport (access road, short-term car park); bicycles and pedestrians; tourist transport (coaches, ships)
- ***Level +1/2:*** Retail, gastronomy, travel agency, lounge.
- ***Level +1:*** Long-distance and regional lines on the urban railway track; S3, S5, S75, S7, and S9 urban railway lines.

The station has 16 platforms that serve many German cities (Hamburg, Dresden, Leipzig, many European countries (like Prague, Budapest, Amsterdam, Warsaw, Switzerland), and city railway (S-Bahn)[266].

6.3.4 Nagoya Station, Japan

Figure 6-15: *Nagoya Station, its towers seen from a far distance.*

Source: JR Central Towers: Nagoya Marriott Associa Hotel. (2018).

[265] GMP Projects: Berlin Central Station. (2016). Retrieved November 2016, from Gerkan, Marg and Partners Official: http://www.gmp-architekten.com/projects/berlin-central-station.html

[266] *A short station guide...Berlin Hauptbahnhof* . (n.d.). Retrieved 2019, from www.seat61.com: https://www.seat61.com/stations/berlin-hauptbahnhof.htm

Nagoya city is Japan's 3rd city. The Station of Nagoya has the operational rate of 193,000 people / day. The original station, along the city- were heavily bombed during World War II. As a result, there are not many historic districts left, and the only distinctive old landmark visible from the station is Nagoya Castle. [267]

Figure 6-16: *Nagoya Station's main facade showing its approach.*

Source: Muza-chan. (2012).

The destruction of the City by the U.S. bombs is followed by the expansion of building skyscrapers and office blocks; a modern aspect that does not mark the city a touristic attraction, and the lack of foreigners in it, which makes the city having a distinct local identity. This local characteristic later merged with the execution of new buildings with appealing aesthetic features, and includes various functions. The current station complex replaces the old station built in 1886 by JNR. After the privatisation of the company, construction of the towers started in 1994, and was completed in December 1999.[268]

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[267] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

[268] *JR Central Towers: Nagoya Marriott Associa Hotel*. (2018). Retrieved March 2018, from Kohn Pedersen Fox Associates: https://www.kpf.com/projects/jr-central-towers

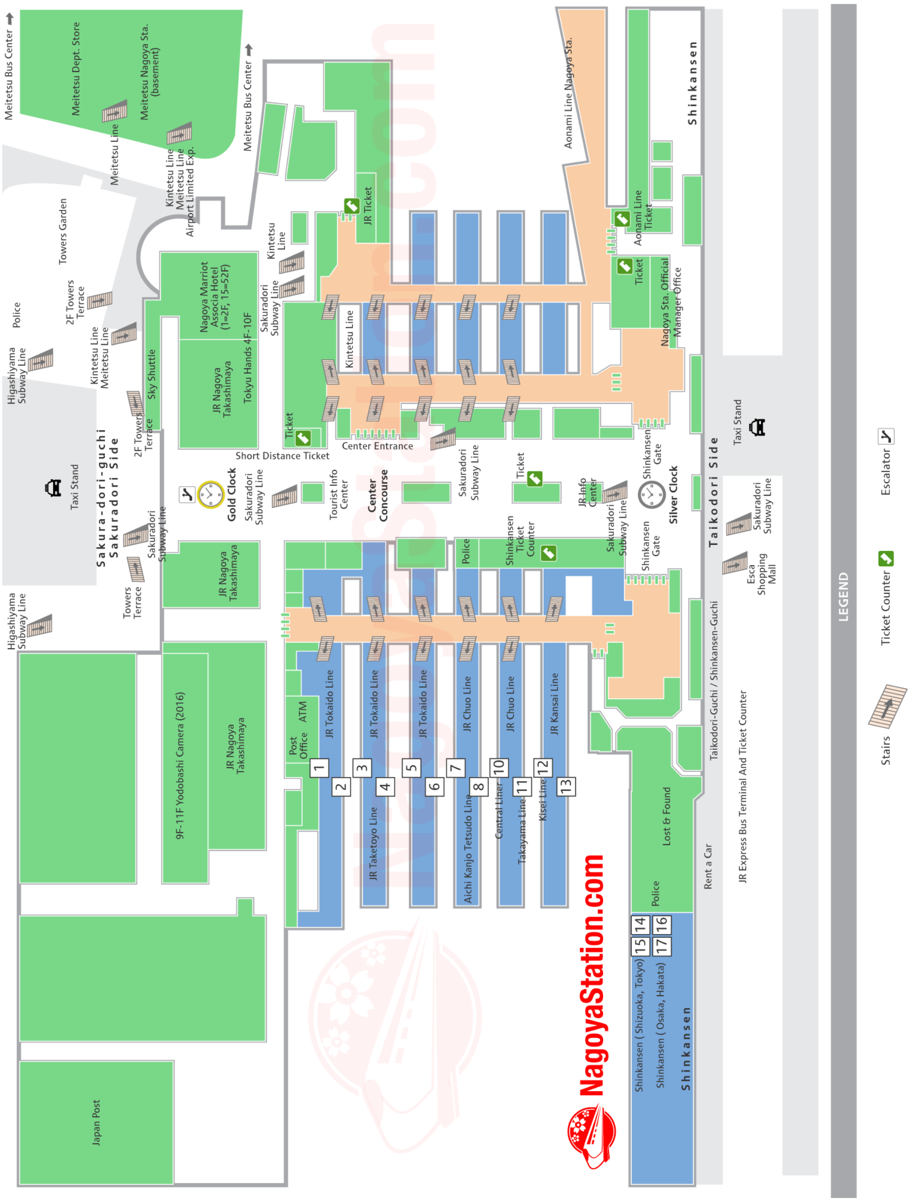

Figure 6-17: *Ground floor plan of Nagoya Station; showing the platforms, entrances, and focal points.*

Source: Nagoya Station Map – Finding Your Way. (2018).

6.3.5 Kenitra Station, Morocco

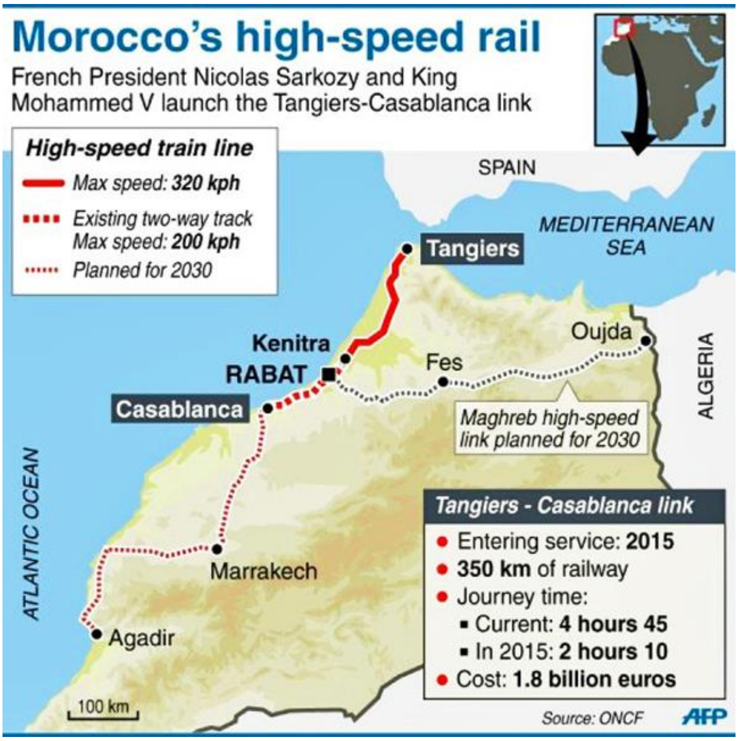

Figure 6-18: *Map of HSR Morocco, showing Kenitra Station in the middle.*

Source: HSR Casablanca – Tangier to be ready for service in 2018. (2016).

A design competition was held to design a new TGV station in Morocco, with Silvio d'Ascia Architecture, Omar Kobité Architecture and Eric Giudice Architects as the winners.[269]

[269] Rosenfield, K. (2014, March). *Silvio d'Ascia Wins Competition to Design Morocco Rail Station*. Retrieved June 2019, from Archdaily: https://www.archdaily.com/485716/silvio-d-ascia-wins-competition-to-design-morocco-rail-station

Figure 6-19: *Kenitra Station, street view.*

Source: Rosenfield, K. (2014, March).

One part of an overall plan to introduce HSR to Morocco is the station in Kenitra; a port city located along the northern Atlantic Ocean, just south of the coastlines of Portugal and Spain. The station will be part of a new 350 km long HSR line that starts north of Kenitra, in Tangier, and extend south to the city of Rabat and on to Casablanca; serving trains that reach 320 km/hr. The project should speed passenger travel and decrease traffic on existing rail lines in the region, to carry more than 10 million passengers a year.[270]

[270] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

Figure 6-20: *Kenitra Station's platforms.*

Source: Zimmer, L. (2014, March)

Figure 6-21: *Kenitra Station, bird-eye view.*

Source: Rosenfield, K. (2014, March).

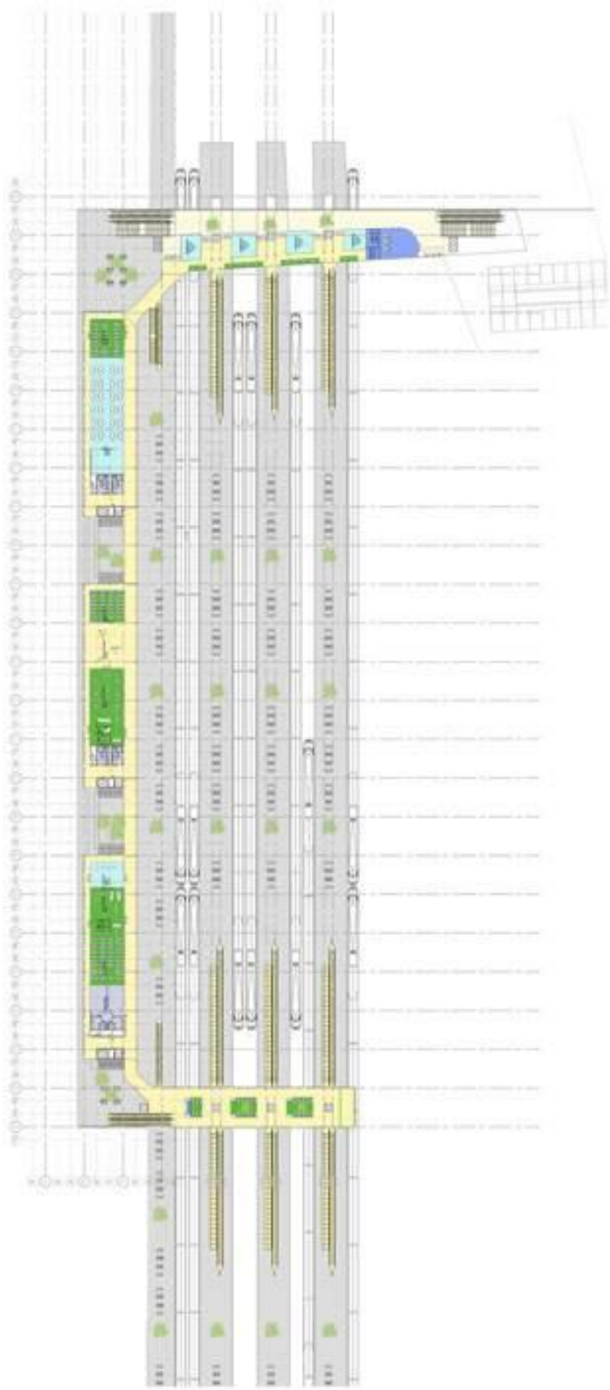

Figure 6-22: *Plan for Kenitra Station, showing both the platforms and elevated floor.*

Source: Zimmer, L. (2014, March)

6.4 Function Elements of Train Stations

6.4.1 Accessibility and quality of station entrance

Table 6-1: *Quality of entrance and accessibility, and their impact on station design parameters.*

Source: Author of the thesis.

Station's Name	Description	Technical	Urban	Spatial	Style
King's Cross	The Western Concourse is to be the entrance to mixed-use developments; an important approach to the eastern entrance of St Pancras International, and extends to King's Cross Square, where a new plaza is between the station's southern façade and Euston Road. [271] **Approach:** Northern ticketing hall are above the new London Underground, with retail elements at mezzanine level; transforming passenger facilities, and better links to the London Underground, vehicles, & train connections for St Pancras.	●	●	●	●
Haramain	In the termini, all gates direct passengers to platform level using escalators (from upper concourse or basement). Pathways for lifts are available with signs next to escalators and leading to the platform gates[272].		●	●	

[271] Frearson, A. (2012, March). *Western Concourse at King's Cross by John McAslan + Partners*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2012/03/14/western-concourse-at-kings-cross-by-john-mcaslan-partners/

[272] Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

Station's Name	Description	Technical	Urban	Spatial	Style
Berlin	The entrance hall has a glass roof that connects to the bridge that has buildings on the sides, serving outside the supporting structure the same as support beams in the shape of a fish's belly, with 470 m high on which rests the glass dome of the roof[273]. The entrance provides information with a glass facade showing the connecting lines of the station drawn on the façade, and representing the train operators and connectivity		●	●	●
Nagoya	While Nagoya Station is made of concrete, asphalt and glass, the station also includes a large, contrasting enclosed area on the front-left approach to the main entrance called the Towers Garden, with variable types of plants and curved benches; open for station users and non-users for relaxing and gatherings[274].		●	●	●
Kenitra	The main entrance is from the street level at the ground floor, with the ticketing offices and other boutique spaces. Then, passengers are led to the upper floor for the platform areas (bridgeway); where there are also waiting areas and shops, and entry to the upper galleries of the main building[275]. The station has two access points; through a vegetated entryway in the south, or a pedestrian walkway at the north[276]. With the		●	●	●

[273] Berlin Central Station. (n.d.). Retrieved 2017, from WikiArquitectura.com: https://en.wikiarquitectura.com/building/berlin-central-station/

[274] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

[275] Rosenfield, K. (2014, March). *Silvio d'Ascia Wins Competition to Design Morocco Rail Station*. Retrieved June 2019, from Archdaily: https://www.archdaily.com/485716/silvio-d-ascia-wins-competition-to-design-morocco-rail-station

[276] Zimmer, L. (2014, March). *Silvio d'Ascia Unveils Gorgeous Lace-Like High Speed Rail Station for Morocco*. Retrieved June 2019, from Inhabitat: https://inhabitat.com/silvio-dascia-designs-a-gorgeous-lace-like-high-speed-rail-station-for-morocco/

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
	distinguishing between the 2 entryways, the station uses its lightweight aluminium canopy framework to emphasise the entrances in a visual expression that is united with the overall visual weight of the station.				

- Train stations aim to provide barrier-free access for reaching spaces and core zones. Stations also aim to emphasise the entrances and their purposes by adding clarity using large surface areas of clear glass that provides clarity and a universal look to avoid confusion and strengthens the ease of access.

- The entrance can provide a visual representation of corporation, promoting the rail services (**Berlin**), while imposing a visual weight, great volume and modern, reflecting materials and massive structural works as entrances for identity (**King's Cross**). Stations can also use the entrance to offer a representation of the Japanese urban cultural identity; with blending coarse, industrial materials with the calming effect of nature (**Nagoya**).

- The entrance is a visual representation of the urban context and the culture of the city **(Kenitra** and **Haramain**).

6.4.2 Quality of station building

Train station buildings, regarding their exterior spaces and facades as urban qualities, witnessed new design concepts that had their impact on station design parameters.

From Chapter 2, the following stations showcase different types of urban structuring; which affects the quality of the building, and the services that they provide:

a) **Adjacency:** Hotels, retail outlets, restaurants, office parks, etc. are usually close and form a cluster around the station. Depends on land availability.

b) **Accessibility:** The station is a centre that connects the activities with roads and transit modes. Intensity and frequency of use affects the distance decay element which affects the users of station.

c) **Networking:** A set of interconnected rail terminals are supporting the specialization and interdependency of locations. HSR systems allow establishing new network effects with increasing interaction levels between cities along the corridors they service.

Table 6-2: *Quality of station building and their impact on station design parameters.*

Source: Author of the thesis.

Station's Name	Description	Technical	Urban	Spatial	Style
King's Cross	• **Intermodality:** Linking to local, national, and international travel; with different types of modes. • New vault and its contrast with the old building create a new image to the city.		●	●	●
	• **Relationship with surrounding context:** For the 2012 London Olympics, an overall master-plan for the development in 2005; to develop the **infrastructural, social and commercial** aspects of the city and linking the station with the huge Kings Cross Central scheme at its north besides St Pancras.[277] The stations urban position is adjacent to other facilities.		●		
Haramain	• **Intermodality:** Reduce journey time between the 4 cities considerably. The approach of HHSR wayfinding system is a modular approach		●	●	

[277] Frearson, A. (2012, March). *Western Concourse at King's Cross by John McAslan + Partners*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2012/03/14/western-concourse-at-kings-cross-by-john-mcaslan-partners/

Station's Name	Description	Technical	Urban	Spatial	Style
	and a network-wide specification for pass-through and termini. Each station has its own special cases, and the wayfinding strategy puts them into consideration. • Movements from/to arrival concourse level need to be supported, in particular at vertical circulations: lifts and escalators by concentrated levels in pass-through or termini. • The 4 stations also offer car parks for long and short parking. **Relationship with surrounding context:** The stations are both gateways to their respective cities and civic social centres. The stations urban design is forming network; meaning an increased interaction between each city.				
Berlin	The station relies on a cruciform base, which simultaneously integrates the dominant diagonal blocks of buildings. The rectangular socket is accessible from all four sides by stairways and offers great public spaces to a height of 4.43 m above street level, clearly separate from the areas of circulation. Special attention was paid to issues of security and fire protection, both in the planning and construction, using parameters that are designed according to the latest advances in safety and prevention.[278] The urban structuring is accessibility; meaning that the station is a centre that connects the activities with roads and transit modes. Intensity and frequency of use affects the distance decay element which affects the users of station.		●	●	

[278] Berlin Central Station. (n.d.). Retrieved 2017, from WikiArquitectura.com: https://en.wikiarquitectura.com/building/berlin-central-station/

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
Nagoya	"Twin Towers" is the name of the station complex, referencing the two cylindrical skyscrapers in the middle, and has a Guinness World Records as the world's largest station building: A total floor area of 410,000 m², and 245 m high. The station has two contrasting sides: Sakuradori (*Cherry Blossom Street*) is across from the main entrance, leads down into the city's main business district, while on the other hand, the opposite the shinkansen side of the tracks, is rich with visually attractive blinking neon signs from leisure and city-life facilities; such as hotels, nightclubs, and massage joints.[279] The urban structuring is accessibility; meaning that the station is a centre that connects the activities with roads and transit modes. Intensity and frequency of use affects the distance decay element which affects the users of station.	●	●	●	●
Kenitra	Kenitra Station's design is based upon airports; with the similar security and the need for fluid transitions from "controlled" to "uncontrolled" zones. The public commercial zone of the station has the purpose of providing a naturally-secured buffer zone; with commercial zone and common facilities for passengers and workers, is designed for public and commercial spaces, with the access to them should be by users (80% of total users) who are either city residents or non-transit travellers. [280] The station has several underground floors that contain mechanical, storage, sorting rooms, and all of		●	●	

[279] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

[280] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

Station's Name	Description	Technical	Urban	Spatial	Style
	the structure required to support the above-ground steel columns. [281] The urban design form a network; meaning an increased interaction between each city.				

1 ***Intermodality & wayfinding:*** speed of journeys, increased reliability, and less confusion; while approaching the train line, and hanging transport modes.

HHSR wayfinding system uses a modular approach and a network-wide specification that reduces journey time between the 4 cities considerably. Each station has its own special cases, and the wayfinding strategy puts them into consideration.

2 ***Airport-inspired zoning system:*** Stations can play a role of an airport; where barrier-free passages, security buffer zones, and travelling services with the similar security and the need for fluid transitions from "controlled" to "uncontrolled" zones. The station's exterior design gives the building an aesthetical value for the cultural side of the city, and also helps with the layout organization in strengthening the value of the station as an urban pivotal point in meeting, travelling, or trading. This is used in the newest stations; unlike before, especially for redeveloped stations. Kenitra in particular uses the commercial zones as a natural buffer zone for security. HHSR stations have several common functional aspects with modern airports, so needs for information and circulation are the same to those in airports. Despite that, communication and information provision should consider the unfamiliarity of a larger group of people to the

[281] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

rules. For a simple type of the service, it is expected for a fast familiarisation from everyday users, with required areas like[282]:

- Arrival/ Departure concourse separation.
- Entrance gateways, where most of passengers arrive using vehicles.
- Dual ticketing options (window and TVMs), the same as the assisted and self-check-ins.
- Security screening protocols; like airports.
- Alternative locker/excess courier facilities.
- Baggage size and/or weight conditions.
- Pre-reservations for all seats.
- Arrival services such as renting cars, and tourism operators.

3 ***Relationship with the urban context:*** comes from 3 elements:

Urban weight, unity & linking with surrounding spaces, & cultural expression.

- **Urban weight:** The station building represents an international transportation hub that is also an icon for the city of **Berlin**. The large scale, zoning, layout design, and levels turn the station complex into a strong urban space. High-Rise stations, like **Nagoya Station**, represent an iconic landmark and represents an international design and style that all users can locate from afar, and also with its position in the urban context. In case of redevelopment of an old station, the designer can use new elements of strong visual weight, composition, and even contrasting with the original construction (**King's Cross**).

- **Unity and linking with surrounding spaces:** Form, structure, and layout organization. **Kenitra Station** uses its layout organisation and its exterior form. The form is

[282] Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

conceived as a geometrical volume whose triangular framework recalls traditional shapes found in vernacular Moroccan architecture, and part building, part pedestrian causeway, which adds a value to the linking of districts and to the historical city in its design by providing 2 entrances that are joined by the framework[283]. The station has the purpose of being a pivotal point for a new urban district for the city, and linking several Eastern and Western neighbourhoods currently divided by railway lines, in other words: the station should be a unifying element between its elements, the university district, and the neighbourhoods, in its circulation and urban weight[284]

For new developments of a station, the designer can use the position and characteristics of the station in redevelopment of the whole area. For the 2012 London Olympics, an overall master-plan for the development in 2005; to develop the **infrastructural, social and commercial** aspects of the city and linking the station with the huge Kings Cross Central scheme at its north besides St Pancras[285].

- **Cultural expression:** can reflect the contradictions of the visuals, such as Japan in lighting, lifestyle, and colours. It can also be from the heritage of the community; like the vernacular themes from **HHSR** and **Kenitra**.

Haramain Stations' design uses a modular plan, with a consistent layout design all over the network; with terminal stations and pass-

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[283] Rosenfield, K. (2014, March). *Silvio d'Ascia Wins Competition to Design Morocco Rail Station*. Retrieved June 2019, from Archdaily: https://www.archdaily.com/485716/silvio-d-ascia-wins-competition-to-design-morocco-rail-station

[284] *KENITRA TGV: High-speed rail station and transit hub*. (n.d.). Retrieved June 2019, from Silvio d'Ascia Architecture: https://www.dascia.com/kenitra-tgv-eng

[285] Frearson, A. (2012, March). *Western Concourse at King's Cross by John McAslan + Partners*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2012/03/14/western-concourse-at-kings-cross-by-john-mcaslan-partners/

through stations share the same basic layouts. So, the approach of HHSR wayfinding system is a modular approach and a network-wide specification, which is applied on both its pass-through stations and termini. Common background should be[286]:

- Service quality and a consistent user experience.
- Environments, protocols and services.
- Overall ticketing disciplines.

6.4.3 Environmental solutions

Over time, energy saving, consumption efficiency, and user comfort grew in importance that they became an integral part of building designing. Train stations, as large and busy they are, adapted several methods in various environmental solutions, such as: resource control, recycling, daylighting, air conditioning, and energy generating.

Table 6-3: *Environmental solutions and their impact on station design parameters. Source: Author of the thesis.*

Station's Name	Description of Element	*Technical*	*Urban*	*Spatial*	*Style*
King's Cross	The restoration includes changing the glazing of the north and south gables, and lining the 2 barrel-vaulted roofs with energy-saving photovoltaic arrays along the linear roof lamps. Heat and power using Combined Heat and Power (CHP) engines that produce about 100% of required heat and hot water. [287] The station adapts eco-friendly air	●		●	

[286] Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

[287] *Green Buildings*. (2018). Retrieved August 2018, from King's Cross: https://www.kingscross.co.uk/sustainable-building-design

Station's Name	Description of Element	Technical	Urban	Spatial	Style
	conditioning supply system which saves energy using waste heat from the "Cogeneration system (Natural gas)" combined with "Ice storage system (electricity)"; the latter is a system for cost reduction and load levelling.[288]				
Haramain	The design provides transitional zones within each station to avoid the risk of thermal shock by buffering the change in temperature between various areas; it starts with entering into **a retail area** that is kept at a cool 18° C, and then passing through to the slightly warmer 24° C of **the main station concourse**. Finally, the traveller passes through a semi-external space where Arabian screens provide shading and maintain a temperature of 30° C, before arriving on the **platform** for a short wait before boarding their train[289]. Along with maximised shading and use of daylight (5% opening), the sustainability in HHSR includes passive cooling in platform and grey water recycling.[290]	●		●	
Berlin	Solar panels integrated to the glass surfaces, and ventilation pipes designed with advanced techniques, and integrated	●		●	

[288] Nagoya Netsukyokyu CO.,LTD. (n.d.). Outline of the JR Central Nagoya Station Area District Heating and Cooling. Retrieved July 2019, from Solar Heating & Cooling Programme: http://task42.iea-shc.org/Data/Sites/9/documents/events/meeting-12/EM12-Central-Nagoya-Station.pdf

[289] *Haramain High-Speed Rail, Saudi Arabia*. (2017). Retrieved August 2017, from Burohappold Engineering: https://www.burohappold.com/projects/Haramain-high-speed-rail/

[290] Singhal, S. (2012, January). Al Haramain High-speed Rail Stations in Kingdom of Saudi Arabia by Foster + Partners. Retrieved June 2019, from AECCafe Blogs: https://www10.aeccafe.com/blogs/arch-showcase/2012/01/14/al-Haramain-high-speed-rail-stations-in-kingdom-of-saudi-arabia-by-foster-partners/

Station's Name	Description of Element	Technical	Urban	Spatial	Style
	to the main form of the station and the corporate identity. Among the glass ceiling, an area of 2700 m² of solar panels is composed of 1250 modules. Four exhaust pipes rise above the roof of the Hauptbahnhof, New Berlin, as are its tallest structure.				
Nagoya	The station adapts eco-friendly air conditioning supply system which saves energy using waste heat from the "Cogeneration system (Natural gas)" combined with "Ice storage system (electricity)"; the latter is a system for cost reduction and load levelling.[291]	●			
Kenitra	Inspired by its local context in providing passive design strategies to naturally ventilate a large part of its interior.[292] The passive design uses the "floating" canopy of the station. While the structure of canopy itself carries several rows of rooftop photovoltaic panels, it also provides shade, wind directing, and collection of rain water during rainy seasons[293].	●	●	●	●

- Those environmental solutions can use peripheral technology-implemented buildings and machinery that are eco-friendly; such as natural gas and waste recycling systems (**King's Cross** and **Nagoya**).

[291] Nagoya Netsukyokyu CO.,LTD. (n.d.). Outline of the JR Central Nagoya Station Area District Heating and Cooling. Retrieved July 2019, from Solar Heating & Cooling Programme: http://task42.iea-shc.org/Data/Sites/9/documents/events/meeting-12/EM12-Central-Nagoya-Station.pdf

[292] *KENITRA TGV: High-speed rail station and transit hub*. (n.d.). Retrieved June 2019, from Silvio d'Ascia Architecture: https://www.dascia.com/kenitra-tgv-eng

[293] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

- Another solution is using the passive methods by using building orientation, building construction materials (**Berlin**), solar shading, and even the designed form of the building itself and their transitional spaces (**Haramain**).

- Can also serve as an aesthetical and cultural representation for the urban context (**Kenitra**). The stations turn into a centre for green systems for the local area, and self-sufficient in energy requirements.

6.4.4 Quality of platforms

Table 6-4: *Quality of platforms and their impact on station design parameters.*

Source: Author of the thesis.

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
King's Cross	Ability for departing passengers to access all 12 platforms in Main Shed, Western Range, & below eastern offices.			●	
Haramain	For covering the platforms, the original concept had glazed station platforms, which later became lightweight fabric canopy; a cost effective solution, and providing required cooling from shading on the platforms[294]. A transitional area on platform level should make the users know their way to their platform; with required display methods for signs and in appropriate sizes[295].	●		●	●
Berlin	Between two frames is the central nave that houses the station platforms, 430 meters long, oriented in the direction east – west, covered by a huge glass dome and light that extends over 321 m. The building with north-		●	●	

[294] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

[295] Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

Station's Name	Description	Technical	Urban	Spatial	Style
	south orientation of 45 m wide and 159 m long, are situated between the two blocks of buildings; covered by a barrel vault, filigree and glass. From the standpoint of architecture and urban planning, these structures, called building bridges form a unit with the glass vessels of the train station. The point of intersection of the two railway lines' long distance is enhanced by the cruise ships of the two windows. [296]				
Nagoya	Contains **12 platforms for JR lines**: numbered from 1 to 13; with Platform 9 only for freight trains carrying cargo bound for Nagoya Port. In addition to them, there are **Shinkansen Platforms**; platforms 14 - 17. Finally, there is also **Nagoya Subway Station**; which can be accessed by stairwells just outside the Sakura-Dori Exit of Nagoya Station.[297]			●	
Kenitra	The connection between the platforms is an elevated bridge to occupy a small footprint. The station uses for access elevators, escalators and footbridges, all lead passengers to platforms and the elevated concourse which includes retail shops, cafes, lounge areas and kiosks[298].	●	●	●	●

[296] Berlin Central Station. (n.d.). Retrieved 2017, from WikiArquitectura.com: https://en.wikiarquitectura.com/building/berlin-central-station/

[297] *Nagoya Station Map – Finding Your Way*. (2018). Retrieved March 2018, from Nagoya Station: https://www.nagoyastation.com/nagoya-station-map-finding-your-way/

[298] Zimmer, L. (2014, March). *Silvio d'Ascia Unveils Gorgeous Lace-Like High Speed Rail Station for Morocco*. Retrieved June 2019, from Inhabitat: https://inhabitat.com/silvio-dascia-designs-a-gorgeous-lace-like-high-speed-rail-station-for-morocco/

Platforms in new stations aim to:

- Handling the traffic with sufficient lines for travel efficiency, time-saving, and reliability.

Platforms have adequate dimensions, with the acceptable daylighting, shading, connection to other amenities and escalators. The geometry of the shed also gives a comforting experience. **Haramain stations** use a combination of external mashrabiya and the deep overhanging roof canopies hide the glazed entrances to the concourse and the platforms depending on the sun path: Madinah Station faces East, while Makkah Station faces North[299].

Figure 6-23: *HSSR platforms covered by canopies.*

Source: González, M.F. (2019, June).

- Element of harmony with other interior areas; to add value to the station, and providing visual comfort: shown in the same materials and language with **Berlin Station**.

- Linking eyesight from inside with the exterior view.

- Creating a totally coherent ground plan for passenger circulation into and through the station. For example: **King's Cross** integrated the main and suburban train sheds in their renovations; with the

[299] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

new glass footbridge extends across the Main Train Shed, linking to every platform and the mezzanine level of the concourse (**Figure 6-24**).[300] Thus, the current platforms are:

Platform 0	**Platforms 1:8**	**Platforms 9:11**
Below the East side offices	Below Main Train Shed	Western Range; inside the Western concourse

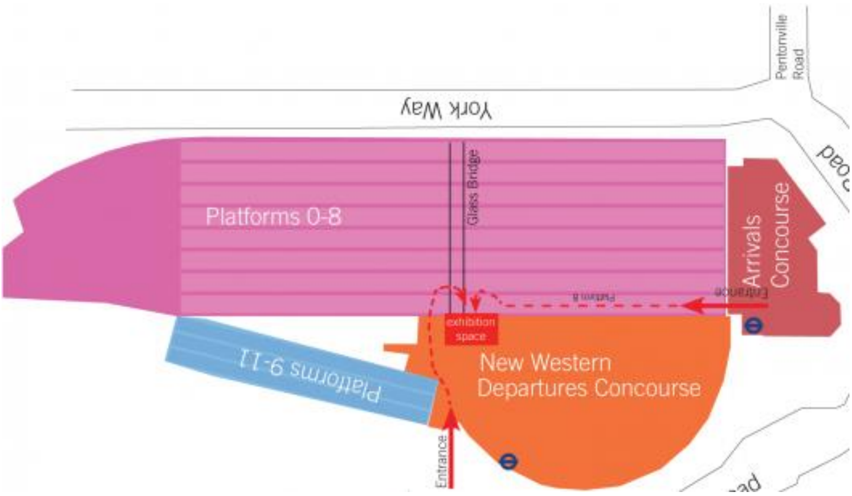

Figure 6-24: Kings Cross' platform diagram.

Source: Frearson, A. (2012, March).

One of the main purposes of renovating the platforms and sheds is the ability for departing passengers to enter the 8 original platforms in the main train shed, plus the added Platform-0; which was opened to the east directly through the new 2-storey hall in 2010 (formerly the old cab road), and adding to them the 3 underground platforms in 2009 [301]. The station's Main Train Shed is two simple yet elegant

[300] Frearson, A. (2012, March). *Western Concourse at King's Cross by John McAslan + Partners*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2012/03/14/western-concourse-at-kings-cross-by-john-mcaslan-partners/

[301] *Ibid.*

steel and glass vaults (250 x 22 x 65 m) cover the halls containing eight platforms (**Figure 6-25**).

Figure 6-25: *One of two steel & glass vaults over the platforms, Kings Cross.*
Source: Frearson, A. (2012, March).

Figure 6-26: *The new glass footbridge at King's Cross.*
Source: Kings Cross Bridge Removal Completed Ahead of Schedule. (2009, January).

Kenitra Station, on the other hand, the main area of the station levels in its mid-height are supported from steel columns to give the impression of hovering in the open space; to create an urban gallery underneath the canopy structure; to provide the spaces below the canopy; mainly for public circulation and commercial functions, the station will have an exciting experience.[302]

6.4.5 Quality of station halls

The station halls of new stations should highlight the important values of: fast movement, ease of locating spaces and directions without hindering, providing a clear definition of spaces and the progression through spaces, and comfort during the flow or waiting of passengers.

[302] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

Table 6-5: Quality of station halls and their impact on station design parameters. Source: Author of the thesis.

Station's Name	Description	Technical	Urban	Spatial	Style
King's Cross	• Creating a totally coherent ground plan for passenger circulation into and through the station by integrating the main and suburban train sheds; to enter platforms either through the ground level gate-lines in the ticket hall through the Western Range building, or by the mezzanine level gateline, leading onto the newly-built footbridge. • **Amenities**: Administrative spaces & user utilities in a barrier-free system. [303]		●	●	
Haramain	Direction of the trains shapes the arrangement of spaces, using few level changes, are used to reduce solar gain. • **Passenger movement** The basement floor internally links the drop-off, pick-up and car park facilities and a piazza at arrival/ platform level externally. The termini concentrate focus mixed user activities on 2 floors, and provide a 3rd floor for passenger departure lounges. [304].		●	●	
Berlin	The two buildings of the station bridge are divided into two distinct functional areas. The areas for commercial uses, restaurants and service for rail users who occupy the lower levels and areas of 50,000 m² offices occupy nine of the ten floors of these buildings. They are functional and adaptable offices as		●	●	

303 *Kings Cross Bridge Removal Completed Ahead of Schedule*. (2009, January). Retrieved August 2018, from Network Rail: https://www.networkrailmediacentre.co.uk/news/kings-cross-bridge-removal-completed-ahead-of-schedule

304 Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

Station's Name	Description	Technical	Urban	Spatial	Style
	required, by contacting the different spaces by stairs. [305]				
Nagoya	The concourse is a huge airy space that reaches both towers on the 15th floor. The concourse has a panoramic view through plate-glass picture windows, from which tourists can look from a row of elevators just inside the left-front entrance to the station[306]. The concourse is also known for other attractions and focal points; such as an ornate golden clock in the middle of the main floor of the station, and also the vegetation planted around the clock and escalators; which connects the station with Nagoya's bus terminal and also has a large outside terrace[307].		●	●	
Kenitra	The Kenitra Station has the design of its layout as a combination between U and L-shaped types. The layout configuration is based on creating 2-L shapes; with one side is for amenities and services, and the other is a bridge that crosses the tracks. Passenger can enter into secured areas from any of the two sides of the station using the pedestrian bridge, and a secured footbridge on the opposite side of the station. The length of each "leg" of the layout is designed with respect to the integration of the TGV model used for the		●	●	

[305] Berlin Central Station. (n.d.). Retrieved 2017, from WikiArquitectura.com: https://en.wikiarquitectura.com/building/berlin-central-station/

[306] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

[307] *Ibid.*

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
	line; where the form of the building covers the entire stopped train. [308]				

1. ***When dealing with redevelopment of an old station, the designer should reconfiguration of the whole ground floor plan by linking the urban space with the core and peripheral areas***; specifically, the ground floor and the tracks (**King's Cross**). The links can be by using new footbridges and new entryways.

2. ***High-rise stations can implement its properties, like view to the surroundings, larger built-up areas to add a value to the station's requirements***; such as **Nagoya Station** and **Berlin Station**: each has a barrier-free concourse with connection to the other services, and provides a view to the city for both travellers and visitors; enjoying the facilities provided by the station, interior design, and daylighting that extends from the highest levels.

Figure 6-27: *The Sakura-Dori side Gold Clock.*

Source: Nagoya Station Map – Finding Your Way. (2018).

[308] Cardno, C. A. (2014, March). *Floating Canopy Defines Morocco HSR Station*. Retrieved June 2019, from American Society of Civil Engineers: https://www.asce.org/magazine/20140401-floating-canopy-defines-morocco-hsr-station/

Figure 6-28: *The Taiko-Dori side Silver Clock.*

Source: Nagoya Station Map – Finding Your Way. (2018).

3. ***Planning decision for layout formation helps in enhancing the core spaces:*** **Berlin Station** designed its layout as 2 intersecting blocks / "crucifix" form; in separating the travelling and commercial services from the administrative services. **Kenitra Station** combines the L & U types of layout design gives the station a stronger connection between the concourse, and the platforms. The connection is further strengthened by the formation of the canopy that is both a shed and an enveloping plane that unites the areas of station.

    - ***For multiple stations working as one on a single railway, designers need to consider a specific solution to be used as a typical planning system for the whole station group.*** For **Haramain stations**, Jeddah and KAEC Stations are pass-through stations. Their main concourse enclosures overlap the centre-line of the ground level platforms. On the other hand, Makkah and Madinah Stations are termini; with their main concourse enclosures are found at the platform ends, and the public front doors to the stations are formed from the pedestrian plazas[309].

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[309] *Haramain High Speed Railway (2017). Retrieved June 2019, from Foster+Partners: http://www.hhr-retail.com/*

Makkah Station has its passenger movements concentrated across three levels: **Basement Floor** (-5.90), **Arrival Concourse and Platform Level** (±0.00), and **Departure Concourse** (+8.40). Basement Level is for arrival services, additional retail areas and connection to car parks and private car pick up points. Movements from/to arrival concourse level need to be supported, in particular at vertical circulations: lifts and escalators[310] (**Figure 6-42**).

The basement floor internally links the drop-off, pick-up and car park facilities and an open space at arriving / platform level externally. Contrast to pass-through stations, Madinah and Makkah termini focus mixed user activities on 2 floors, and provide a 3rd floor for passenger departure lounges. The middle floor in particular (±0.00) presents the main challenge from a wayfinding perspective in respect to its multiple functions and probable high rates of users.[311] See (**Table 6-6**), (**Figure 6-29**), and (**Figure 6-30**).

Table 6-6: *Main inward & outward flows& destinations, Makkah Station.*

Source: Foster + Partners Ltd. (2010). Format: Author of the thesis.

Inward	Outward
Through 2 or more vertical movements using lifts or escalators, from drop-off and car parks to ticketing services at arrival concourse/platform level (±0.00), and then (upwards) to concourse level (+8.40) to later return to platform level to alight the trains.	Providing with same-level exit from any of the 10 platforms to either internal or external connections/ pick-up points & car parks. A unique exit point from platform to concourse, with subsequent outward movements changed direction to specific destinations within the station area.

310 Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

311 Foster + Partners Ltd. (2010). Haramain High Speed Rail Wayfinding Strategy. London. Retrieved from http://www.renfe.com/docs/SenaleticaEstacionesHHSRFoster.pdf

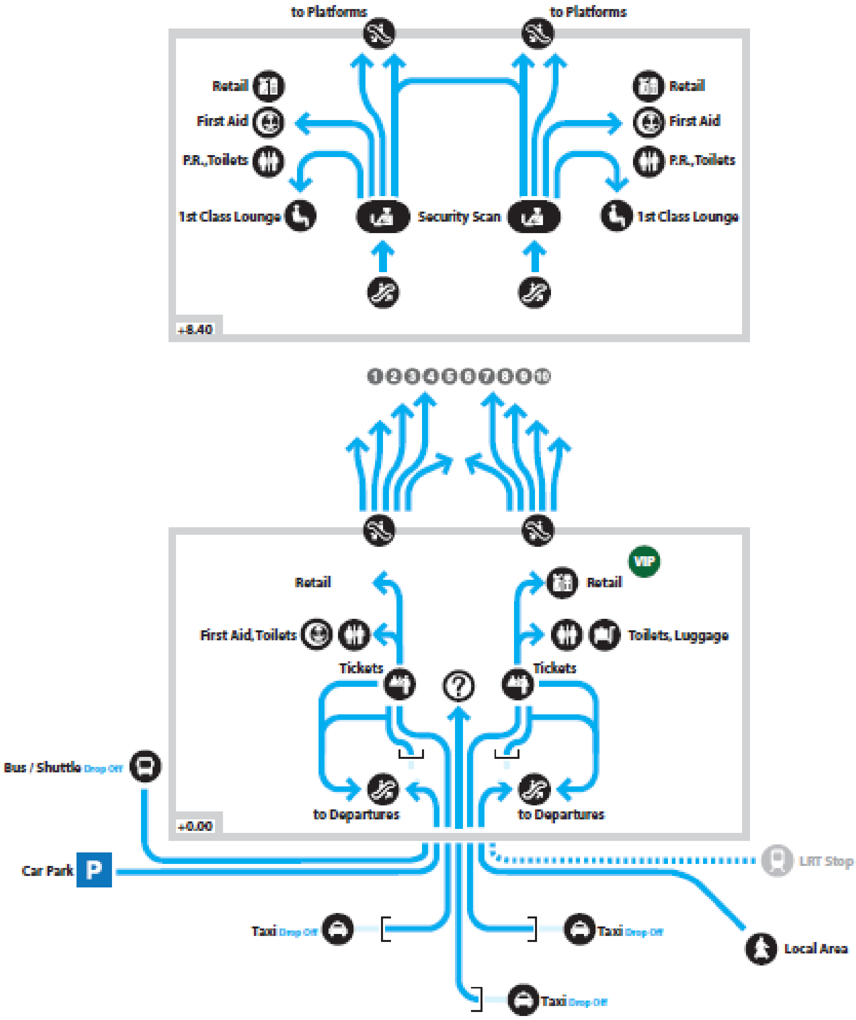

Figure 6-29: *Main inward flows& destinations, Makkah Station.*

Source: Foster + Partners Ltd. (2010).

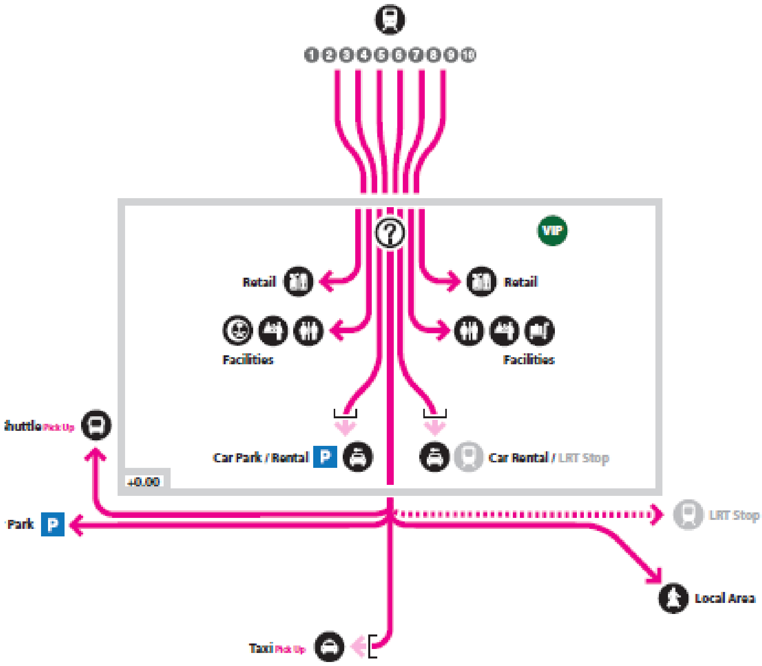

Figure 6-30: *Main outward flows& destinations, Makkah Station. Source: Foster + Partners Ltd. (2010).*

6.4.6 Commercial & cultural functions

Table 6-7: *Quality of station halls and their impact on station design parameters. Source: Author of the thesis.*

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
King's Cross	The renovations intended to provide new facilities that will serve over 50 million passengers per year.[312] Hotels, retailing inside & outside; close to		●	●	

[312] Frearson, A. (2012, March). *Western Concourse at King's Cross by John McAslan + Partners*. Retrieved July 2017, from www.dezeen.com: https://www.dezeen.com/2012/03/14/western-concourse-at-kings-cross-by-john-mcaslan-partners/

Station's Name	Description	Technical	Urban	Spatial	Style
	travellers; including the overall master-plan for the development in 2005; transforming Kings Cross area.				
Haramain	The train stations should include several facilities, like: business class lounges, a public transport centre, parking lots, civil defence stations, mosques, and commercial spaces serving the traveller's needs[313].			●	
Berlin	Of its 175,000 m² total area, 21,000 m² of them are intended for rail transport, occupying two levels and have 14 platforms, and 15,000 m² are intended for shops and restaurants, office space 50,000 buildings, and 5,500 bridge functional purposes of the railway. The platforms are spread over an area of 32,000 m² and the garage area occupies about 25,000 m. Its empty 3 floors of shops and restaurants between the two levels of terraces, the station also became the commercial and business centre of the future neighbourhood around the station[314].		●	●	
Nagoya	• The 1st tower is a 53-storey **Hotel Tower**: Nagoya Marriott Associa Hotel; separated from the station by a 30-second walkway, and takes 4,100 m² of space. • The other is 51- floor **Office Tower**, 60,000 m² of space for rent. Both towers share a common base 15 floors high, plus six more floors underground. The station towers also contain gardens,		●	●	

[313] King Salman to inaugurate Haramain high-speed train line on Tuesday. (September 2018). Retrieved June 2019, from Travel Wire News: https://travelwirenews.com/king-salman-to-inaugurate-Haramain-high-speed-train-line-on-tuesday-1102440/

[314] GMP Projects: Berlin Central Station. (2016). Retrieved November 2016, from Gerkan, Marg and Partners Official: http://www.gmp-architekten.com/projects/berlin-central-station.html

Station's Name	Description	Technical	Urban	Spatial	Style
	spas, cafes, bars, restaurants, and department stores. [315] • **Department stores** occupy 13 floors. Below that are two underground sales levels offering great varieties of food and drinks. There are several shops like bookshops; that include seating to enjoy reading, and various restaurants that offer food from many countries from the Far East or Europe; all occupy 8,400 m² of the station complex. [316]				
Kenitra	The public commercial zone is a natural security buffer zone, and occupies 2,200 m^2 of area, not included in 10,000 m^2 of the main area that includes common facilities for passengers and workers, is designed for public and commercial spaces, including a pharmacy, restaurants, magazine and news kiosks, convenience stores, and a food court, with the access to them should be by users (80% of total users) who are either city residents or non-transit travellers. The elevated concourse which includes retail shops, cafes, lounge areas and kiosks[317].		●	●	

- Commercial services inside train stations should be located on the sides of main circulation, and avoids hindering the speed and reliability of travelling services.

[315] Carr, S. (2014, March). *JR Nagoya Station: Almost a town within a city*. Retrieved August 2017, from The Japan Times: https://www.japantimes.co.jp/life/2014/03/15/travel/jr-nagoya-station-almost-a-town-within-a-city/#.WagdoLIjHDc

[316] *Ibid.*

[317] Zimmer, L. (2014, March). *Silvio d'Ascia Unveils Gorgeous Lace-Like High Speed Rail Station for Morocco*. Retrieved June 2019, from Inhabitat: https://inhabitat.com/silvio-dascia-designs-a-gorgeous-lace-like-high-speed-rail-station-for-morocco/

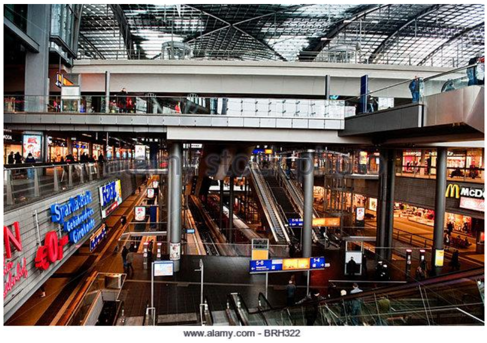

Figure 6-31: *Shopping centre & lobby, Berlin Central.*
Source: http://www.alamy.com

- Commercial services inside the stations are either separated in a different level from the ticketing area, or on the same level. However, it is common to place commercial spaces close to the main concourse.

- While retail spaces are the most essential commercial space type for a train station, there are more types that got increased in importance and became integral to the station, such as the necessity of adding a hotel to large station, and adding comfort and leisure spaces, like VIP lounges and fancy restaurants.

- Train stations have different levels of being a provider for commercial service for users:

1. Inside the station building, and almost exclusive for travellers (**Haramain**).

2. Inside the station, but serving the neighbourhood, tourists, and travellers.

3. Adding a value to the urban parameter of the station by becoming a pivotal point in redevelopment an entire urban community.

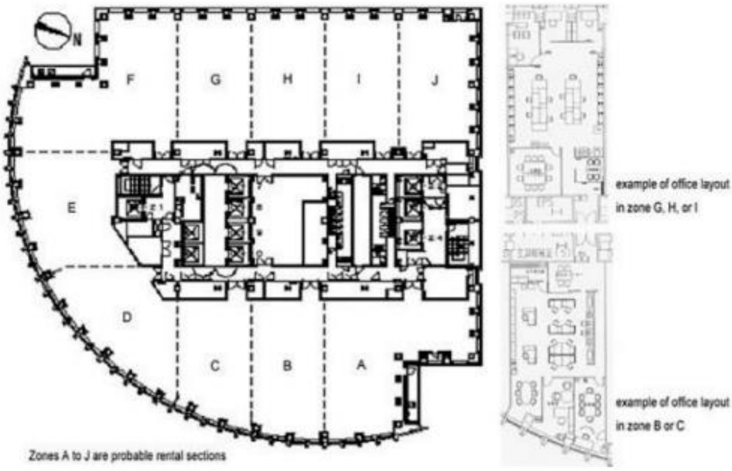

Figure 6-32: *Typical administrative floor in one of Nagoya Station's towers.*
Source: Wolfgang F. E. Preiser, A. E. (Ed.). (2017).

Kings Cross Redevelopment

Kings Cross area is a distinguished neighbourhood. It connects 3 mainline stations: King's Cross, St. Pancras International and Euston; providing domestic links, and foreign: Paris, Brussels, etc., besides links to major international airports. The area witnessed a community growth; with new recreational areas, open spaces, business, and cultural activities. So, the 21st century witnessed improvements and additions to the area. (**Table 6-8**), (**Figure 6-33**), and (**Figure 6-34**) shows the urban plan of Kings Cross, London[318]:

[318] Tapestry Brochure: Handmade at King's Cross. (2013). Retrieved August 2018, from King's Cross: https://www.kingscross.co.uk/media/Tapestry_Brochure_Lo_Res.pdf

Table 6-8: *Urban plan elements of Kings Cross area.*

Source: Tapestry Brochure: Handmade at King's Cross (2013).
Format: Author of the thesis.

Tag	Building	Description
1	**Tapestry**	Originally the 19th Century Grade-II Listed Gasholder Number 8, re-configured as the setting for a new urban park.
2	**The Regent's Canal**	A Victorian canal through the King's Cross landscape where visitors enjoy the view outside the café and restaurants of nearby Kings Place.
3	**Camley Street Natural Park**	Replacing a former coal yard.
4	**The Coal Drops**	Set within historic buildings; to be London's most exciting new shopping, bar, and restaurant destination.
5	**University of the Arts London & Central Saint Martins**	A world-leading centre for creatives in the arts, theatre, fashion, and design.
6	**Granary Square**	One of Europe's largest public squares with fountains is the meeting point for visitors, the University of the Arts residents, students, and office workers or visit nearby cafés, restaurants and shops.
7	**King's Boulevard**	The broad shopping boulevard stretches from the stations to Granary Square past a new London Underground entrance.
8	**The Great Northern Hotel**	On the south-west side aligned to Old St Pancras Road, Lewis Cubitt designed **The Great Northern Hotel** for the patrons of the Great Northern Railway Company in 1854; as one of the earliest purpose-built railway hotels in the country. The stylish boutique hotel is a Grade-II listed building, and advanced construction. The hotel features over 90 luxurious rooms.[319]

[319] *Great Northern Hotel: The world's first great railway hotel is back in business*. (n.d.). Retrieved August 2017, from www.kingscross.co.uk: https://www.kingscross.co.uk/great-northern-hotel

Tag	Building	Description
9	**King's Cross Station**	---
10	**Pancras International Station**	With regular trains to Paris, Brussels and Lyon and services to the Southeast and the Midlands, with more planned international connections.
11	**St Pancras Renaissance Hotel**	The newly-restored 19^{th} century 5-star Renaissance Hotel.

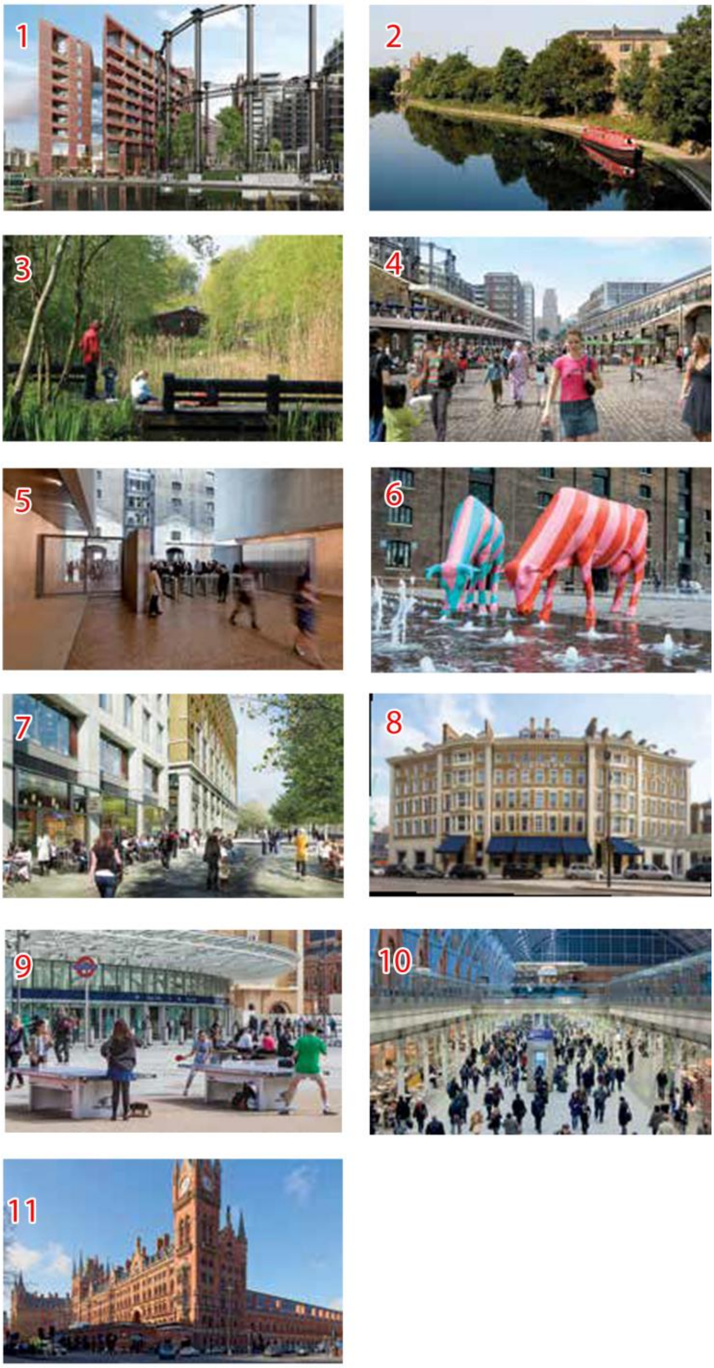

Figure 6-33: *View of Kings Cross features.*

Source: Tapestry Brochure: Handmade at King's Cross (2013). Format: Author of the thesis.

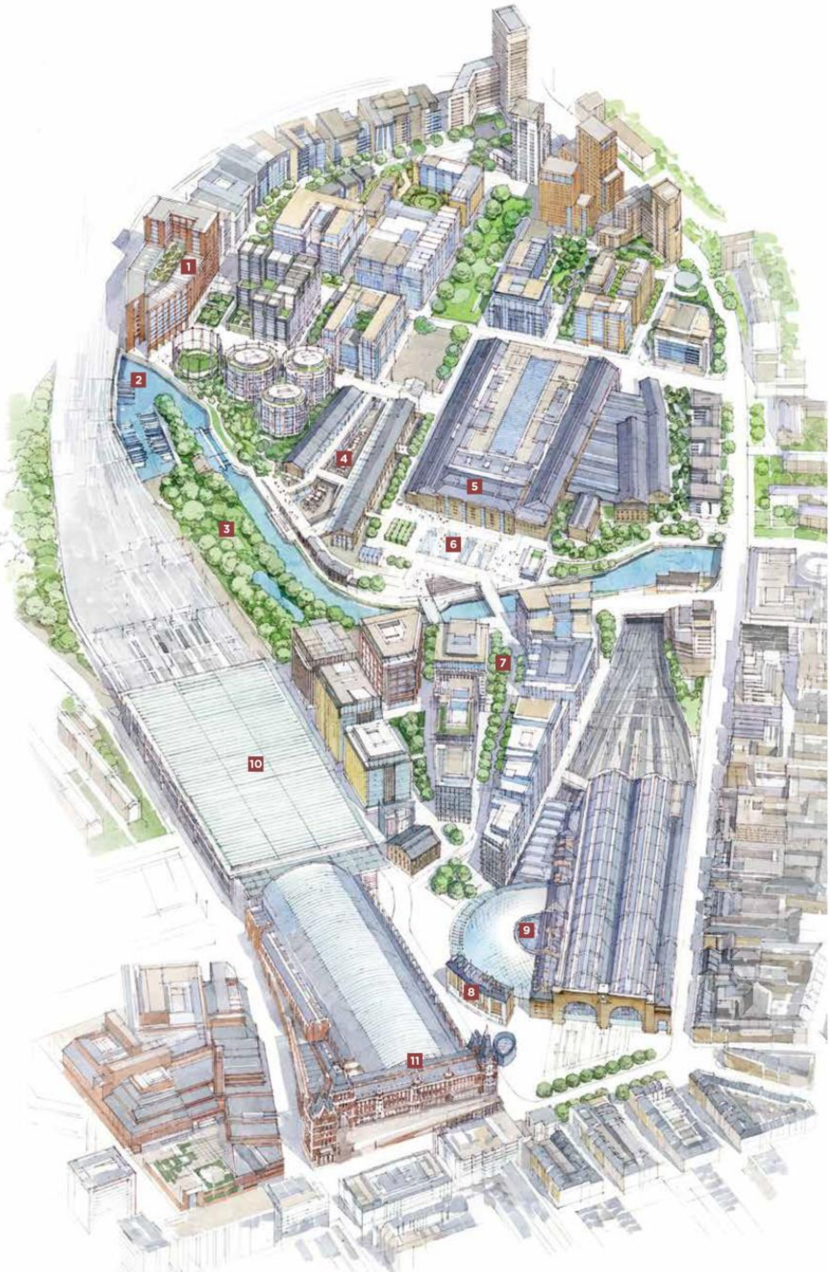

__Figure 6-34:__ Kings Cross redevelopment layout.

Source: Tapestry Brochure: Handmade at King's Cross. (2013).

6.5 Form Design Elements

From the previous chapters, there is a conclusion that form and function for train station design became over time more integrated with each other to the point of reaching some difficulty in some cases to separate their effects on the station design parameters; especially with reviewing of the “Station Users’ Pyramid of Needs” in the prelude: How can the necessities of travelling modes contribute to an experience for the user? What are the tools needed to shape a concept or deliver a message through designing a station? What message / expression should be used in the first place?

The research conducts a comparative analysis to determine the changes in the aesthetical expression and symbolism in the new era of train station design, and to determine the possible trends and themes for upcoming station buildings.

6.5.1 Aesthetical expression

6.5.1.1 Volume

1. ***Scale, space, proportions, & shapes:***

Each of the stations depends on expressing the relationship between each volume from the point of their spatial connections and hierarchy using form expression.

- Berlin uses 2 intersecting horizontal boxes as the final form to create a hierarchy and zone organization within the station building, and the outside plaza, and using bridges as linear elements for the connection between them.

- The urban parameter value of a station Nagoya station uses a vertical approach in the design that adds a larger sense of scale to users; especially from street level. The vertical solution helps the spatial parameter in arranging the spaces in a complex form, and connecting them with a visible connection element (lifts, atriums, etc.)

- Fully-glazed walls are a common feature as a part of a universal design; giving the feeling of a naturally-increased space, and linking the outside with the inside.

2. *Movement & rhythm*

- Adding new and modern elements to an old station can add a contrast to the old design and also an element of attraction. King's Cross's diagrid form accomplishes an urban value, and creating a new value for spatial parameter.
    - From an urban and spatial value, a station building can use a single form to connect more than one urban space to each other that were unlinked with the construction of the railway and its buildings. Kenitra Station uses its latticework membrane for that purpose, and adding a sense of movement to a solid form that envelopes the entryways, core, and peripheral areas.
    - For a system of train stations, the designer can use a unity in the design that adds a sense of articulation to a single design entity. The designers of HHSR a modular design with its repeated sets of structural elements, with variations in colour that represent the four cities served[320].

[320] Welch, A. (2016, January). *Haramain High-speed Railway Saudi Arabia*. Retrieved 2019, from E-Architect: https://www.e-architect.co.uk/saudiarabia/Haramain-high-speed-railway-stations

Figure 6-35: *Exterior night shot of Madinah Station.*

Source: González , M.F. (2019, June).

6.5.1.2 Light

Train stations tend to use natural lighting to add a spatial value to the interior of the station; by providing comfort for the users, adding a sense of familiarity to the spaces and passageways, and a better identification of zones.

- Nagoya and Berlin use atriums to connect light to all spaces; particularly the former with its long structures.
- Daylighting can be permitted into the space using the style parameters of train stations. Perforations in a solid form in a modern or a traditional theme.

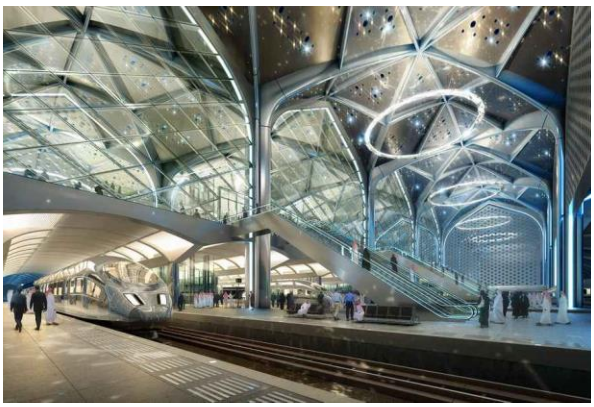

Figure 6-36: *Focused lighting and chandeliers inside KAEC station.*

Source: Welch, A. (2016, January).

Figure 6-37: The diagrid structure plays an important role in daylighting.
Source: Stewart, C., & King, S. (2018).

6.5.1.3 Colours

- Colours affect the perception of a volume, feeling of safety, and comfort. Colours can be used for adding new themes and experience for the users. King's Cross's lighting design for the concourse was done by Arup. To strengthen the visual impact of the diagrid structure, the lighting uses ceramic-based metal halide projectors that produce from the mezzanine roof structure an indirect, highly efficient and colour-stable light, which offers a comforting atmosphere to connect passengers to the time of day and the life of the city outside.[321] The original plan was to make the lighting colour blue; to contrast with the yellowish-coloured masonry, but it was changed to add more colours with stable hue all over the diagrid structure. The uniformity of the colour is done by a lighting modulor software to adjust lighting angles[322] (**Figure 6-38**).

[321] Stewart, C., & King, S. (2018). New Concourse and Stunning Diagrid Roof. Retrieved August 2018, from ARUP: https://www.arup.com/projects/kings-cross-station

[322] *Ibid.*

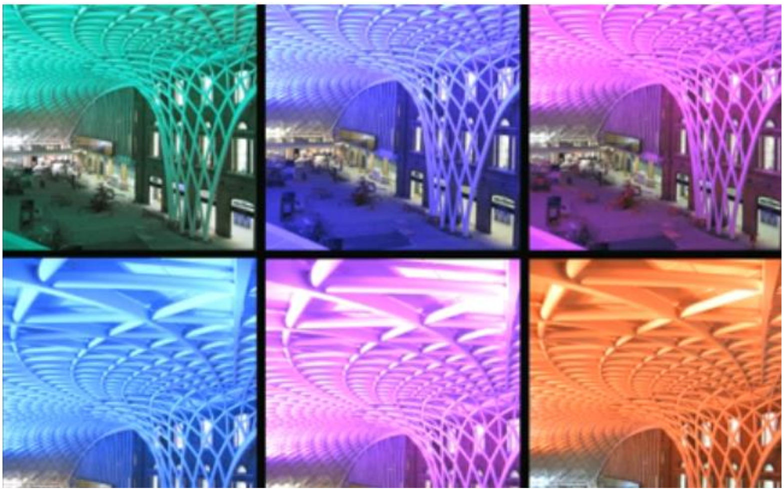

Figure 6-38: *Different hues on the diagrid structure at night.*

Source: Stewart, C., & King, S. (2018).

- Colours can represent an urban parameter value by representing a significant characteristic of its city. HHSR has each of its four stations varies in colour; which signify the four cities while remaining symbolic to the HHR system[323]:

Makkah	**Madinah**	**Jeddah**	**KAEC**
Gold; references the gold leaf of the decorated Kab'ah and the city's significance as a holy site.	*Green*; draws inspiration from the Mosque of Prophet Mohammad.	*Purple*; symbolises the city.	*Blue & silver*; representing the future role as a modern new city.

6.5.1.4 Texture and materials

- King’s Cross has its new roof in layout is a semi-circle between the rear of the Great Northern Hotel and the Western Range Building; where they revealed the bricks of the original Italianate station.

323 *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

- Lightweight materials give a sense of warmth and spaciousness; especially when contrasted with "colder" materials. HSSR uses structural materials in concrete super-structure, and steel roof structure, in addition to metal mashrabiya, fabric platform roof, GRP roof, and metal and glass facade[324]

- Berlin Station uses modern materials with neutral colours, such as metal cladding, electrostatic paint for roof structure, and transparent glass; to add spaciousness and lightness in weight that emphasise a modernist look which also adds clarity to the spaces and speed during circulation.

Figure 6-39: *Revealed brickwork of Kings Cross inside the concourse.*
Source: Frearson, A. (2012, March).

[324] Singhal, S. (2012, January). Al Haramain High-speed Rail Stations in Kingdom of Saudi Arabia by Foster + Partners. Retrieved June 2019, from AECCafe Blogs: https://www10.aeccafe.com/blogs/arch-showcase/2012/01/14/al-haramain-high-speed-rail-stations-in-kingdom-of-saudi-arabia-by-foster-partners/

Table 6-9: Aesthetical expressions and their impact on station design parameters.

Source: Author of the thesis.

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
King's Cross	• **Form & space:** 2 steel and glass vaults cover the halls containing 8 platforms, alongside the new diagrid structure covering the Western concourse; to offer daylighting and clarity for a delightful experience.	●		●	●
	• **Visual weight:** The new vault and its contrast with the old building create a new image to the city.		●		●
	• **Colours:** with stable hue all over the diagrid structure that contrast with the yellowish-coloured masonry of the Italianate style, and the new Post-Modern style of the new additions of structure.			●	●
	• **Lighting** a comforting atmosphere to connect passengers to the time of day and the life of the city outside.	●		●	●
Haramain	• **Lighting**: The external mashrabiya for light tubes bring daylight down to the concourse level and animate the space. Spotlights at night and spherical chandeliers.	●		●	●
	• **Dimensions of space, & proportions:** Arches rising from the concourse, complemented by smaller high arches at platform level. Supported by freestanding structural trees, repeated on a 27-metre square grid, the arches connect to form a flexible vaulted roof[325].			●	●
	• **Visual weight:** modular design strategy allowing the use of the same elements – such as shading louvers and chillers–		●	●	●

[325] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
	across all four stations, and controlling their numbers[326].				
	• **Colours:** Each of the four stations varies in colour; which signify the four cities while remaining symbolic to the HHR system.		●		●
Berlin	2 intersecting horizontal boxes as the final form to create a hierarchy and zone organization within the station building, and the outside plaza, and using bridges as linear elements for the connection between them.		●	●	●
	• **Light:** atriums to connect light to all spaces; particularly the former with its long structures.			●	●
	• **Visual weight and materials:** modern materials with neutral colours, such as metal cladding, electrostatic paint for roof structure, and transparent glass; to add spaciousness and lightness in weight that emphasise a modernist look which also adds clarity to the spaces and speed during circulation.			●	●
Nagoya	• **Visual weight:** The urban parameter value of a station Nagoya station uses a vertical approach in the design that adds a larger sense of scale to users; especially from street level. The vertical solution helps the spatial parameter in arranging the spaces in a complex form, and connecting them with a visible connection element (lifts, atriums, etc.)	●	●	●	●
	• **Light:** atriums to connect light to all spaces; particularly the former with its			●	●

[326] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

Station's Name	Description	*Technical*	*Urban*	*Spatial*	*Style*
	long structures.				
Kenitra	Latticework membrane adds a sense of movement to a solid form that envelopes the entryways, core, and peripheral areas. **Visual weight, colours, and materials:** modern materials with neutral colours, such as metal cladding, electrostatic paint for roof structure, and transparent glass; to add spaciousness and lightness in weight that emphasise a modernist look which also adds clarity to the spaces and speed during circulation.	● 	● 	● ●	● ●

6.5.2 Image-based elements

Considering that image-based elements as a representation of the themes, and while the old stations had the common theme of expressing a “monumentality” value to the station building, there are other themes that guide the style parameter with the treatment of its design element.

6.5.2.1 Traditionalism

Traditionalism is not just about duplicating old vernacular elements from history. It is about the adaptation of old cultural reference that characterises the urban surroundings, and adding modern qualities and expressions to them.

- Kenitra Station is inspired by the traditional art and culture of the city; an inspiration that created its canopy lattice work that has function for the station and has a strong aesthetical expression in movement, rhythm, and composition. The lights and shadows from the latticework give the users a special experience that is unique to the city and its history.

- The case of HHSR with external traditional latticework (*mashrabiya*) and the deep overhanging roof canopies changing position is enhanced by means of roof openings, through which light tubes bring

Figure 6-40: *Interior lighting inside Jeddah Station's hall.*
Source: Welch, A. (2016, January).

daylight down to the concourse level and animate the space[327]. During night time, spotlights between the perforations give the impression of stars in a night sky. Spherical chandeliers, suspended between the arches, provide focused lighting, mediating between the scale of the roof and concourse level and enhancing the rhythm of the structure[328] (**Figure 6-40**).

6.5.2.2 Universal theme

A theme in which a building uses an international style that expresses a technological expression, corporate identity, modernity, and / or inclusiveness to multiple nationalities.

- Berlin Hauptbahnhof went with the concept of an international style for expressing a gateway to Berlin for all the European lines it serves. The materials used for the construction express a modern theme that differs from the previous iteration of the station. All the aesthetic values of volume, colour, and lighting are products of function design elements of the train station.

Some designs do not apply a whole universal theme expression for their style parameter. Stations can also blend natural and artificial elements that add a contrast to the “industrial” features of the universal theme; in order to express a symbolic value, or an image - based element.

- Nagoya Station in its urban position and design elements reflect two contrasting themes; as witnessed in the lives of the Japanese: The Japanese urban lifestyle; with its vibe, artificial lights, colours and technology, and the nature that; represented in ornate figure, planting, and daylighting.

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[327] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

[328] *Haramain High Speed Rail-Saudi Arabia 2009*. (2009). Retrieved November 2016, from Foster+Partners: http://www.fosterandpartners.com/projects/Haramain-high-speed-rail/

6.5.2.3 Blending themes, and image - based elements

Kings' Cross blends new structures and morphed geometry (the new vault and footbridges) and its contrast with the old building create a new image to the city. Image-based elements are present by embracing the history of the original building, and also the literature associated with the place (e.g. the "Harry Potter" book & movie series) (**Figure 6-41**).

Figure 6-41: *A "platform 9¾" on the wall in the station concourse; for Harry Potter fans. A "The Harry Potter Shop" is also available.*
Source: https://www.kingscross.co.uk/harry-potters-platform-9-34

6.6 Effects of the Design Elements on the Station Design Parameters

From the comparative analysis of each design element, the research conducts an analysis of the current era (renaissance era) to demonstrate the changes in the designing of a train station building; all affecting the 4 design parameters of train station: technical, urban, spatial, and style. The analysis is for the overall changes in design parameters, whether the station is renovated, built on an existing line, or a whole new railway.

Table 6-10: *Analysis of the he governing station design parameters in the current age.*

Source: Author of the thesis.

	3rd Era: 1980's: Today
Technical	**Structural solutions** continued the strategy of vertical planning efficiently. Structure also started to play a role in aesthetics with rhythm, straight or organic motion, etc. with the new concepts of morphology and other computer-generated forms. **New technological applications** with other function and form elements; such as lighting, displays, guiding, etc. **Environmental solutions** became more sophisticated; providing comfort & efficiency through lighting without glaring, suitable air conditioning, and noise control. There is also the choice of materials and technology in energy saving and recycling.
Urban	Continuing the concepts from 1970's. Integration is the new concept of transportation, whether it is an intercity or across borders. Intermodality in terms of railway stations means each transportation mode is an extension of the other.
Spatial	Four main elements of stations (core, transit, peripheral, and administrative) governed by interrelationship, with practical considerations in designing the area requirements of stations: external circulation, ticket offices, commercial areas, waiting rooms, platform shelters, toilets barrier-free access, information signs. Airport special solutions became an influence on train station planning.
Style	The first goal in style determination is looking for conserving old elements of station buildings, renovating, and refurbishing them to accommodate needed spatial elements. New stations witnessed the new trends of architecture expressing new themes and new materials. The station as a landmark expresses the icon of a gateway, a visual landmark in the urban context, a cultural and a social centre, or a visual representation for the operators' companies; sometimes in a standardised visual design for several stations for the same line (e.g. Haramain Stations).

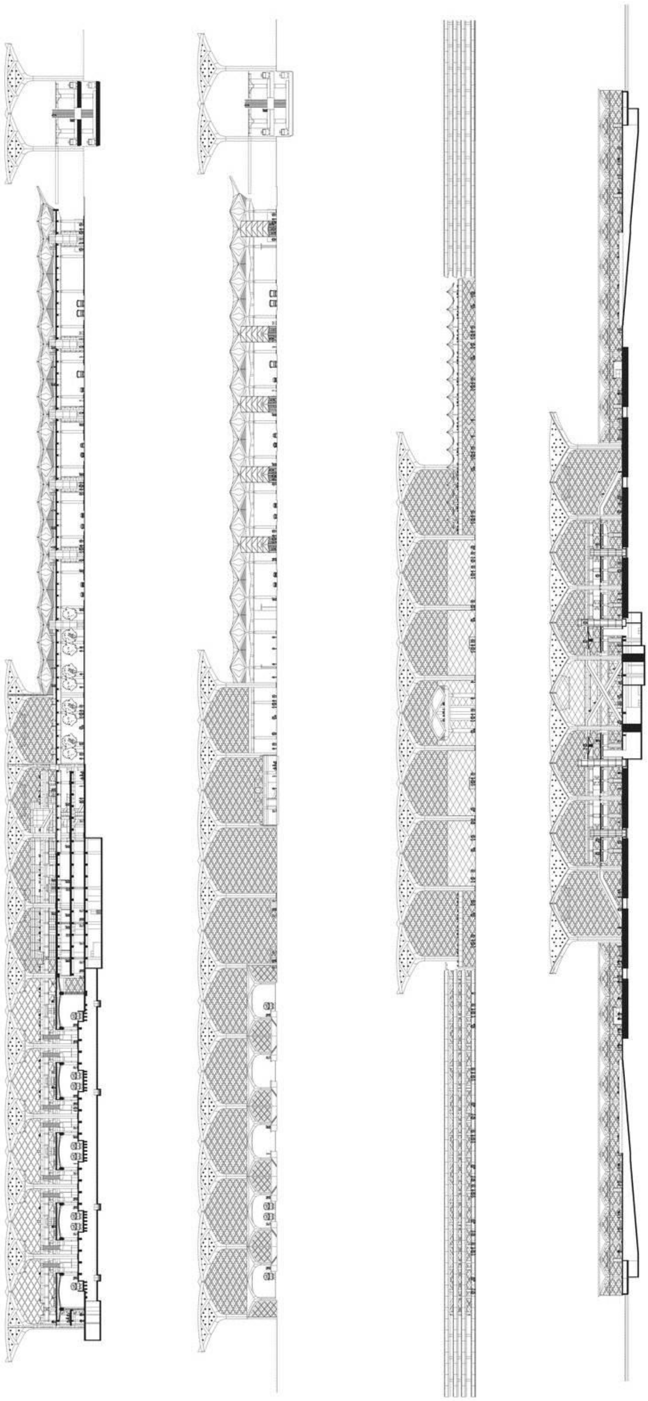


Figure 6-42: *Elevations & sections of HHSR.*

Source: González , M.F. (2019, June).

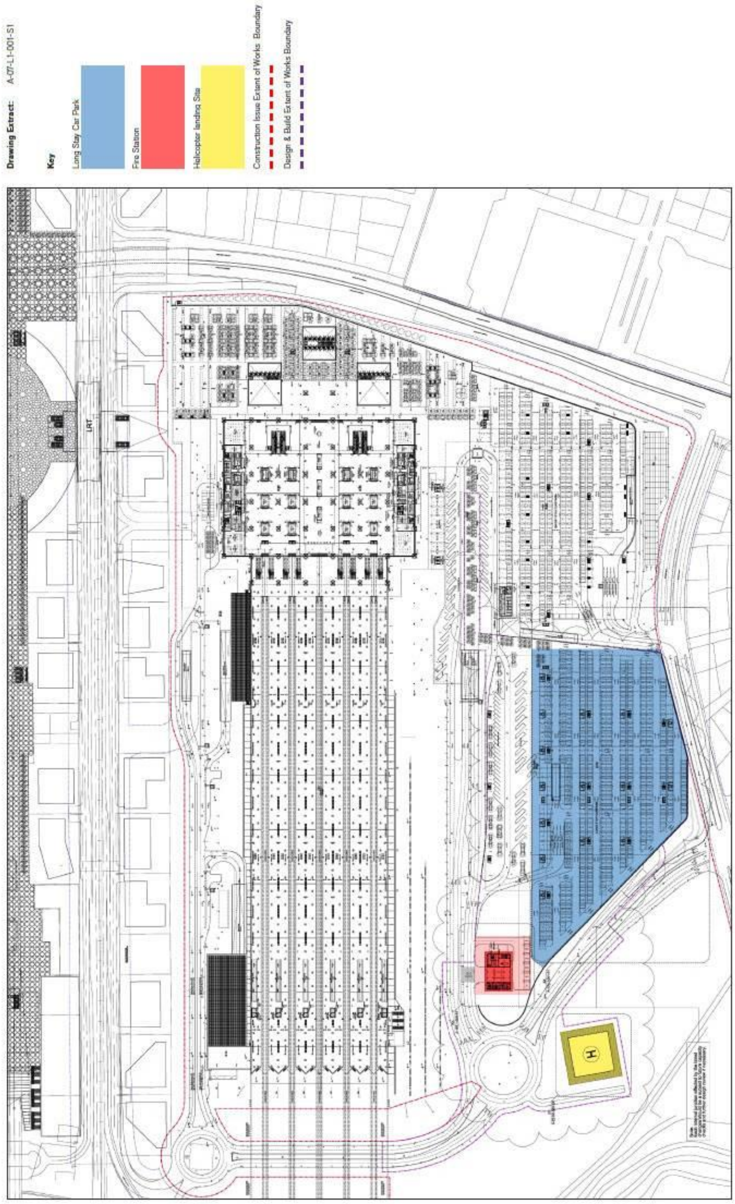


Figure 6-43: *Makkah Station site plan.*

Source: HHR Site Plans (2019).

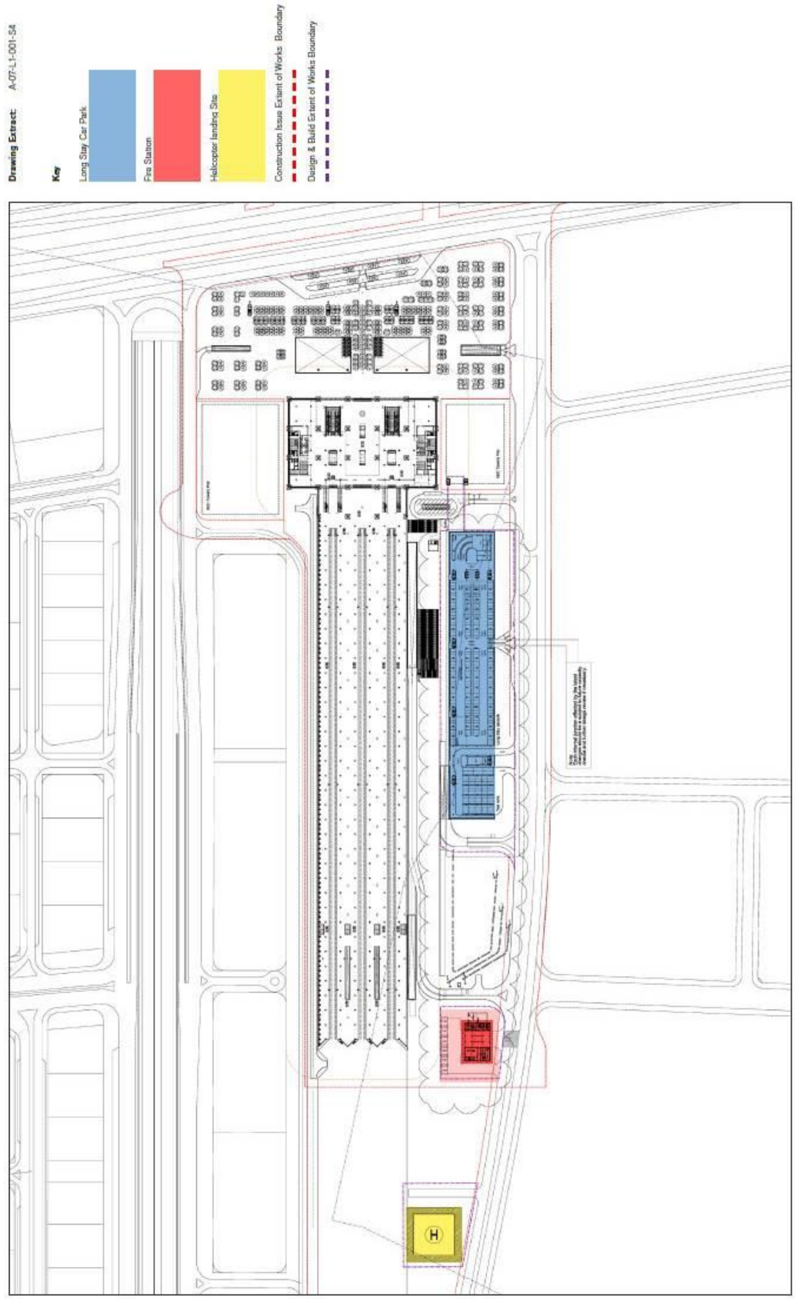


Figure 6-44: *Madinah Staion site plan.*

Source: HHR Site Plans (2019).

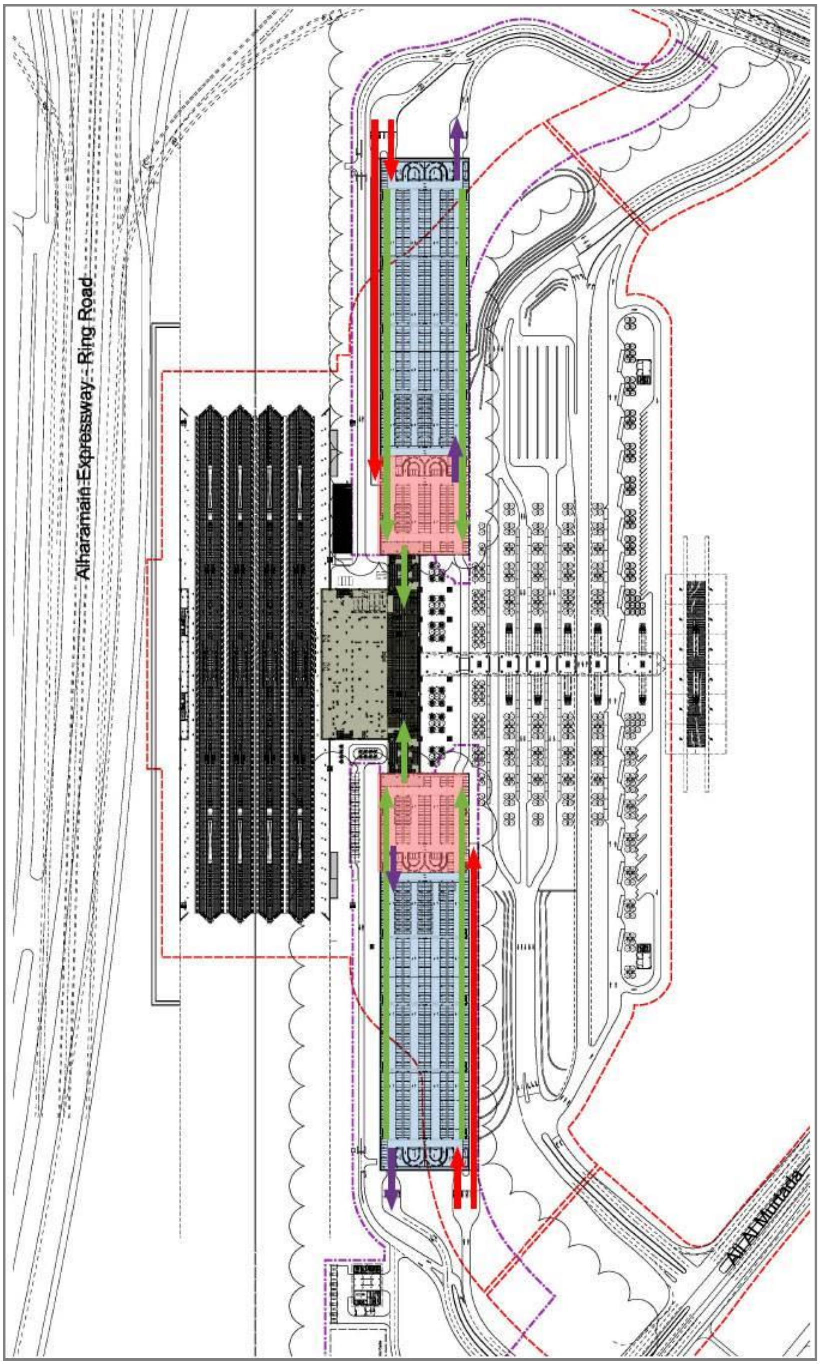


Figure 6-45: *Jeddah Station site plan.*

Source: HHR Site Plans (2019).

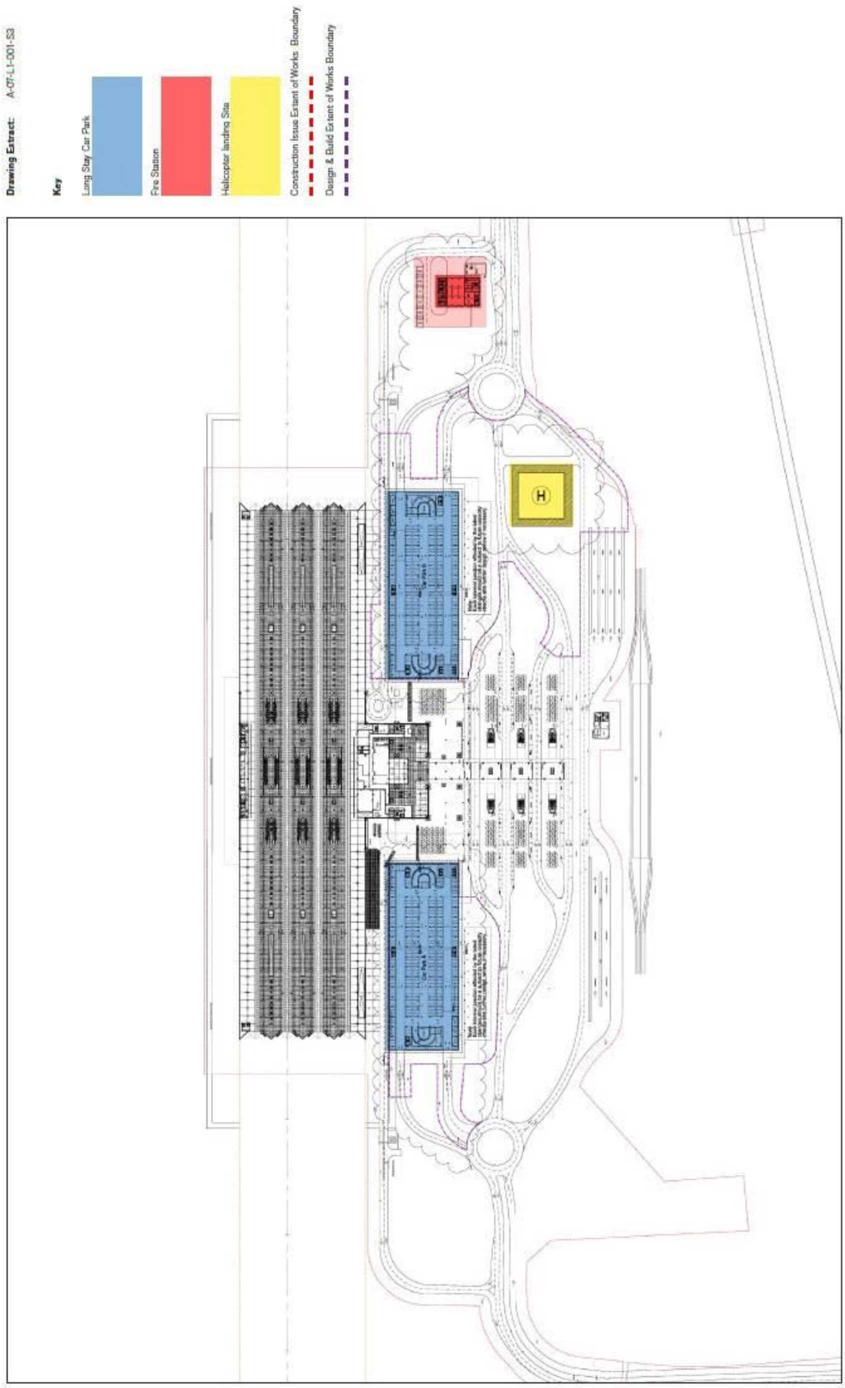


Figure 6-46: *KAEC Station site plan.*

Source: HHR Site Plans (2019).

6.7 Conclusion

The research conducts a comparative analysis that finds several results, which should bring a proposal for the possible design direction that is currently ongoing with the new train station buildings, and how it could affect the designers' approach to the design operation of said building type, in the current "Renaissance Era". The research assumes that there are common design goals between the renovation and new construction directions; which stemmed from the developed design elements -of function and form- during the renaissance of train stations.

The chapter found many results:

1. **Technical solutions** are not exclusive to innovative civil works in solving large spans or train mechanics' requirements that affect the urban & spatial parameters of the station building, but technical aspects evolved to include providing comfort & efficiency through lighting without glaring, suitable air conditioning, noise control, and choosing materials and technology in energy saving and recycling. Providing information for travelling and directions (remote or on-site) help in realizing of spaces and passages; providing ease and decreasing confusion.

2. Design elements -of form and function- became more integrated with each other; with one function can serve form on its own, and serve more than one design parameter. For example: **Commercial functions** were upgraded from being peripherals to become integral parts of a station. Other qualities like **environmental solutions** (which in the past were part of the technical parameter) had become diluted in various design aspects, such as: quality of station building and platforms are related to the thermal comfort and adequate lighting; lighting itself is an aesthetic value adding to the users' experience and delight, and finally: the sustainability and energy saving; all of those should be found, not just in the machination, but in the materials, open spaces, voids in solids, and even structure.

3. Designing the form and style choice offer an expression of new technologies and visual expressions of the new age. Whether the new structures are additions to old building, renovated structures, or newly-built stations, the result in form can be a result of:

    - Historical, cultural, or urban context.
    - Theme-based styles, including image-based elements and landmarks.
    - Standardisation of the same design for more intense expression of the single visual image, and even making the architectural design the dominator in the station design and construction in regards to the civil works.

4. **Ecological solutions** become more integral to the function of the station building; in saving energy, conserve resources, and providing comfort to the users in more passive ways. Passive solutions can be found in integrating the form to the environmental solutions; such as Kenitra Station and Haramain Stations.

5. **Vertical planning** becomes more important. The continuation of the strategy of vertical planning efficiently; for technical, and civil functions, and also for land use, inclusivity of functions, and even creating landmarks. Structure also started to play a role in aesthetics with rhythm, straight or organic motion, etc.

6. **Station halls** are designed as open spaces, and include buffer areas for security and crowd control; mainly inspired by airports. To eliminate confusions and delays, amenities and shops are organized to help in determining routes, clear information methods, and even aesthetical treatments.

7. **Commercial facilities and social services** can be either integrated to the station building, peripheral to the building, or part of the urban context of the station's surroundings. Stations turned for self-sustaining in resources; not just from ticketing. Flowing income found many sources, like: adjacent

hospitalities, attached services, shopping, leisure, art exhibitions, advertisements, other cultural activities, etc.

8. **Centre to the city:** Stations over time became closer to a social, commercial, and cultural centre; whether those activities are inside the station, adjacent to it, or in a link with the station with clear routes.

CHAPTER 7: RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

7 Topics of Chapter 7

7.1 Introduction

The design paradigm of train stations went through multiple phases that reshaped the overall look and properties of said building type. In the 19th century, the concept of a building that would serve rail transportation evolved from a simple platform; gradually adding more construction units that created the basics of a train station: sheds, postal offices, administration units, grand hall, and amenities are among them. With the setback and return of rail travel to the spotlights; mainly due to the upgrading of transportation modes that re-evaluated the concept of intermodality, train stations also evolved in its functions and form; as witnessed through the design parameters of space, style, urbanism, and technology.

Exterior and interior spaces overcome the problems of ambiguity and complexity in their relationships and their connectivity. Facilities like hotels, youth centres, libraries, shopping centres that were considered a luxury became more integrated into the station building or within its urban context; even becoming necessities in many cases. The visual language of the exterior and the interior of the building had a shift in its concepts and themes: from the monumentality and classical movements to the expression of commercialism, corporate identity, international themes, new art movements, or even popular culture.

The chapter aims to review the results of the previously-discussed train station projects throughout 3 eras spanning from the late 19th century to the early 21st century; analysing the changes through the design parameters of train stations. The results are then put to conclude the development results on the train station design paradigm. The chapter ends with recommendations for those who are concerned with the development and research for train station designing and regulations.

7.2 Study Results

Train stations evolved from being the node of railways to a gateway and an expression for the city which the station lies within; an expression of its social, cultural, economic, and historical aspects. This expression was materialized with adapting new technologies from mechanics and structure; added to the architectural aspects of site planning, floor planning, space functions, materials, etc. and there was the aesthetical expression and visual representation of a station of how a station should look like. Station building started from the raw visual of the structure and became a symbol of monumentality and art directions, in addition to the space elements that distinguish the building, like the arches in the façade of the main hall.

The results section is divided into 4 consecutive parts:

1. ***A summary of station design parameters:***

   A quick review of the station parameters in its history, and discussing the strengths of the intersections of each parameter; through 3 eras:

   - 1st Era: *late 1800's: 1945*.
   - 2nd Era: *1945: 1970's*.
   - 3rd Era: *1980's: today*.

   Discussing the concept of reading each station parameter, and the strengths of the intersections of each parameter.

2. ***Statistical analysis of merging station parameters:***

   A display of the statistical representation of the intersections of each parameter, in their function elements for a quantitative reading, using the case studies from the previous chapter.

3. ***Timeline of the development of station parameters:***

   A display of all categories within each station parameter through all 3 eras in a linear diagram; in order to analyse the development of each category, and the results of their effects on each other.

4. ***Design requirements for station buildings in the current era:***

   Following the previous analysis discussions, the research produces a design programme that is adequate to the basics of the station parameters in the current era.

7.2.1 A summary of station design parameters

The research after it had discussed all examples, when were put to discussion into the 4 parameters:

7.2.1.1 1st era: late 1800's: 1945

1. ***Technical parameter:***

It is considered the 1st driving parameter of the four; as it includes:

- New structural solutions in materials, spans, and load transferring.
- The strong role of selecting a locomotive in providing requirements to be considered in providing spaces, and also sustaining the users' health and structures' lifespan.

2. ***Urban parameter:***

- The parameter that guides the relation between the station with its surrounding urban plan; with the integration with the roads surrounding the station, the urban masses, the problem of space availability for trains' entrance into the city.
- Ease of access and clearance of approach to the station for all users.
- Structuring effects of rail terminals:
  - Adjacency
  - Accessibility
  - Networking

3. ***Spatial parameter:***

- The interior parameter that controls the safety of users in a volume with machines and crowds, the clearance of passageways and wayfinding.

- Establishing available spaces and utilities that witnessed upgrades in style and class to accommodate different types and classes of people; reaching new levels of ease and comfort.

- The addition of several facilities to serve the passengers like hotels, restaurants, and postal services that started to turn the train station into a central hub to the city socially and economically.

In general, the 4 design parameters are influenced by the basic design elements (function & form) which are specific to the design of train stations. Each of function & form has its own set of sub-categories; where each of these sub-categories varies in presence, value, and effect throughout time period.

4. *Style parameter:*

- The parameter used new and old materials to find new expressions of the age and the fitting style of the city as a "gate" to it.

- Finding new ways to express symbolic messages that form an artistic or a philosophical meaning to the art form of the building externally and internally.

7.2.1.2 2nd era: 1945: 1970's

1. *Technical parameter:*

Following WWII, there was a decline in railway progress, relying more on motor roads. High Speed Trains by Japan in 1963 changed typology of terminal & platform design.

2. *Urban parameter:*

Outside the building witnessed poor organization of activities, consumption of spaces, and therefore complexity of functions at the end of the era

However, it should be stated the new arrangement and planning of the station; especially as a result of HSR:

Interaction with the urban matrix and planning:

- Head-type terminals: Outdated, multiplied head-type terminals connect to one another and move away from the city centre.
- Pass-through stations: Integrating vertical plans of the entire complex vertically for content; which add functionality to the city.

3. *Spatial parameter:*

Japan introduced 2 types of stations:

- Over-the-tracks stations: creating a free passage between the station sides. Many stations thereafter were built in three simultaneous steps: Passage construction, Over-the-track construction, station building construction.
- Under-the-tracks Stations: Projects were implemented as part of urban planning, and even today, elevation is used to create many new under-the tracks stations e.g. Shinkansen station.

4. *Style parameter:*

The era following WWII witnessed a decline in the expressive architectural language; in favour of more functionality practicality, and budget constraints. These factors to standardization of visual elements, against building conservation, and lack of comprehending an aesthetical value for the age; represented in the late modernism.

7.2.1.3 3rd era: 1980's: today

1. *Technical parameter:*

- **Structural solutions** continued the strategy of vertical planning efficiently. Structure also started to play a role in aesthetics with rhythm, straight or organic motion, etc. with the new concepts of morphology and other computer-generated forms.
- **New technological applications** with other function and form elements; such as lighting, displays, guiding, etc.

- **Environmental solutions** became more sophisticated; providing comfort & efficiency through lighting without glaring, suitable air conditioning, and noise control. There is also the choice of materials and technology in energy saving and recycling.

2. Urban parameter:

Continuing the concepts from 1970's of structuring effects of rail terminals and Interaction with the urban matrix and planning.

Integration is the new concept of transportation, whether it is an intercity or across borders. Intermodality in terms of railway stations means each transportation mode is an extension of the other.

3. Spatial parameter:

Four main elements of stations (core, transit, peripheral, and administrative) governed by interrelationship, with practical considerations in designing the area requirements of stations: external circulation, ticket offices, commercial areas, waiting rooms, platform shelters, toilets barrier-free access, information signs. Airport special solutions became an influence on train station planning.

4. Style parameter:

The first goal in style determination is looking for conserving old elements of station buildings, renovating, and refurbishing them to accommodate needed spatial elements. New stations witnessed the new trends of architecture expressing new themes and new materials. The station as a landmark expresses the icon of a gateway, a visual landmark in the urban context, a cultural and a social centre, or a visual representation for the operators' companies; sometimes in a standardised visual design for several stations for the same line (e.g. Haramain Stations).

7.2.1.4 The evolution of design parameters, and their connectivity

The previous discussion was about the function and form elements as products of the new design paradigms of train stations of today; following the development of transport modes, integration of several social activities; the adapting of the train station to the new circumstances of urban constraints (planning, society, economy)- whether the train station is a new building in a new urban space, a new building in a pre-defined space, or an updated original building.

As discussed before, the research assumed that the design paradigm of any given station is guided by 4 distinct parameters:

1. **Technical** 2. **Urban** 3. **Spatial** 4. **Style**

With the advancement in technology and the development of new aesthetics expressions for the architectural product, the research notices the problem of the interference of the design parameters with each other; blurring the lines between each parameter, and losing the "purity" of each parameter that distinguished each one; i.e. losing the ability to adequately analyse the differences and changes among each station design.

For example: **Public art** -an obvious aesthetic design element- is considered by operators and lawmakers (and in turn: the artists) as a **function** design element that is controlled by guidelines for revenue and barrier-free spaces. **Commercial functions** were upgraded from being peripherals to become integral parts of a station. Other qualities like **environmental solutions** (which in the past were part of the technical parameter) had become diluted in various design aspects, such as: quality of station building and platforms are related to the thermal comfort and adequate lighting; lighting itself is an aesthetic value adding to the users' experience and delight, and finally: the sustainability and energy saving; all of those should be found, not just in the machination, but in the materials, open spaces, voids in solids, and even structure.

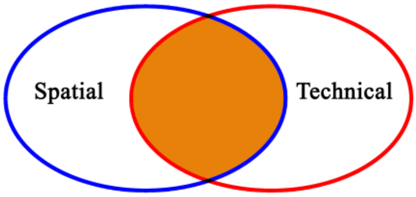


Figure 7-1: Results of merging spatial and urban parameters.

Source: Author of the thesis.

Sub-parameters:	• Approach • Accessibility & Quality of station entrance • Facilities

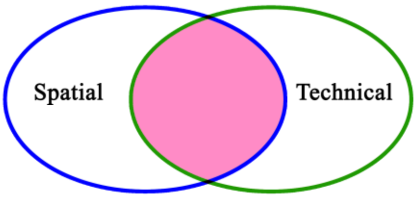


Figure 7-2: Results of merging spatial and technical parameters.

Source: Author of the thesis.

Sub-parameters:	• Intermodal exchange & wayfinding. • Safety & quality: platforms, hierarchy, etc. • Environmental design

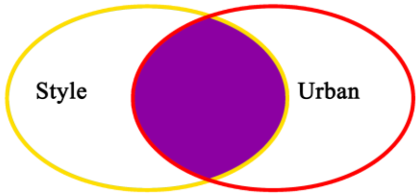


Figure 7-3: Results of merging style and urban parameters.

Source: Author of the thesis.

Sub-parameters:	• Urban integration • Theme • Landmarks

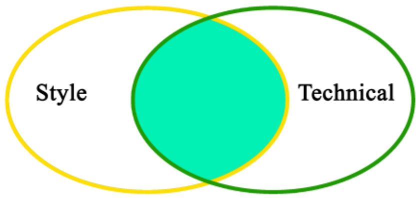


Figure 7-4: Results of merging style and technical parameters.

Source: Author of the thesis.

Sub-parameters:	• Integration of light and structure. • Materials (sustainability). • Materials (expression).

7.2.2 Statistical analysis of merging station parameters

Based on the comparative analysis from the previous chapter, the research is able to summarise the effects of function elements on the station parameters, and finding out an estimated quantitative value that represents the effect of the multi-purpose function elements on the impact of each station parameter.

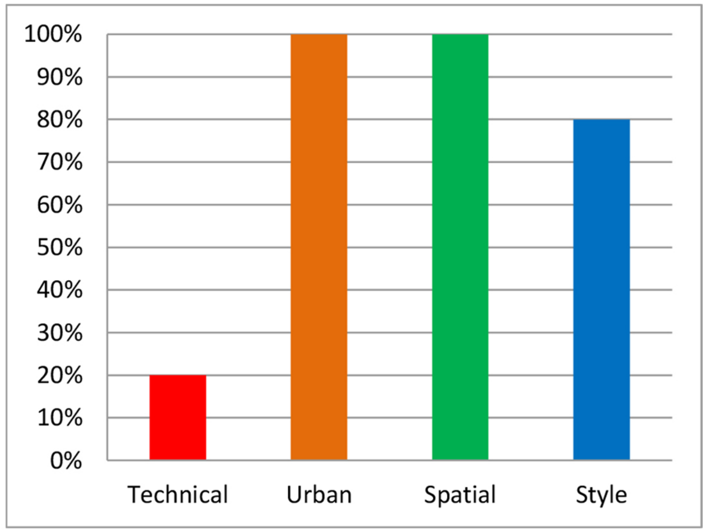


Figure 7-5: Statistical representation of quality of entrance's effect on station parameters.
Source: Author of the thesis.

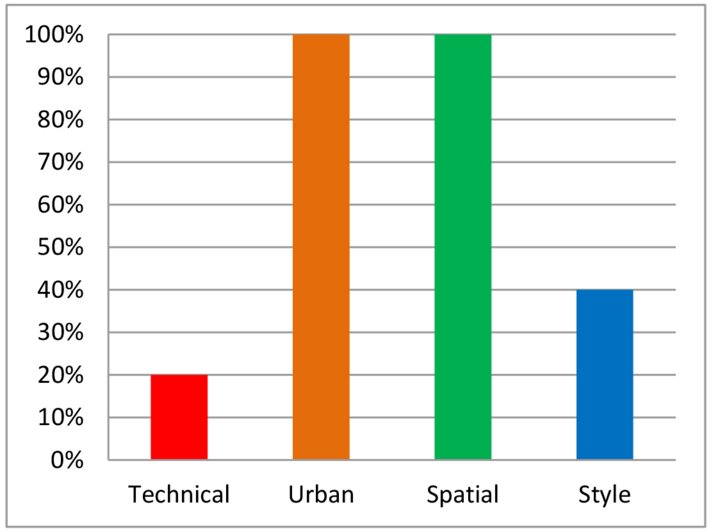


Figure 7-6: Statistical representation of quality of station building's effect on station parameters.
Source: Author of the thesis.

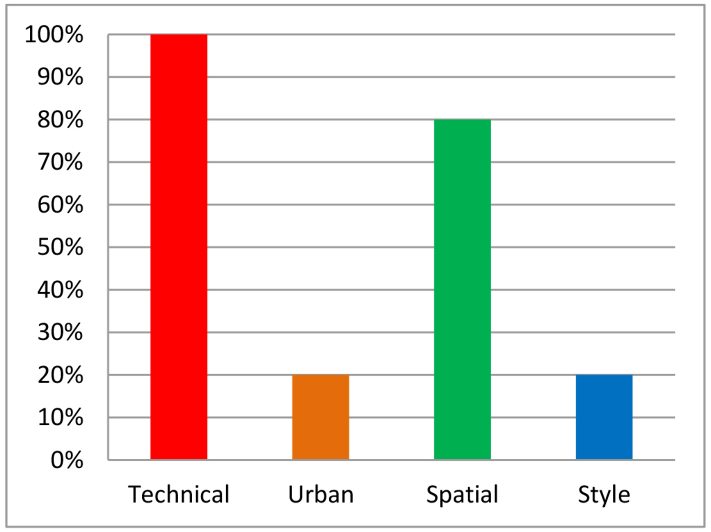


Figure 7-7: Statistical representation of environmental solutions' effect on station parameters.
Source: Author of the thesis.

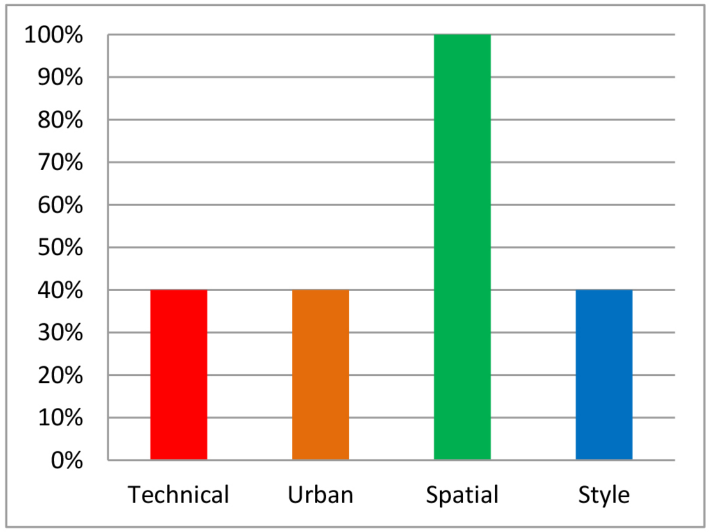


Figure 7-8: Statistical representation of quality of platforms' effects on station parameters.
Source: Author of the thesis.

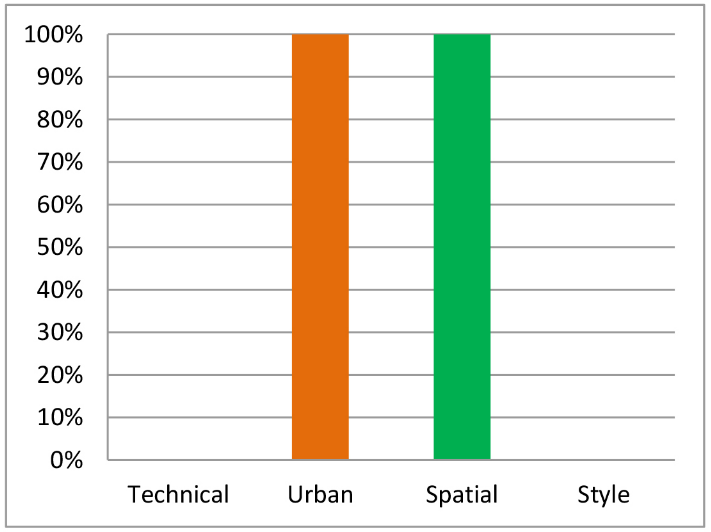


Figure 7-9: Statistical representation of quality of station halls' effects on station parameters
Source: Author of the thesis

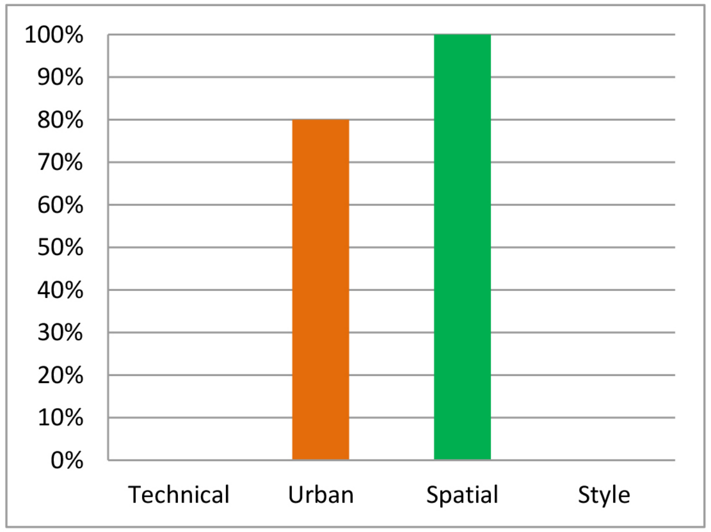


Figure 7-10: Statistical representation of commercial & cultural functions' effects on station parameters.
Source: Author of the thesis.

7.2.3 Timeline of the development of station parameters

The research uses the results of the analysis of station buildings and design paradigms through all 3 eras of railway technology; in order to provide a timeline for each station parameter which identifies the main elements of each station parameters, and to determine the common elements, their progress, and their regressions. (**Figure 7-11**) explains the categories of station parameters' timeline study.

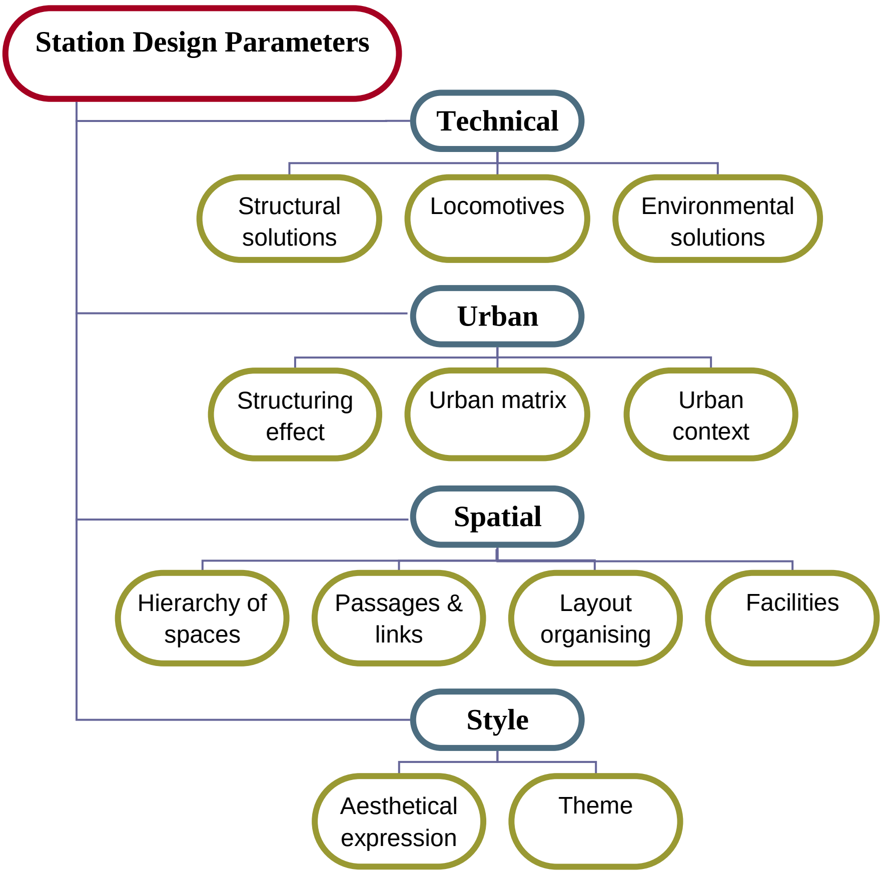


Figure 7-11: *Categories of station parameters.*

Source: Author of the thesis.

This section is divided into two parts: **Part 1** consists of linear diagrams, which demonstrates horizontal and vertical effects, and explains the main categories of each station parameter in all 3 eras to determine the new and continuing categories (**Table 7-1**) and (**Table 7-2**); in order to:

1. Determine the development of station parameters in design a station building (horizontal effect).
2. Analysing the interrelationship between several categories that led to the intersections between each station parameter (Vertical effect).

Part 2 is the summary of the previous diagrams; as shown in the figures from (**Figure 7-12**) to (**Figure 7-16**). While part 1 explains the progress of each category (horizontally) and their causes and effects (vertically), part 2 is about curve diagrams that express an overall development and regression figure of each category within each design parameter through the 3 study eras; showing a general and a brief result of both their progress and intersections.

Table 7-1: *Key label for the station parameters' timeline.*

Source: Author of the thesis.

	Node / pivotal point.
	Branch starting from the main timeline.
	Disrupted / weak category.
	Continued to this day.
	Cause and effect of one category on other categories.

7.2.4 Design requirements for station buildings in the current era

This section is the collective categories that an architect needs to design a station building. Using the results from the comparative analysis model about the station parameters' categories, the research determined the necessities of a train station for establishing a design programme to reach the utmost design parameters' goals (**Table 7-7**), (**Table 7-8**), (**Table 7-9**), and (**Table 7-10**).

Table 7-2: Timeline diagram for the development of station parameters' categories, and their interrelationships.

Source: Author of the thesis.

Table 7-3: *Timeline diagram for the development of station parameters' categories: Technical component.*

Source: Author of the thesis.

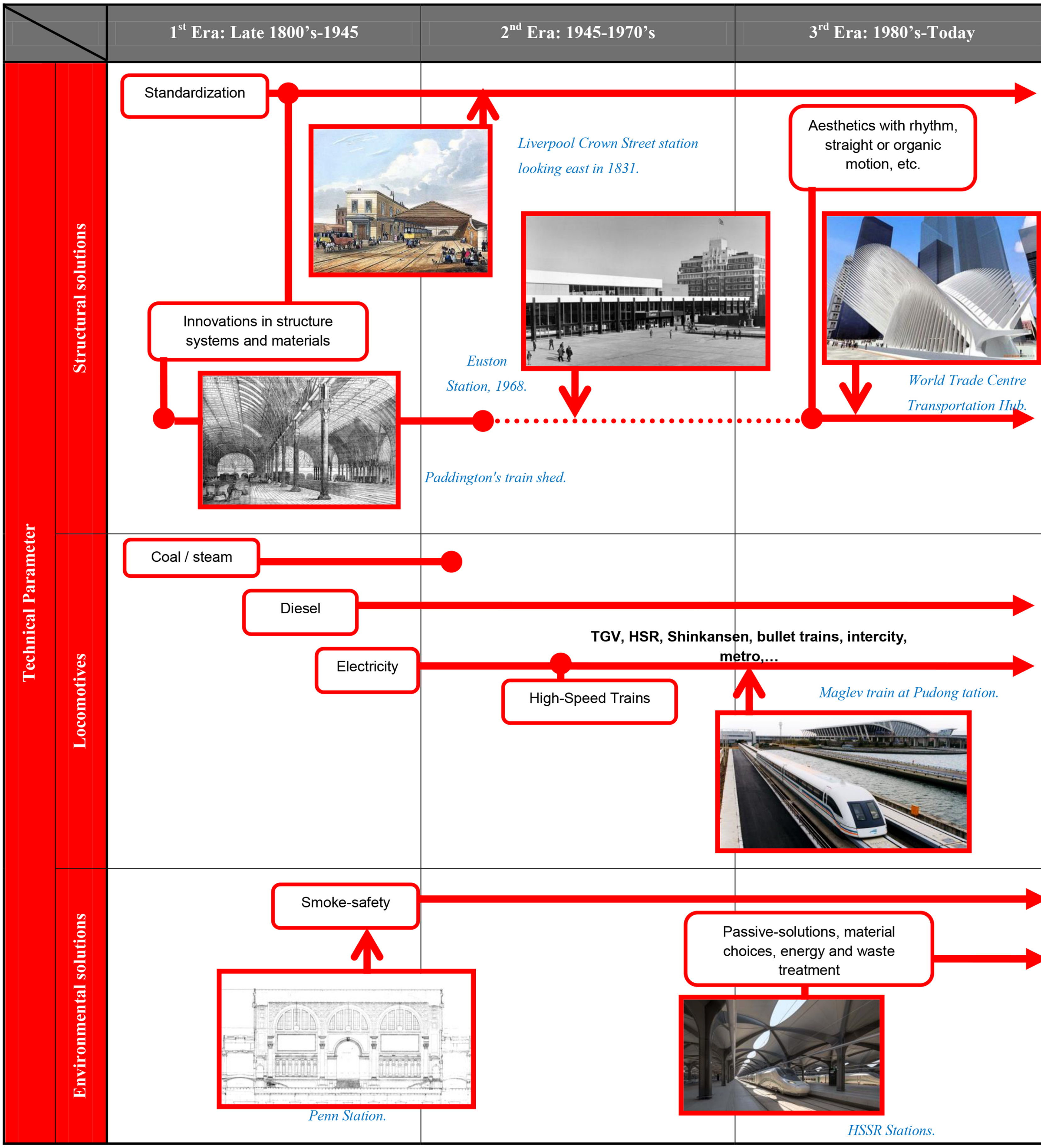


Table 7-4: *Timeline diagram for the development of station parameters' categories: Urban component.*

Source: Author of the thesis.

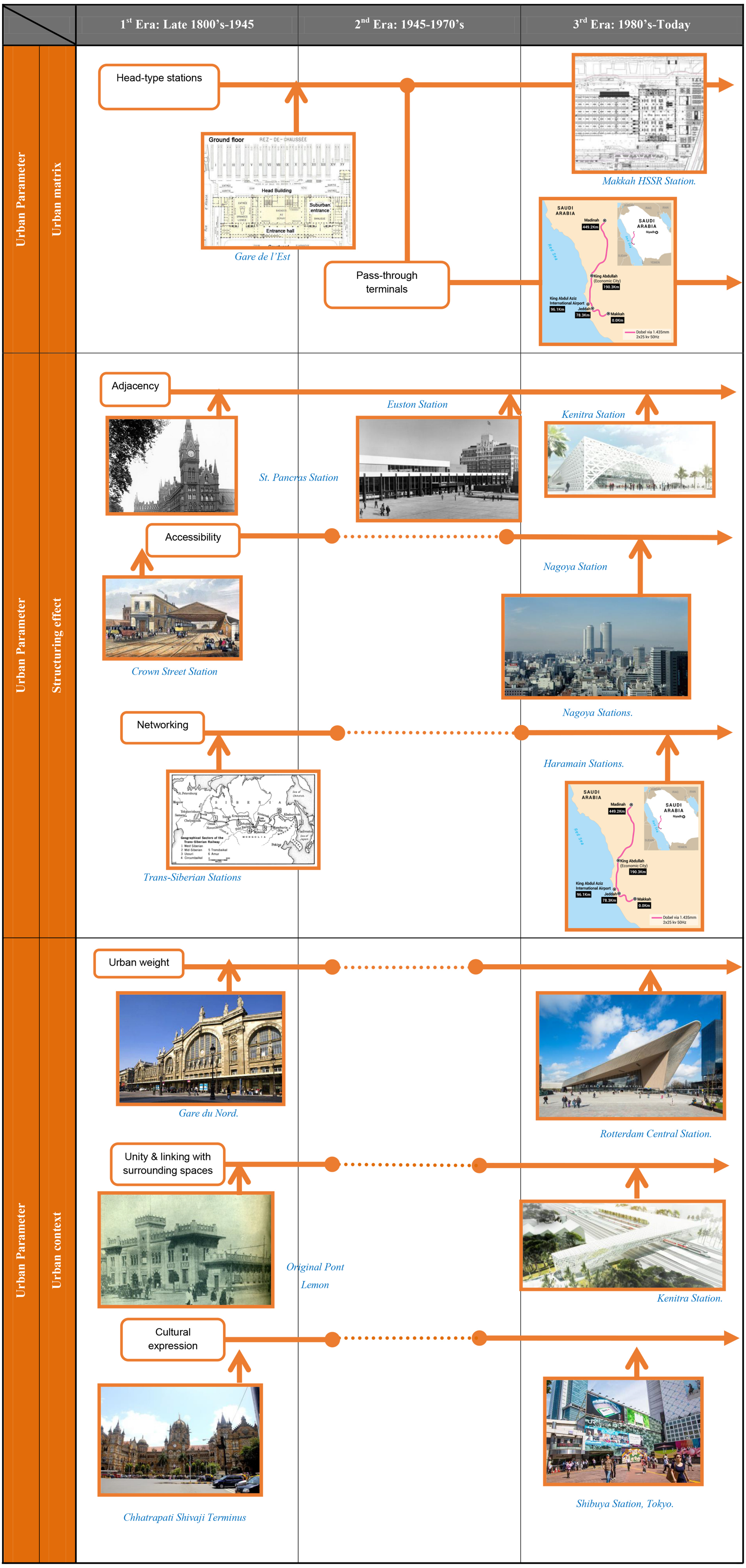


Table 7-5: Timeline diagram for the development of station parameters' categories: Spatial component.

Source: Author of the thesis.

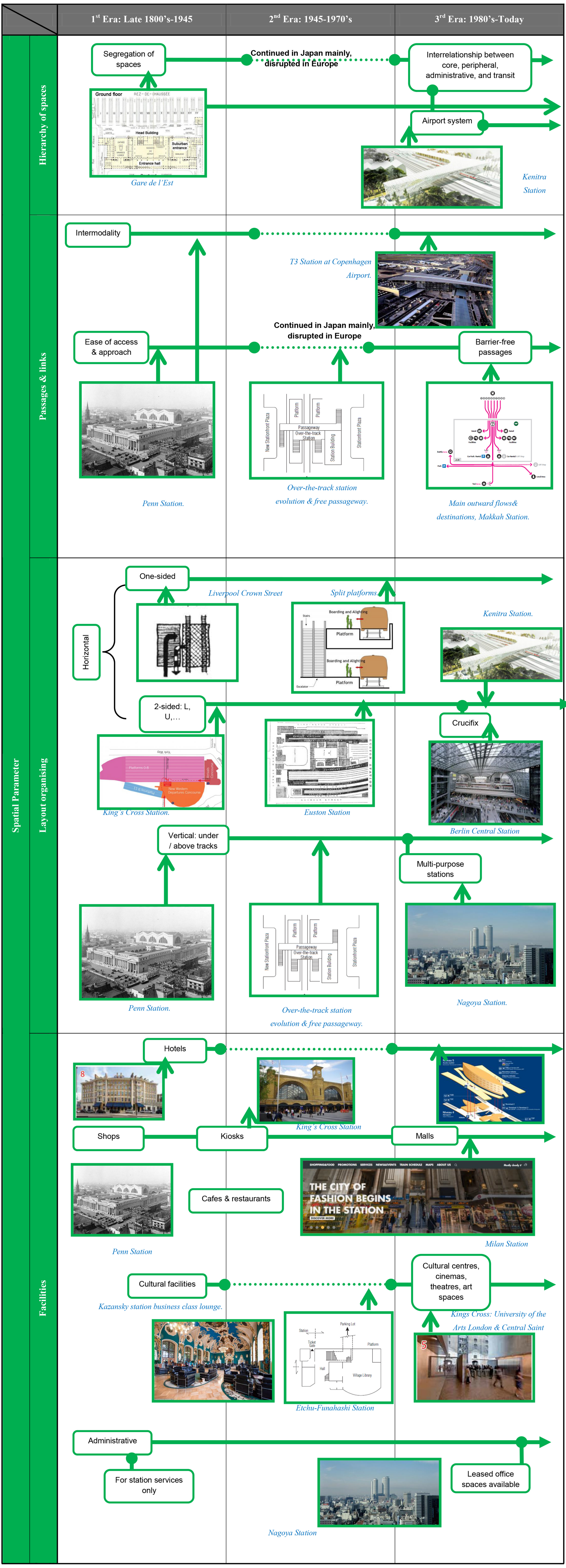
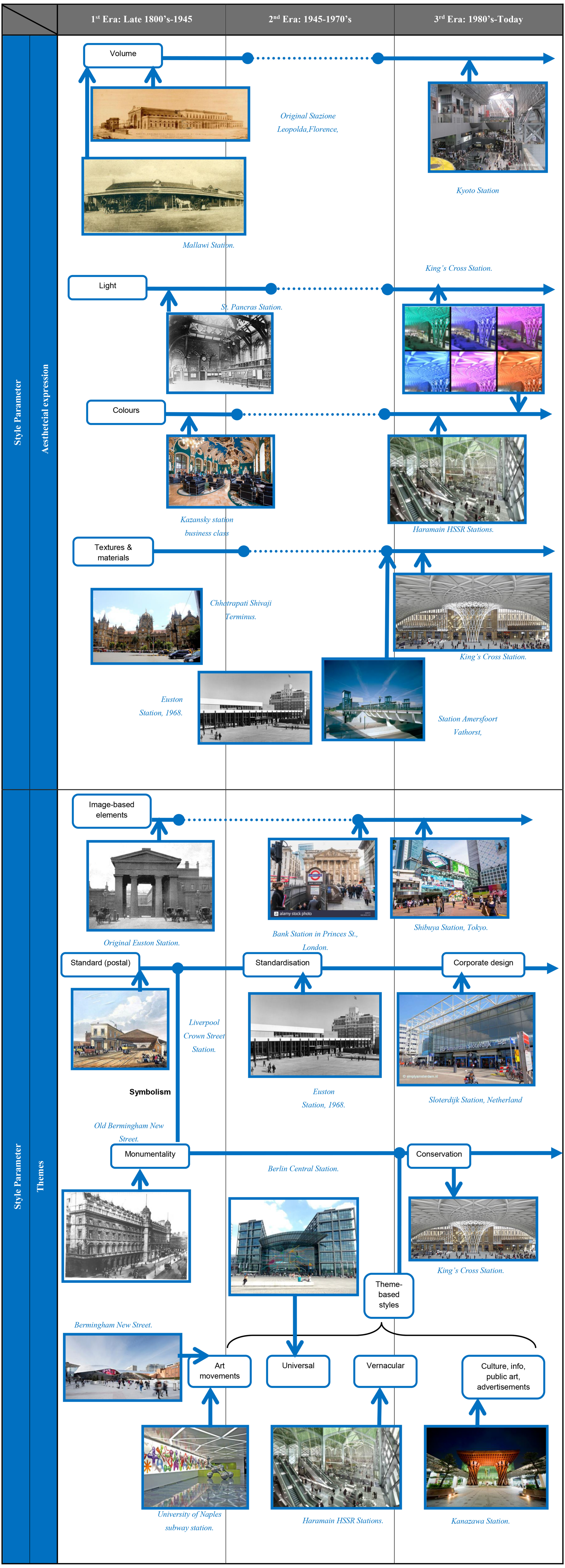


Table 7-6: Timeline diagram for the development of station parameters' categories: Style component.

Source: Author of the thesis.



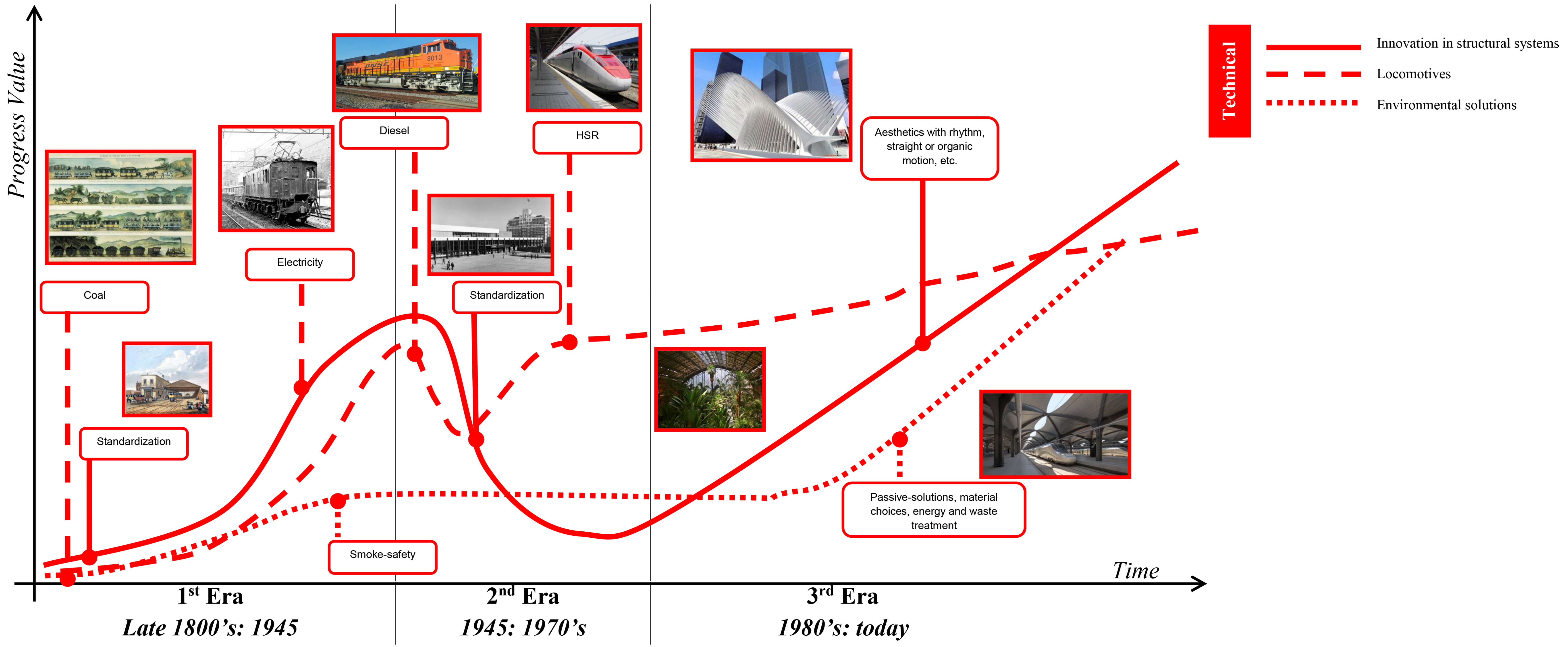


Figure 7-12: *Timeline curves of the technical parameter.*

Source: Author of the thesis.

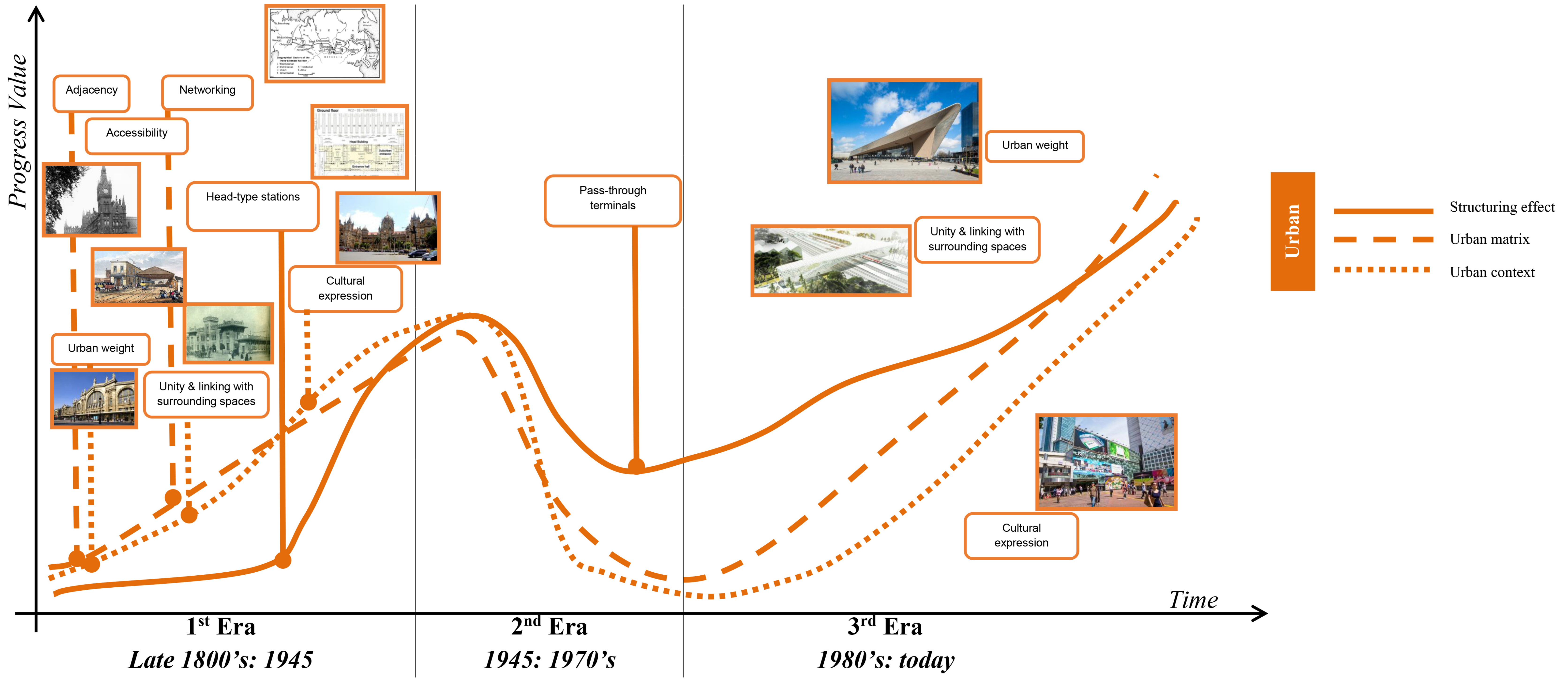


Figure 7-13: *Timeline curves of the urban parameter.*

Source: Author of the thesis.

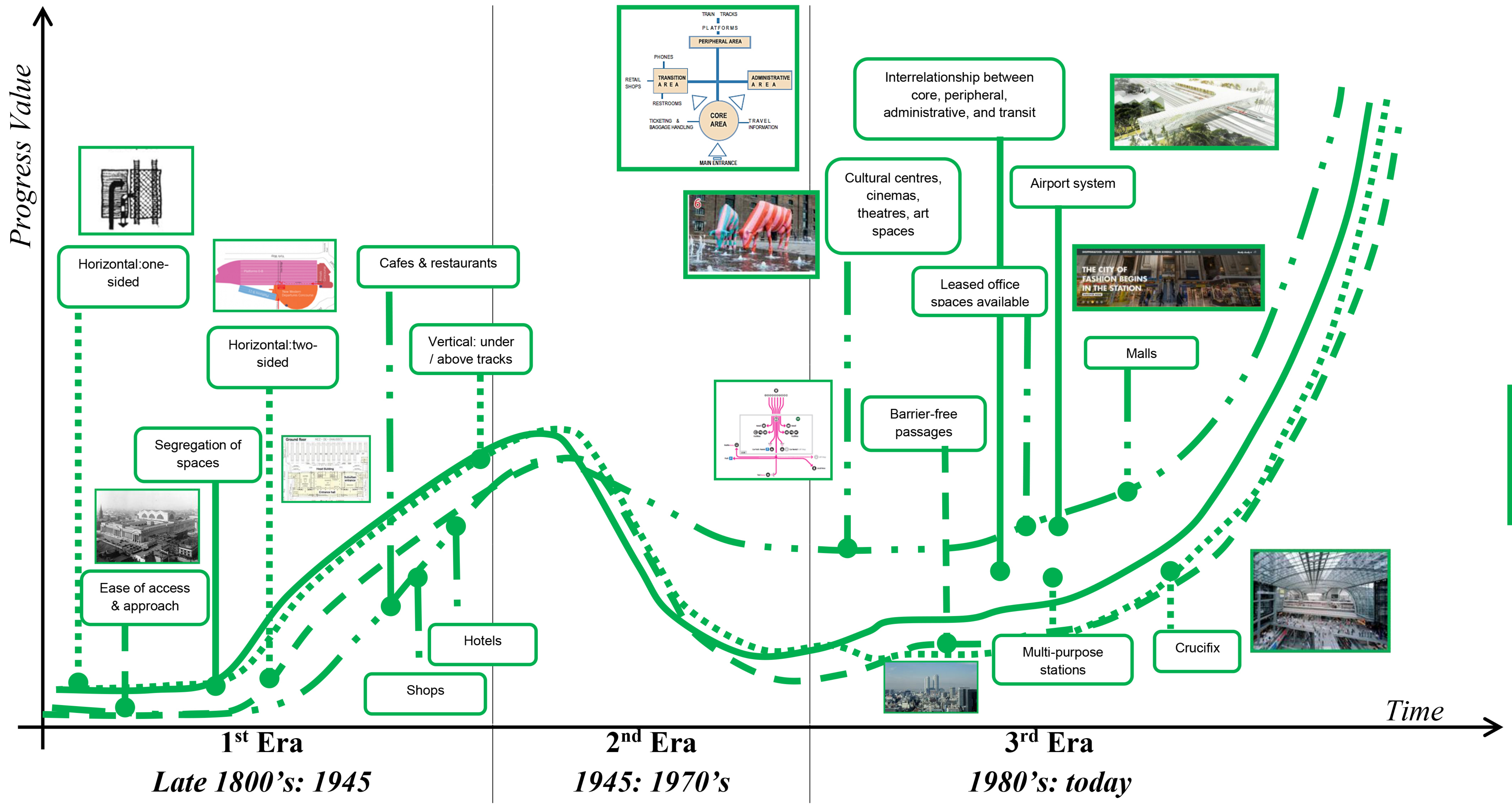


Figure 7-14: *Timeline curves of the spatial parameter.*

Source: Author of the thesis.

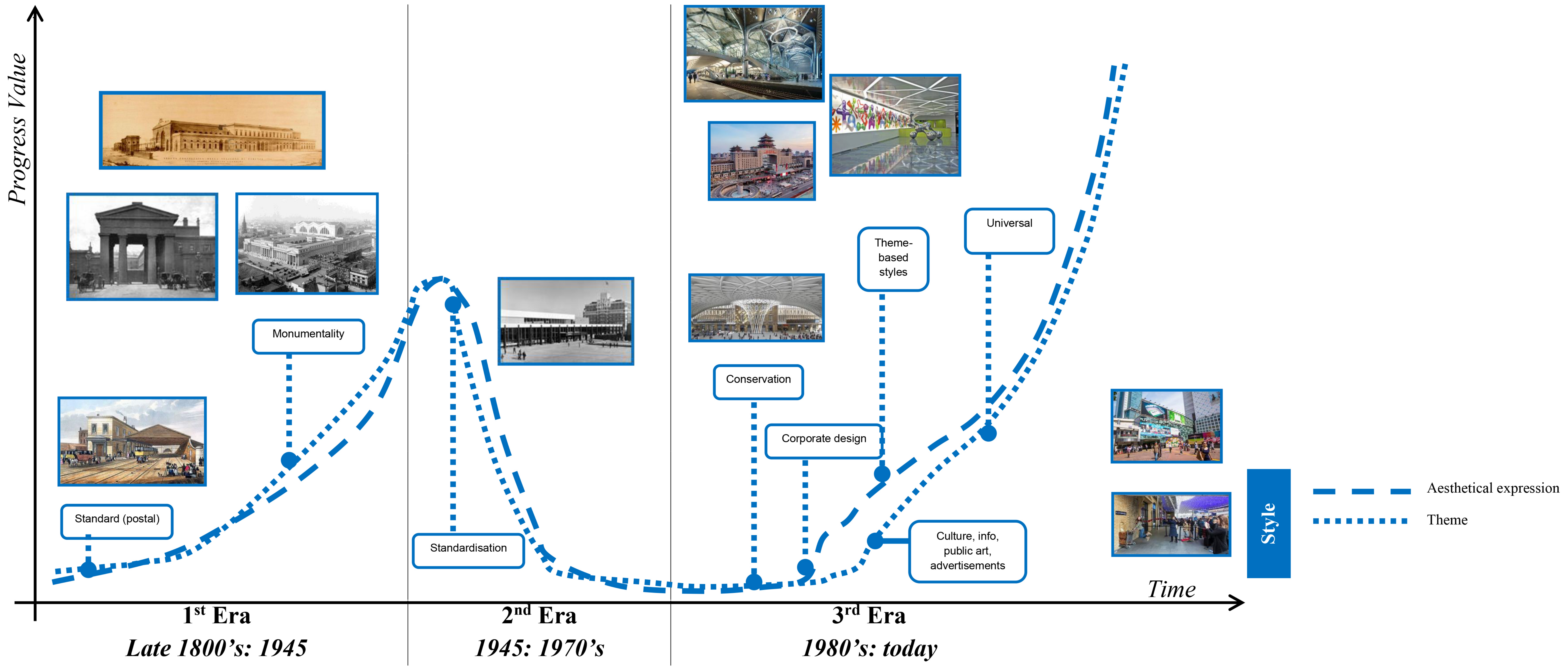


Figure 7-15: *Timeline curves of the style parameter.*

Source: Author of the thesis.

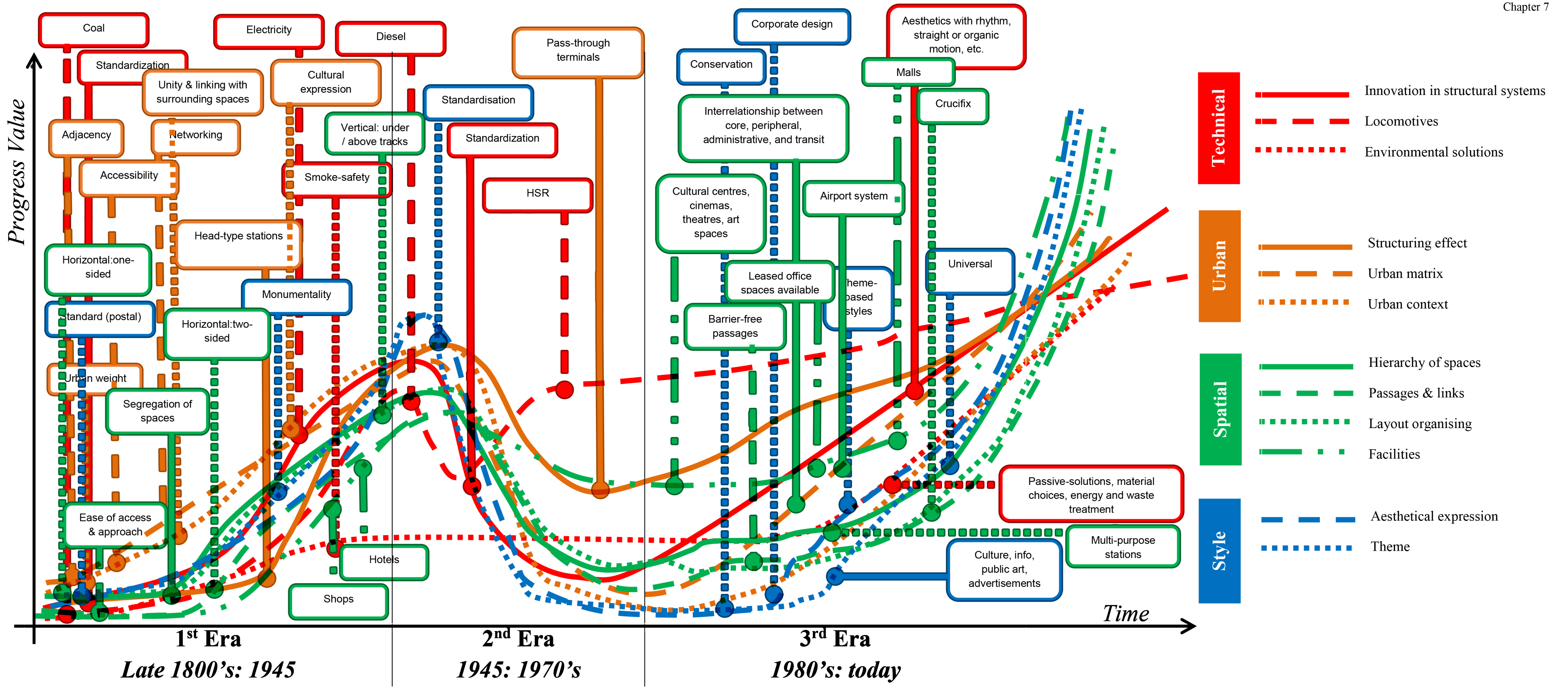


Figure 7-16: Timeline curves of all 4 station design parameters.

Source: Author of the thesis.

Table 7-7: *Station building design requirements' results: Technical component.*

Source: Author of the thesis.

<table>
<tr><th colspan="4">Parameter Categories</th><th>Comments</th></tr>
<tr><td rowspan="10">Technical Parameter</td><td rowspan="3">Structural solutions</td><td colspan="2">Innovations in structure systems and materials:</td><td></td></tr>
<tr><td>1</td><td>Load-bearing, span coverage, and site challenges</td><td rowspan="2"></td></tr>
<tr><td>2</td><td>Aesthetics with rhythm, straight or organic motion, etc.</td></tr>
<tr><td rowspan="2">Locomotives</td><td colspan="2">Diesel</td><td>For low capacity, small stations, and developed countries.</td></tr>
<tr><td colspan="2">Electricity</td><td>For subway trains, HSR, TGV, Intercity, commuter, urban transit, etc.</td></tr>
<tr><td rowspan="5">Environmental solutions</td><td colspan="2">Smoke-safety</td><td></td></tr>
<tr><td colspan="2">Sustainability:</td><td>A centre for green systems for the local area, and self-sufficient in energy requirements.</td></tr>
<tr><td>1</td><td>Peripheral technology-implemented buildings and machinery that are eco-friendly; such as natural gas and waste recycling systems.</td><td rowspan="3"></td></tr>
<tr><td>2</td><td>Passive methods by using building orientation, building construction materials, solar shading, and rain collecting.</td></tr>
<tr><td>3</td><td>Energy conservation, energy generating, solar power.
Acoustic treatment.</td></tr>
</table>

Table 7-8: Station building design requirements' results: Urban component.
Source: Author of the thesis.

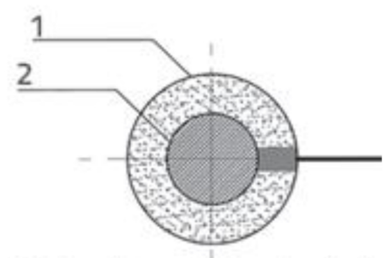
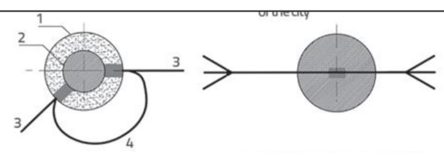
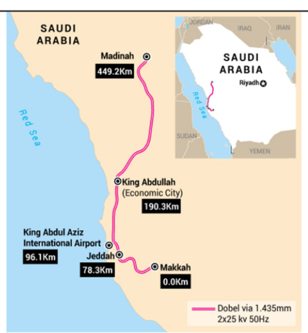
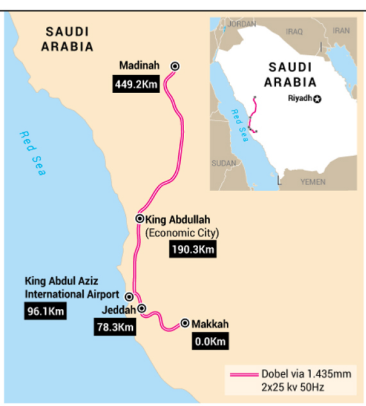
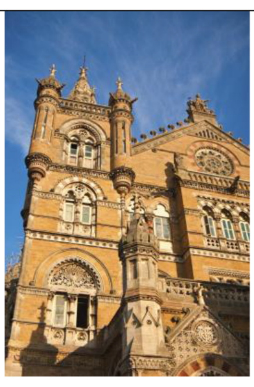
		Parameter Categories		Comments
Urban Parameter	Urban matrix	Urban matrix:		
		1 *Head-Type terminals*		Mainly for old stations; considering renovations: • Greater spaciousness. • Located away from the city centre. • A rich value of heritage.
		 *Typical head-type position*	 *King's Cross Station within Kings Cross area*	
		2 *Pass-through terminals*		• Lower line number with overall traffic control. • Various interregional lines / other lines into the urban area • Configuration and splitting of rail networks and types (passenger/freight) when integrated to the city transportation system Better accessibility to the stations (station or pass-through).
			 *HHSR Stations*	
	Structuring effect	Structuring effects of rail terminals:		
		1 *Adjacency*  *Kings Cross area*		Hotels, retail outlets, restaurants, office parks, etc. are usually close and form a cluster around the station. Depends on land availability.
		2 *Accessibility*  *Nagoya station leads to the Business District and entertainment*		The station is a centre that connects the activities with roads and transit modes. Intensity and frequency of use affects the distance decay element which affects the users of station.
		3 *Networking*  *HHSR Stations*		A set of interconnected rail terminals are supporting the specialization and interdependency of locations.
	Urban context	Urban weight  *Rotterdam Central Station*		The station building represents an international transportation hub that is also an icon for the city. The large scale, zoning, layout design, and levels turn the station complex into a strong urban space.
		Unity & linking with surrounding spaces		Form, structure, and layout organization.
		 *T3 station, Copenhagen Airport*	 *Sloterdijk Station*	
		Cultural expression		It can reflect the contradictions of the visuals and themes within the urban surrounding, representing a heritage to the surroundings (related to the theme).
		 *Chhatrapati Shivaji Terminus*	 *Gare de Paris-Est.*	

Table 7-9: Station building design requirements' results: Spatial component.
Source: Author of the thesis.

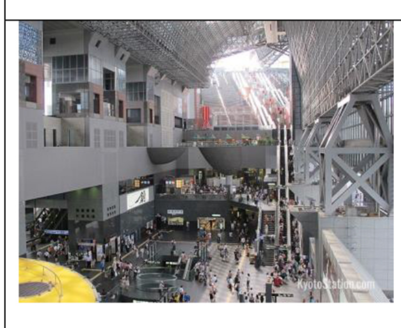
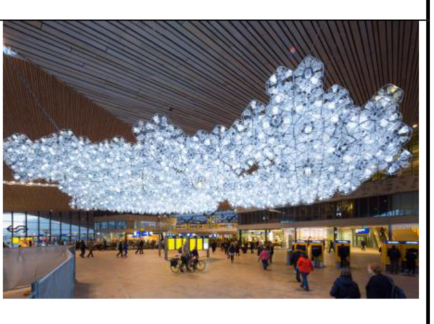
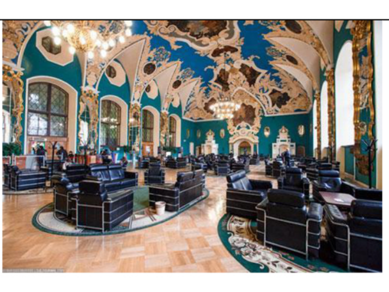
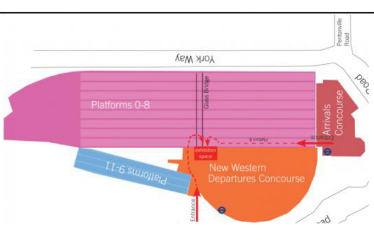
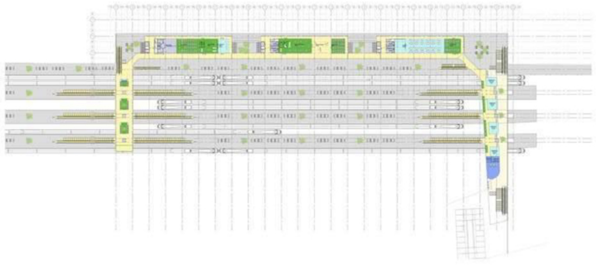
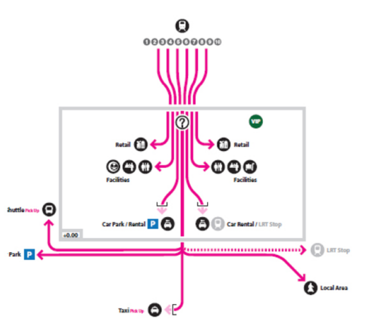
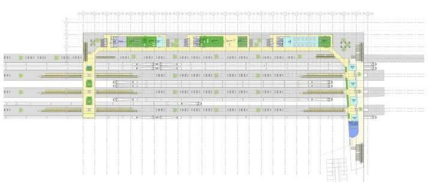
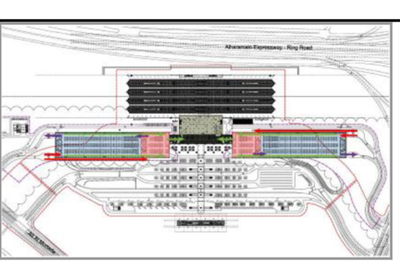
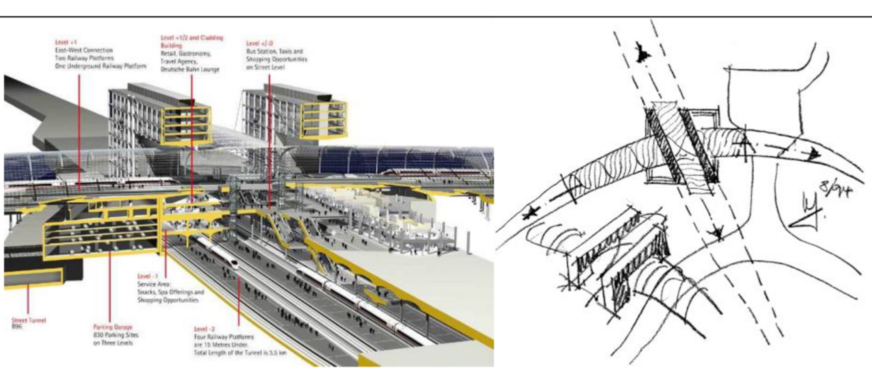
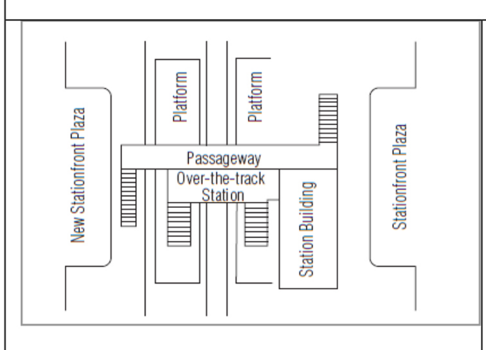
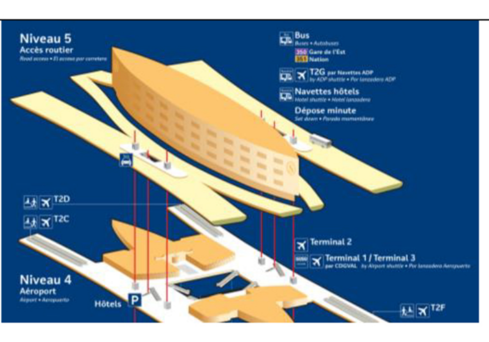
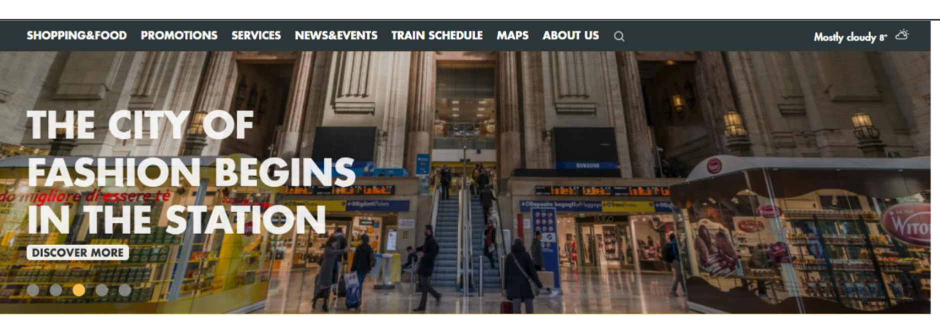
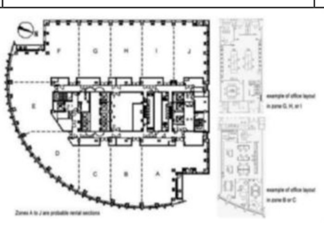
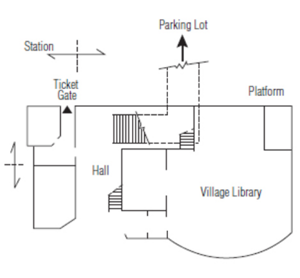
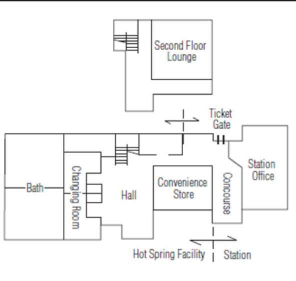
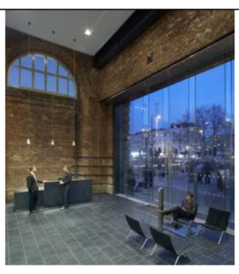
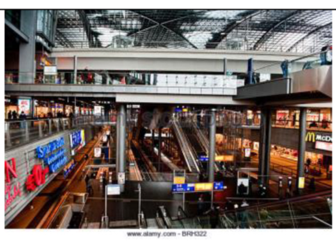
Parameter Categories			Comments
Spatial Parameter	Hierarchy of spaces	Interrelationship between core, peripheral, administrative, and transit.	All spaces (transit, peripheral, etc.) should be located with ease and without hindering, with suitable dimensions for visibility and orientation.
		1 Core — *Main entrance*  *Berlin Central Station*  *Kenitra Station*  *King's Cross original building*  *b, f) Bank Station in Princes St., London.*	a) Protection from weather conditions. b) Clarity. c) Barrier-free access for reaching spaces and core zones d) Visual weight and volume for identity. e) A visual representation of the urban context and the culture of the city. f) Visual representation of corporation.
		Ticketing	
		Travel info	Audible and visual information should be present, near entrances and main spaces
		Main halls  *Kyoto Station*  *Rotterdam Central Station*	
		Waiting areas  *Kazansky station business class lounge*	For the passengers to get some rest before travelling. Contains amenities such as travelling information, communication means, comfortable furnishing, etc.
		2 Peripheral — *Platforms*  *Haramain Stations*  *King's Cross Station*  *Kenitra Station*	a) Handling the traffic with sufficient lines for travel efficiency, time-saving, and reliability. b) Linking eyesight from inside with the exterior view. c) Platforms have adequate dimensions, with the acceptable daylighting, shading, connection to other amenities and escalators. d) Creating a totally coherent ground plan for passenger circulation into and through the station.
		3 Transit — *Phones, commercial areas, toilets, services*	
		4 Administrative — *Station control.*	
		Airport system  *Kenitra Station*	Barrier-free passages, arrival/ departure concourse separation, security buffer zones, and travelling services with the similar security and the need for fluid transitions.
	Passages & links	Intermodality	Increasing speed of journeys, increased reliability, and less confusion; while approaching the train line, and hanging transport modes. Using clear spaces and modular designs.
		Ease of access and approach  *Kenitra Station*	Linking elements (stairs, lifts, ramps, etc.) should have an appropriate finishing, handicapped-friendly elements, safety, and clarity.
		Barrier-free corridors  *Makkah Station: Segregation between arrivals and departures*  *Nagoya Station*	• Using furniture and other services to separate main areas of high-rate passing from other areas of a slower rate. • Ease of movement, comfort and speed are important for circulation through the station.
	Layout organising	Horizontal planning:	
		1 *On one side of the track*	Mainly for smaller stations.
		2 *On both sides of the tracks: across them, or in combination in U or L-form.*  *Kenitra Station*  *HHSR - KAEC Station*	a) U- station: a connection between the 2 sides, but in a through station required raising the cross buildings above the tracks. b) L-stations: with arrival at the end of the tracks and departure at one side or vice versa.
		3 *Crucifix form*  *Berlin Central Station*	For separating the travelling and commercial services from the administrative services
		Vertical planning:	
		1 *Over-the-tracks stations.*  *Over-the-tracks solution*  *Berlin Central Station*	Free passage between the station sides.
		2 *Under-the-tracks stations.*	Shinkansen stations; for projects were implemented as part of urban planning.
	Facilities	Hotels  *The Great Northern Hotel, Kings Cross*  *CDG2 Hotel*	More attached to the station building.
		Shops  *Milan Station*	
		Food and beverages	For passengers and locals.
		Cultural facilities  *Kings Cross: University of the Arts London & Central Saint Martins, and Granary Square*	Depending on the urban planning of the area, and the size of the station.
		Transportation mode rentals and reservations	
		Others:	Other activities can prove importance in cases like smaller stations and downsizing.
		1 *Administrative offices for rent*  *Typical administrative floor in one of Nagoya Station's towers*	
		2 *Libraries*  *Etchu-Funahashi Station*	
		3 *Leisure*  *Hotto-Yuda Station Floor include hot-baths*	

Table 7-10: Station building design requirements' results: Style component.
Source: Author of the thesis.

		Parameter Categories			Comments
Style Parameter	Aesthetical expression	Advertisement and public art			Advertisements should not increase complexity or decrease clarity of the visual representation of the facades. Lighting up the stations. Could help identify the stations, give them images, serving as backgrounds or focal points.
		 *Advertisements covering the façade of Shibuya Station*	 *Paddington Station*		
		Light and colours as expression			
		 *King's Cross's Station*	 *HHSR*	 *Atocha Station*	
		The structural expression (rhythm, proportion. Movement, etc.) with Light penetration			
		 *King's Cross - The diagrid*	 *World Trade Centre Transportation Hub*	 *Madinah Haramain Station*	
		Texture and materials			Values for surfaces can be articulated by texture variations. Smoothness, roughness, and their intensities can create patterns, which affect the visual weight of objects
		Restoration	Clear and modern	Lightweight	
		 *Kings Cross inside the concourse*	 *Berlin Central Station*	 *HHSR platforms*	
	Themes	Image-based elements			A method for linking a visual element to a place using symbolism or other visual means that links the mind to a fixed idea.
		 *Berlin Central Station (map)*	 *King's Cross Station (Harry Potter)*		
		Morphological	Socialism + traditionalism	Futuristic	Including blending of styles, vernacular styles, or futuristic styles. Also using image-based elements and landmarks.
		 *University of Naples subway station*	 *Beijing Station*	 *Bermingham New Street Station*	
		Universal	Traditional + universal	Conservation + futuristic	
		 *Berlin Central Station*	 *Makkah Station*	 *King's Cross*	

7.3 Conclusions

Based on the comparative analysis of case studies, statistical analysis, and reviewing their effects on station design parameters, the research reached several conclusions for reaching a design for station buildings that would serve as the current design paradigm and the expected design paradigm for the near future:

1. **Defining a theme:** For architects, it is the first step in designing a train station. Finding a theme is the enveloping element of the design plan for the building; outdoors and indoors. Even in the early days of train station buildings, when designers and operators were in the process of defining the parameters of a train station, there was a philosophy that treated said buildings as a representation to a social, economic, cultural, or a historical idea; thus came the idea of the “monumentality” theme. The standardisation theme was a result for an economic and social shift in the society. In the “renaissance” era, the railways’ importance increased, and so their buildings; as a function, and as an architectural product. Designers should sustain the old architectural themes of old building, while redeveloping them by adding required function elements, or when deciding to add new forms of other visual representations.

   Themes can take many directions; like a universal theme to connect to various travellers’ backgrounds and showing an industrial, progressive identity. Themes can also represent a cultural value by varying degrees of vernacularism, or even adapting a futuristic art movement that evokes the subconscious and enhances the image of technology development.

2. **Implementing technical parameters in both active and passive ways**: Technical aspects are not limited to providing the requirements of HSR locomotives, but it should also extend to:

   - Using advanced environmental solutions for energy conservation, resource control, and providing comfort and experience to users. This should include energy generating, noise dampness, waste control, air conditioning, and lighting. Station buildings should apply for “Green Building” certification.

- Providing information and guidance for wayfinding, reservations, rentals, trip announcements, and advertising.

- Structural engineering -especially for new railway lines- can solve the problem of constructing stations; where a station can be constructed simultaneously with the construction of the railway itself. This means that construction is not necessarily limited to the usual construction, site constraints, and project schedules.

3. **Adapting airport’s spatial solutions:** Barrier-free passages, arrival/ departure concourse separation, security buffer zones, and travelling services with the similar security and the need for fluid transitions from “controlled” area (like entrances, ticketing, and luggage) to “uncontrolled” zones (like platforms and concourses). Transitional spaces (like retail, toilets, etc.) can be a security separator between the two zones.
4. **Passenger movement and layout arrangement:** The designer should consider the difference between pass-through stations and termini. While pass-through stations can have their main hall intersect the platforms, the termini should have the main hall at the end of the platforms.
   - While the departures and arrivals are separated in passages, the entrances can be either on the same side (with different entry points), or opposite to each other and having each of the 2 entry points (departures & arrivals) at one end of the building.

   - The ticketing for departures and arrivals must be separated; on the same level but on different sides, or on the same side, but different levels. In both cases, the platforms can only be on a single level, usually the main floor level; according to the number of tracks and density of train passage.

- The main hall can be a single hall, but needs more clarity with separating the circulation of departures and arrivals, or creating 2 main halls (one for each of the departures and arrivals), but needs duplicating almost all of the services, and larger building heights.

- Termini have less trouble in creating its main hall (or two main halls) onto on side of the building, compared to pass-through stations; because termini must have one side as the end of the line. Pass-through stations, however, can have one for each of the main hall and station square, but with the careful design of not increasing circulation distances, hierarchy maintenance, and confusion in the circulation.

5. **Urban parameter and its types:**

- **Urban weight:** The station building represents an international transportation hub that is also an icon for the city. The large scale, zoning, layout design, and levels turn the station complex into a strong urban space. High-rise stations can represent an iconic landmark and represents an international design and style that all users can locate from afar, stronger function segregation, and also with its position in the urban context. In case of redevelopment of an old station, the designer can use new elements of strong visual weight, composition, and even contrasting with the original construction.

- **Unity and linking with surrounding spaces:** Form, structure, and layout organization. In all cases, the designer should consider the gathering of all travellers in the station square. A station can have more than one side of entry and, as a result, more than one station square. The designer then has to consider the availability of building area and other constraints with the site and mechanics. The station should be a unifying element against the problem with introducing the railway line that disrupts the urban matrix of the city or town. The unity and linking should vary from one station to another according to its adjacency, accessibility, or being a part of a network.

- **Cultural expression:** can reflect the contradictions of the visuals and themes within the urban surrounding, representing a heritage to the surroundings; with choosing the train station's theme from the beginning is vital. A train station can be the centre of a local urban redevelopment of its urban matrix.

6. **Cultural and commercial uses:** due to train stations' urban value, the station can represent a business model, a landmark, and a social gathering. Stations' importance requires them to provide hospitality activities for passengers and other users, and even retail shops, coffee shops and high-class restaurants. Stations can also serve the cultural activities of the neighbourhood by providing activities inside the building like cinemas, theatres, and art performing. Stations should also extend their activities to the outside of the building; for more attraction, and can also serve budget concerns for smaller stations.

7. **Intermodality's relationship with the spatial and urban parameters:** Nowadays, designing for a train station requires designing for other transport modes as well. Train stations should adapt with many factors, like: desire to increase density of trains, reconnecting with other road networks, adapting to new urban fabrics and neighbourhoods, and increased demand on other transport modes.

   - So, stations have to be designed carefully to adapt its outdoor environment to entries, parking lots, and points of gathering and transportation change.

   - Adapting a train station should also be planned for a present or a future connection to a broader rail network; meaning to design the approach, entrances, shunting areas, core and peripheral areas, as areas and levels, for other types of rails, such as HSR, commuter rail, or LRT.

7.4 Recommendations

Since its inception, railway business has been a joint collaboration between engineering and capital money; which added architectural design to them following the realization of train stations. Over the decades, and especially in the recent times, railway industry witnessed an escalation in popularity that was the result of grasping of new technologies, new needs, and new regularities that act as guiding principles for the best railway service for users.

The thesis offers several recommendations for current and future contributors to railway service:

7.4.1 For architectural designers

1. Designers should treat each station as a unique design case, regardless of any constants for the same line like the operator or locomotive types. The designer should put into consideration the specific characteristics of a station, such as: surface area, topography, urban fabric, surrounding urban/rural context and history, history of the station building (for renovating old buildings).

2. Planning for facilities and amenities should serve the required functions of providing a quality to the station building, services, experience, and comfort; all without impeding the main function of the station which is safety and time efficiency for transportation.

3. It is required from the designer a thorough research for providing the most appropriate solutions for functionality; which includes the careful study of materials, structural technologies, lighting methods, energy saving, etc. to achieve the most efficient and affordable methods in providing the appropriate transportation, commercial, and cultural services.

7.4.2 For authorities and policy makers

1. Stating governing regulations that establishes the relationship between owners, operators, and designers.

2. Organising policies regarding standardization of design elements; with respect to the uniqueness of each station as a landmark or a design form in relationship with its urban and historical context.

3. Establishing standards for the quality of materials, route and passages' dimensions, required lighting, heating, and noise levels required guidelines; without hindering the architecture's role in the choice of aesthetic elements, or enhancing peripheral and cultural aspects for example.

7.4.3 For future researchers

1. Researchers can examine the relationship between the design parameters in this thesis and the studies that established the Pyramid of Needs for customers and users of train stations. Further studies can examine the effect of each design element on the satisfiers and dissatisfiers of customer needs, and so the priorities of design requirements.

2. Further research can calculate the feasibility of any improvements, renovations and additions to a given station

APPENDIX

- ## Glossary

B

Big Four

The term that was coined as a name used to describe the four largest railway companies in the United Kingdom in 1923–47; the Railways Act of 1921, which required the grouping of over 120 separate railways into four, consisted of:

1. Great Western Railway **(GWR);** later became **Western Region of British Railways.**
2. London, Midland and Scottish Railway **(LMS).**
3. London and North Eastern Railway **(LNER).**
4. Southern Railway **(SR).**

On 1 January 1948 the companies were nationalised to form **British Railways** as a result of the Transport Act 1947.[329]

BR (British Rail)

The former operator of most of the rail transport in Great Britain between 1948 and 1997. It was formed from the nationalisation of the "Big Four" British railway companies and lasted until the gradual privatisation of British Rail, in stages between 1994 and 1997. On privatisation, responsibility for track, signalling and stations was transferred to **Railtrack** (which was later brought under public control as **Network Rail**) and that for trains to the train operating companies. [330]

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[329] *Big Four (British railway companies)* (n.d.). Retrieved 2017, from Wikipedia.org: https://en.wikipedia.org/wiki/Big_Four_(British_railway_companies)

[330] *British Rail* (n.d.). Retrieved 2017, from Wikipedia.org: https://en.wikipedia.org/wiki/British_Rail

C

Corridor

A linear orientation of transport routes and flows connecting important locations that acts as origins, destinations or points of transshipment. Corridors are multi-scalar entities depending on what types of flows is being investigated. Thus, they can be composed of streets, highways, transit routes, rail lines, maritime lines, or air paths. [331]

D

DBAG (Deutsche Bahn Aktien Gesellshaft)

A German railway company. National railways Deutsche Bahn AG were privatized in 1994. In 2011 DBAG was divided into five main operations groups[332]:

1. Arriva
2. DB Bahn
3. DB Schenker
4. DB Netze
5. DB Dienstleistungen

E

ENR (Egyptian National Railways)

The current name of the national (and only) railways of Egypt to this date. Previously called **ESR (Egyptian State Railways)** [333].

[331] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

[332] Kido, E. M. (2013). *Stations for People: Recent Developments in Railway Station Design*. Tokyo: Construction Technology Research Institute Ltd. National Cultural Research Institute, p.54

[333] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

ESR (Egyptian State Railways)

The former name of the national (and only) railways of Egypt. Founded in 1854, it later became **ENR (Egyptian National Railways)**. By 1914, Egyptian state grouped all the railway companies in the country under the aforementioned state operated umbrella.

There were other operators in the late 19th century besides the state service railway: concessions to several private railway companies were granted, including Delta Light Railways, Qena Aswan Railway, Chemin de Fer Economiques L'Est Egyptien, and Chemin de Fer de la Basse Egypte.[334] By the 1930s, ESR was a very well established company. Most all towns in Egypt were serviced by the Egyptian railway. The institution boasted many peripheral activities, such as the telegraph company, parcel delivery services, a printing house and even an inhouse Arabic-English magazine edited by Cooke.[335]

H

HSR (High Speed Rail) & HST (High-Speed Trains)

High speed rail (HSR) refers to passenger rail systems running at operational speed between 200 and 300 km/h, and above in some cases. The HSR era originates from Japan with the Tokaido line, bridging Tokyo and Osaka, which entered into service in 1964 in time for the Tokyo Olympics. Japan presented several suitable conditions for the setting of a HSR system, particularly a high population density and closely interconnected large cities. It simply became a matter of overlapping the HSR network over this spatial structure. HSR is perceived as an efficient alternative to highway and airport congestion. Evidence underline that rail travel time is

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[334] Seif, O. (2015, October). *Train of Thoughts*. Retrieved October 2016, from AhramOnline: http://english.ahram.org.eg/NewsContent/32/138/152456/Folk/Photo-Heritage/Train-of-thoughts.aspx

[335] *Ibid.*

cut in about a half when a high speed service is established between two city pairs.[336]

Also called by its brand-name **InterCity 125**, British long-distance passenger train operating nationwide since 1976, when the first service was opened between London and Bristol-South Wales. The HST introduced high-speed rail travel to the United Kingdom. HSTs operated by British Rail and its various successors have been refurbished periodically, but in 2006 the government announced that the trains would be replaced within a decade. [337]

I

Intermodality

Movement of containerized (unitized) cargo over air, land, or sea through the use of different transport modes (aircraft, truck, rail, boats, ships, barges, etc.) capable of handling containers.[338]

J

JNR (Japanese National Railways)

The former business entity as a state-owned public corporation which operated Japan's national railway, with an independent budget. Preceeded by **JGR (Japanese Government Railways)**, until the reorginasiation in 1949.

In 1987, JNR was privatized and divided into seven railway companies, six for passengers and one for freight, collectively called **JR Group (Japan Railways Group).** [339]

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[336] Rodrigue, J.-P. et al. (2017), *The Geography of Transport Systems*, Hofstra University, Department of Global Studies & Geography, New York, https://transportgeography.org. Retrieved February 2018.

[337] *High Speed Train* (n.d.). Retrieved 2017, from Encyclopaedia Britannica: https://www.britannica.com/technology/High-Speed-Train-British-passenger-train

[338] *"Intermodal" definition*. (2017). Retrieved 2017, from businessdictionary.com: http://www.businessdictionary.com/definition/intermodal.html

L

Listed Building and Conservation Areas: Planning Act 1990

Supervised by the Department for Culture, Media and Sports (DCMS), a "**listed building**" is a building, object or structure that has been judged to be of national importance in terms of architectural or historic interest and included on a special register, called the List of Buildings of Special Architectural or Historic Interest. The term includes the building itself or any structure fixed to it.[340]

1. Types of building works for approval for listed buildings:

- Demolition.
- Alteration or extension (interior/exterior) which would affect its architectural or historic character.

[339] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 26

[340] *Application for Listed Building Consent for Alterations, Extension or Demolition of a Listed Building.* (n.d.). Retrieved November 2017, from Interactive guidance for householders: https://ecab.planningportal.co.uk/uploads/appPDF/Help011_england_en.pdf

2. *Criteria to decide which buildings to include on the list of protected buildings:*

Architectural interest	historic interest	Historic association	Group value
Buildings of importance because of their design, decoration & craftsmanship.	Showing an aspect of the nation's social, economic, cultural or military history.	Showing close historical association with nationally important people or events.	Part of an architectural ensemble, such as squares, terraces or model villages.

3. *Grades of listed buildings:*

Grade I	Grade II*	Grade II
Buildings of exceptional interest (approximately 2% of all listed buildings)	Particularly important and more than special interest (approximately 4%)	Buildings of special interest, warranting every effort being made to preserve them (94%)

LRT

Light-rail transit.

N

Network Rail

The British company formed after the privatization of British Railways. With its public control / re-nationalisation under **Railtrack** since 2002, it is responsible for track, signalling and stations of Great Britain[341].

Neo-Mamluk style

Neo-Mamluk was one of the modernists styles in Egypt, along with other Neo-Classic types like Neo-Ottoman style. Neo-Mamluk, however, was more prominent in railway station's style of

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[341] *Network Rail* (n.d.). Retrieved 2017, from Wikipedia.org: https://en.wikipedia.org/wiki/Network_Rail

buildings[342]. The style blossomed between 1870 and 1930; the style is characterized by a hybrid of:

- **Western European, 19th century:** construction principles.
- **Mamluki era, Egypt (1250 – 1517 A.D):** largely limited to decorative elements, with certain aspects of interior space design.[343]

S

SNCF (Société Nationale des Chemins de Fer Français)

"National Society of French Railways" is France's state-owned railway company and manages the rail traffic in France and the Principality of Monaco. SNCF was formed in 1938 with the nationalisation of France's main railway companies[344]:

1. Chemins de fer de l'Est (Est) *(Eastern Railways).*
2. Chemins de fer de l'État (État) *(State Railways)* (merged in 1908 with the Chemins de fer de l'Ouest).
3. Chemins de fer du Nord (Nord) *(Northern Railways)*
4. Chemins de fer de Paris à Lyon et à la Méditerranée (PLM) *(Paris, Lyon and Mediterranean Railways).*
5. Chemins de fer de Paris à Orléans et du Midi *(Paris, Orléans, and Southern Railways)* (PO-Midi, formed in 1934 from the merger of the Chemin de fer de Paris à Orléans and the Chemins de fer du Midi).
6. Administration des chemins de fer d'Alsace et de Lorraine (AL) *(Alsace-Lorraine Railways).*

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[342] Dizdar, G. (2010). The Neo-Mamluk Style in Architecture. Retrieved 2016, from Academia.edu: http://www.academia.edu/432897/The_Neo-Mamluk_Style_in_Architecture, p.1

[343] *Ibid.*

[344] *SNCF* (n.d.). Retrieved 2017, from Wikipedia.org: https://en.wikipedia.org/wiki/SNCF

7. Syndicats du Chemin de fer de Grande Ceinture et de Petite Ceinture *(Great and Little Belt Railways).*

T

TGV (Train à Grande Vitesse)

"High-speed train" of France. Originally designed as turbotrains to be powered by gas turbines, TGV prototypes evolved into electric trains with the 1973 oil crisis. Dates of operation: 1980–Present. [345]

Tokaido shinkansen

A Japanese high-speed Shinkansen (*"bullet train"*) line, opened in 1964 between Tokyo and Shin-Ōsaka. Since 1987 it has been operated by the Central Japan Railway Company (JR Central), prior to that by Japanese National Railways (JNR). It is the most heavily travelled high-speed rail route in the world by far; its cumulative ridership of 5.3 billion passengers dwarfs all other systems and lines worldwide. [346]

[345] *TGV* (n.d.). Retrieved 2016, from Wikipedia.org: https://en.wikipedia.org/wiki/TGV

[346] Ando, K. (2010, December). *Breakthrough in Japanese Railways 5: Japan's Rail Stations*, Japan Railway & Transport Review, issue 56, p. 26

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وَقُل رَّبِّ زِدْنِي عِلْمًا

سورة طه، الآية ١١٤

إلى معلمي...

أ.د/ عمرو فاروق الجوهري

إهداء

إلى أمي وأبي، وعائلتي، وأصدقائي:

أرجو أن تكونوا فخورين بهذا العمل. بمساعدتكم، أنتم شركاء في إنتاجه.

إلى كل مهتم بمجالات المعرفة و التطبيق:

أرجو أن يكون هذا العمل مرشدا لطريقكم في الحياة، وإلى وجهتكم التي تريدونها.

شكر

بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

أتقدم بجزيل الشكر و العرفان للأستاذ الدكتور/ **عمرو فاروق الجوهري**؛ على مجهوده و وقته لاقتراحاته لخطة البحث، التوجيه في التطوير، و التفكير النقدي في خطوات البحث و نتائجه.

أتقدم بخالص الشكر و العرفان للأستاذ الدكتور/ **خالد محمد دويدار**؛ على وقته الثمين، ودعمه الأكاديمي؛ من أجل إنتاج هذا المنتج البحثي.

كما أتقدم بأعلى درجات التقدير لكل من مدّ لي العون، والتشجيع، والمساندة؛ على رأسهم أمي وأبي، إخوتي و عائلتي، و أصدقائي.

الملخص

قدم الطالب دراسة نظرية وتحليلية لتطور فكر تصميم مبنى محطة القطارات؛ منذ نشأتها في أواخر القرن التاسع عشر حتى يومنا هذا.

اعتمد الباحث على تحديد مشكل بحثي: وهو تداخل العناصر الهندسية في مختلف التخصصات بحيث يجعل من الصعب تحديد مكونات المشروع منفصلة وعليه، صعوبة تحديد أولويات العناصر لوضع برنامج تصميمي يخدم احتياجات المحطة في موقعها المحدد تبعا للمحددات الجديدة.

افترض الباحث وجود أربعة عوامل توجه العملية التصميمية والمجالات الهندسية لتصميم محطات القطارات وهي: التقنية، والتخطيطية، والفراغية، والطرازية.

قام الباحث بتحليل معماري نمطي لجانبي التصميم بالنسبة للمحطات: وظيفة، وشكل؛ من أجل تحديد مكونات المحطة، ثم دراسة علاقتها بكل عامل من الأربعة. وجد الباحث أن كل عامل موجه في قوة تأثيره هو متغير بحسب ظروف التصميم المتحكمة في الأساس في الوظيفة والشكل، و أن كل عامل من هذه العوامل مرّ بصعود وهبوط على مر العقود السابقة؛ متأثرا بمتغيرات اجتماعية واقتصادية وسياسية.

وبعد تقسيم مراحل تطور تصميم محطات القطارات إلى ثلاث حقبات زمنية، تم تحديد أنماط التغيرات لكل عامل، ومنها نشاط كل عنصر وظيفي وشكلي، أمكن من كل هذا عمل تحليل لأمثلة متنوعة لمحطات مختلفة في الثقافات المحيطة والحجم والعمر؛ مما أدى إلى استنباط محاكاة لأنماط تأثير كل عنصر في العوامل الموجهة على بعضها البعض، ومنها وضع تصور لبرنامج تصميمي لأي محطة قطارات؛ مع اعتبار المحددات والظروف التصميمية لكل محطة يراد إنشائها أو تطويرها تبعا للمتغيرات الجديدة التي طرأت على اقتصاد المدن والمتطلبات التصميمية تبعا لذلك.

كلمات المفتاح: محطة، قطار، مواصلات، عوامل، نهضة.

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كلية الهندسة
قسم الهندسة المعمارية

رسالة ماجستير:

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عنوان الرسالة: تطور تصميم محطات القطارات.
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موافقة مجلس الكلية موافقة مجلس الجامعة

/ / / /

القاهرة ٢٠٢٠

الموافقة على المنح

كلية الهندسة

قسم الهندسة المعمارية

تطور تصميم محطات القطارات

إعداد

حسام أمير محمد ترك

بكالريوس الهندسة المعمارية، يونيو ٢٠١٠

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أ.د/ خالد محمد دويدار	....
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التاريخ: / /

كلية الهندسة
قسم الهندسة المعمارية

تطور تصميم محطات القطارات

مقدمة للحصول على درجة الماجستير
في الهندسة المعمارية
التصميم المعماري

إعداد

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