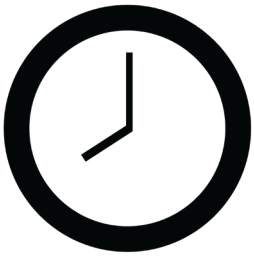

RUSH HOUR

HOW WILL DATA IMPACT THE DESIGN OF A TRAIN STATION FOR RUSH HOUR?

Complex Projects AR3CP100
P2 Article
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2024

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complex-projects/

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Projects-422914291241447

Berlin Studio
Digitalization

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ABSTRACT

The Rush Hour project is initiated by the German Federal Ministry of Digital and Transport to accelerate the transformation of the German railway infrastructure, including modernizing its train stations. For many decades, the rail infrastructure has been neglected, leading to failing rush hours at stations with overcrowded platforms and unprecedented delays. Digital infrastructure is regarded as the future backbone of the train station by optimizing transport efficiency and user experience. Berlin Westhaven has been chosen as the most suitable site, responding to the client's ambition of creating a digital and transport node as the urban anchor. Westhaven is situated between the city center and a large urban tech development. The station aims to become a highly efficient transport node during peak travel times, simultaneously acting as a destination and gateway of an innovative ecosystem. The main users are local commuters, tech workers, and TU Berlin students. A benchmarking study of existing train stations, in combination with client and site requirements, resulted in a design brief for a train station with an integrated data center. The total proposed GFA is 113,000 m2, with 65% allocated to transport, the core functionality supported by 4% data centre.

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Client Research
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Site Requirements

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INTRODUCTION

01

TRAIN STATION

A train station is a facility designed for the loading and unloading of passengers and freight from trains, serving as a transportation hub within a railway network.

- Chat GPT

RUSH HOUR

Rush hour refers to the peak periods of the day with the highest traffic congestion or demand for transportation, typically occurring during commuting times in the morning and evening.

- Chat GPT

DATA

Data refers to information, often in the form of facts, figures, or statistics, that is collected, processed, and used for various purposes, including analysis, decision-making, and storage.

- Chat GPT

RUSH HOUR & DATA

1.1.1 RUSH HOUR

Rush hour is the 'break or make' moment of train station. It determines whether a station is efficient and appreciated by its users. Twice a day, within a time span of two hours, thousands of people flow simultaneously through the building. Time sensitive passengers are rushing on their journey to their destinations, predominatly commuting to work or school. Over time, stations have turned into a true piece of machinery in order to move people efficiently from A to B.

Recent academic research and state-of-the-art stations such as Rotterdam central station show a significant shift by increased incorporation of User Experience (UX) design methods to improve customer satisfaction (Van Hagen, 2014). There is no longer generalization of 'the passenger' (Bureau Spoorbouwmeester, 2011). Instead passengers are acknowledged as individuals with their own emotions and well-being.

1.1.2 DATA

In the age of digitalization, designers gain valuable insights into user experience through big data and digital technology (Schneider et al., 2023). Additionally, the increasing presence of technical devices (Internet of Things) connected to digital infrastructure presents opportunities for increased efficiency. Optimization has the potential to reduce pressure on stations during rush hours.

The gathered data informs design decisions, encompassing space optimization, services, and overall station layout—a process of iterative design from both inside-out and outside-in perspectives. Analyzing user journeys helps identify peak commuting times, popular routes, and common pain points. Ultimately, enhancing customer satisfaction contributes to building customer loyalty and increasing ridership for railway companies, such as Deutsche Bahn in Germany (Van Hagen et al., 2017).

1.2 PROBLEM STATEMENT

The posed problem revolves around the critical issues faced during rush hour at train stations, especially in metropolitan cities such as Berlin. Around 8 am on weekdays millions of individuals commute from home to work, school, or business appointments. Stations have to efficiently facilitate this substantial flow of people within a limited time span. Any delay in this process results in platform overcrowding, creating safety risks and creating negative passenger experiences.

At current times, Deutsche Bahn, the German Railway Operator and Provider is in a performance crisis. Decades of neglected infrastructure and insufficient funding have led to outdated systems, frequent delays (with one-third of DB German trains delayed in 2022), and overcrowded stations. This situation is further intensified by certain stations being underused due to the greater attractiveness of car traffic and misalignment between rail and land-use planning.

Amidst rapid urbanization (e.g. 60,000 p/ year influx in Berlin), energy and climate transition, and technological disruptions, the German Ministry of Transport and Planning has committed a record amount of 40 billion euros to modernize the German Railway infrastructure into a Digital Rail. This underscores the urgency of the situation. Digitalization emerges as a key strategy in achieving efficient transportation of people and goods. Data is seen as a way to make operational aspects more effective and enhance the user experience. The urgency is highlighted by Deutsche Bahn's ambitious goal of doubling passenger numbers, replacing 5 million car trips, and eliminating 1/6 of domestic flights by 2050.

The big challenge lies in aligning infrastructure investments with broader urban visions, including urban development and energy infra development. Effectively addressing these problems requires a strategic and innovative approach to transform the current state of railway systems and stations in Germany.

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DB

1.3 RESEARCH QUESTION

Main research question

How will data impact the design of a train station for rush hour?

Sub-research questions

1.How much of the train station design is specific vs. generic?

2.How will data impact the user experience at the train station during rush hour?

3.How will data impact efficiency of transport at the train station during rush hour?

4. How will data impact the train station area development?

08:00

RESEARCH FRAMEWORK

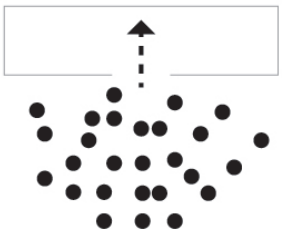
02

2.1 THEORETICAL FRAMEWORK

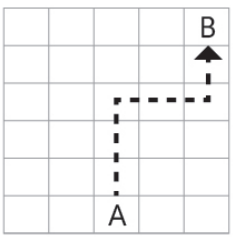
In the academic field, rush hour experience are significantly influenced by three major research domains: Natural Wayfinding, Crowd Control and Waiting Experience. Satisfying passengers proves challenging, with control over reliable, safe, and seamless transport serving as a benchmark. Minor disturbances can profoundly impact the overall experience, while comfort and additional amenities contribute to satisfaction. Unpleasant waiting experiences before boarding or during delays elongate the perception of time, eliciting anger and frustration (Van Hagen, 2014).

Natural Wayfinding prioritizes an intuitive flow of people through spaces, emphasizing lines of sight, well-articulated spatial flow, and clear legibility (Ferri & Popp, 2022). Crowd control, crucial for efficient flow and spacing, alleviates bottlenecks and congestion, preventing overcrowded conditions (Li, 2019). Train stations face a constant conflict between individuals creating static areas and others requiring dynamic spaces for movement, influencing circulation within the building (Triggianese et. al, 2018).

Crowd Control



Natural Wayfinding



Waiting Experience

2.2 RELEVANCE

The rush hour project seeks to push the boundaries of the today's standards of train stations, responding to the societal shift into the digital era and changing urban conditions. It aims to integrate Bodies and Building Berlin, aligning with the topic of the complex projects studio. The digitization lens is introduced by the studio itself (not a personal choice), aligning with the future trends in railways and emphasizing a strong focus on data.

This exploration serves to understand the impact of digitalization on the built environment, with the intentional strong presence of the concept. It included the strong statement that data is the digital backbone of future railway and cannot function independently. The studio, similar to the master program and track prepares students into architects who play an active role in society. It demands a balance of being a generalist and a specialist, requiring awareness of societal trends and the ability to respond through architectural design in terms of program, form, materialization, and articulation.

The station design process begins with a comprehensive understanding of the context and a broader urban vision. While architecture traditionally revolves around the building itself, the studio also emphasizes its relationship with the city. The multifaceted nature of a station design requires a deep understanding of other disciplines urban planning, transport planning, management and building engineering.
Innovation stands central in this graduation project, implementing an academic approach with a station database and methodology that can be useful for fellow academics, including future students, and professionals for diverse research and design projects. The train station, as a part of many people's daily life, holds a pivotal role in people's experience and shaping society. Frustrations related to delays, overcrowding, and the associated feelings of anxiety or boredom are universally recognized.

This project aims to highlight that the station is more than a transfer machine; it plays a vital urban role and a place where people can pleasantly stay. The increasing standards to human comfort aligns with the railway's effort to compete with carbon and space-intensive alternatives like cars and air travel. Benchmarking of renowned existing train stations and assessing the impact of data on traditional typologies, the project acknowledges the digital future. The projects contributes to closing a substantial knowledge gap in the built environment compared to other industries. The recent addition of an AI department to the TU Delft faculty of architecture marks the relevance of digitalization within our discipline.

RESEARCH METHOD

03

To address the main question, "How will data impact the design for a train station during rush hour?" the research is structured into three key categories: program, client, and site. The exploration of these categories is iterative, without a strict order, and answers will be presented in the design brief at the P2 stage, with ongoing research continuing into the next design phase.

Program Research

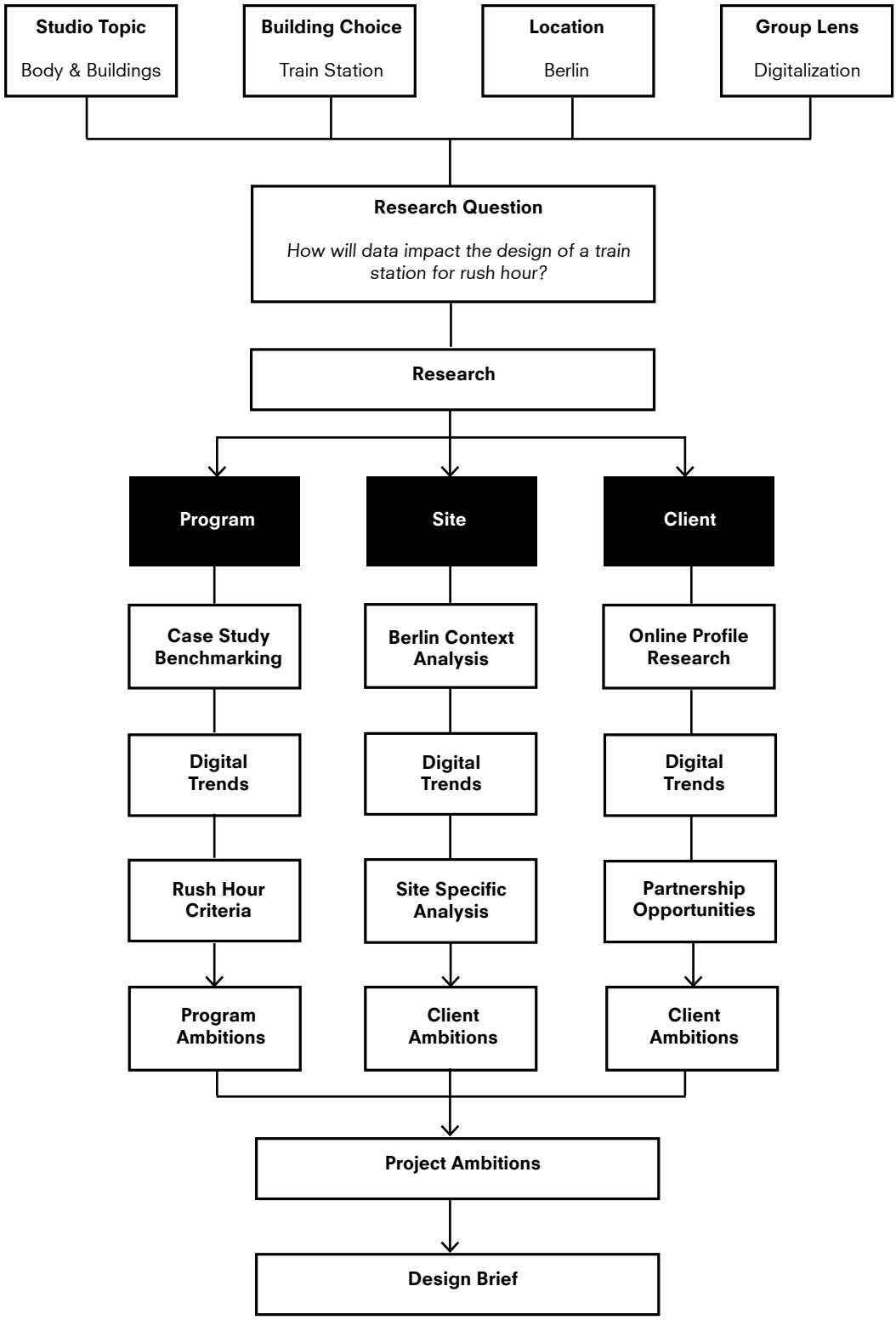
Program research involves benchmarking and a literature study to understand the balance between generic and specific aspects of a station, focusing on core functionality versus complementary functionality. The research hypothesis considers data as the digital backbone and energy as an essential resource. A framework with five main domains (three operational and two soft) has been developed, offering criteria for assessing existing case-study train stations and projecting objectives for new or redeveloped stations. Analysis of a station database, comprising 16 case studies (incl. Vienna Hbf, Rotterdam CS, Berlin Hbf), informed the creation of a program bar and additional elements resulting from digitalization and site-specific contexts. For instance, spatial dimensions for key spaces such as platform, entrance hall and data centre have been identified but also overall program requirements with GFA's for accommodating an estimated 100,000 passengers per day.

Client Research

Client research looked into Deutsche Bahn as the core client and relevant stakeholders, including Berlin, rush hour passengers, and Siemens. Ambitions from each stakeholder are synthesized into a unified project ambition: a "future digital and transport node as the urban anchor in Berlin." A stakeholder is assigned to each studio domain (Building, Body, Berlin) to cover a holistic spectrum of ambitions. Specific client ambitions, such as Deutsche Bahn's aim to double passenger numbers and Siemens' role as a tech partner to accelerate digital innovation, are highlighted.

Site Research

Site research begins with formulating site selection criteria, aligning with the station and data center typologies, and project ambitions. The preferred site, Westhafen, undergoes analysis on both Berlin and district scales to understand future passenger flows and specific requirements. Opportunity and constraint analysis results in concrete site-specific ambitions and spatial guidelines. Key site-specific details such as station role as an urban gateway are identified. After completing program, client, and site research, massing studies were done to develop a preferred massing option that aligns with combined site, program, and client requirements. The preferred massing serves as the starting point for the design phase after P2.

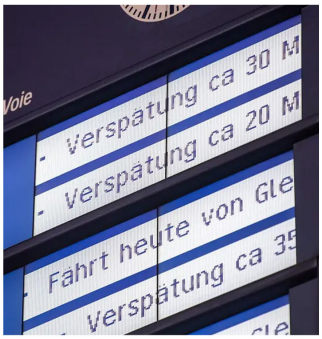

Studio Topic
Body & Buildings
Building Choice
Train Station
Location
Berlin
Group Lens
Digitalization
Research Question
How will data impact the design of a train station for rush hour?
Research
Program
Site
Client
Case Study Benchmarking
Berlin Context Analysis
Online Profile Research
Digital Trends
Digital Trends
Digital Trends
Rush Hour Criteria
Site Specific Analysis
Partnership Opportunities
Program Ambitions
Client Ambitions
Client Ambitions
Project Ambitions
Design Brief

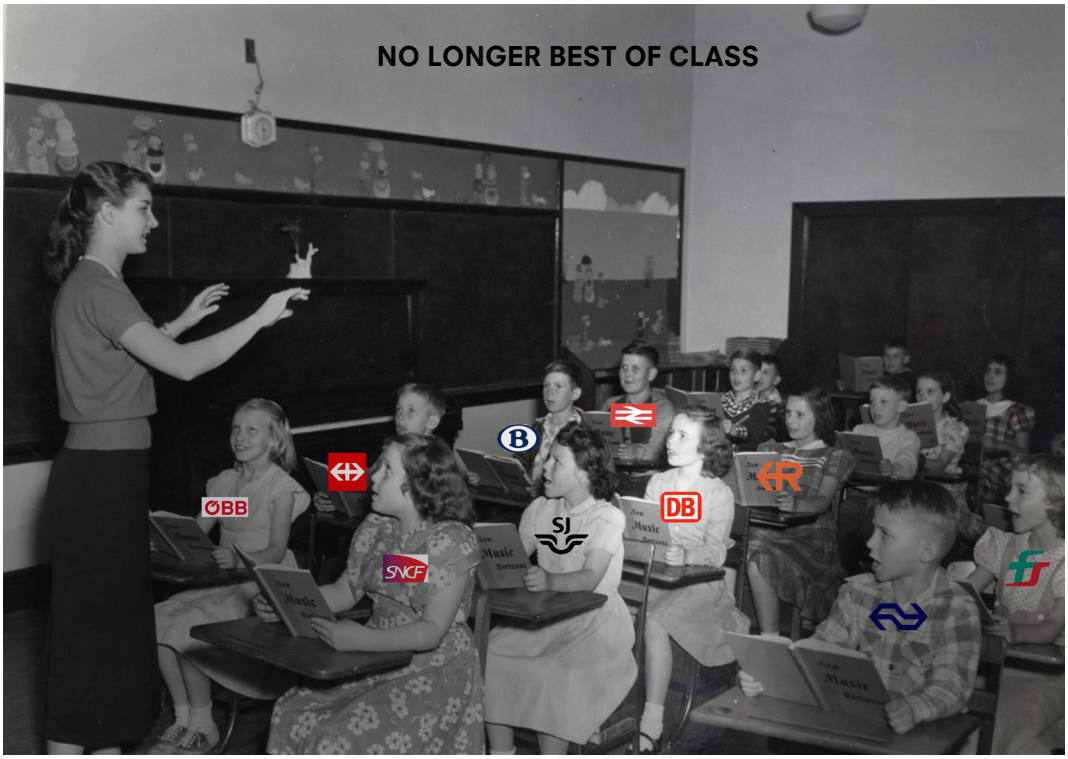
3.1 CLIENT RESEARCH

What happened to Deutsche Bahn?

Deutsche Bahn, the state-owned German railway operator once internationally known for its efficiency, is currently facing a crisis marked by an unprecedented number of delays and overcrowded stations. Insufficient funding has resulted in outdated systems and trains, struggling to meet the transportation demands of a growing population. The pressure on the railway to transform is steadily increasing due to factors such as climate change, rapid urbanization, and technological disruptions.

Recognizing the inadequacy of the current infrastructure for a modern economy, the Federal Ministry of Digital and Transport, led by Minister Volker Wissing, has announced a 45 billion euro investment to modernize the rail infrastructure, including stations.



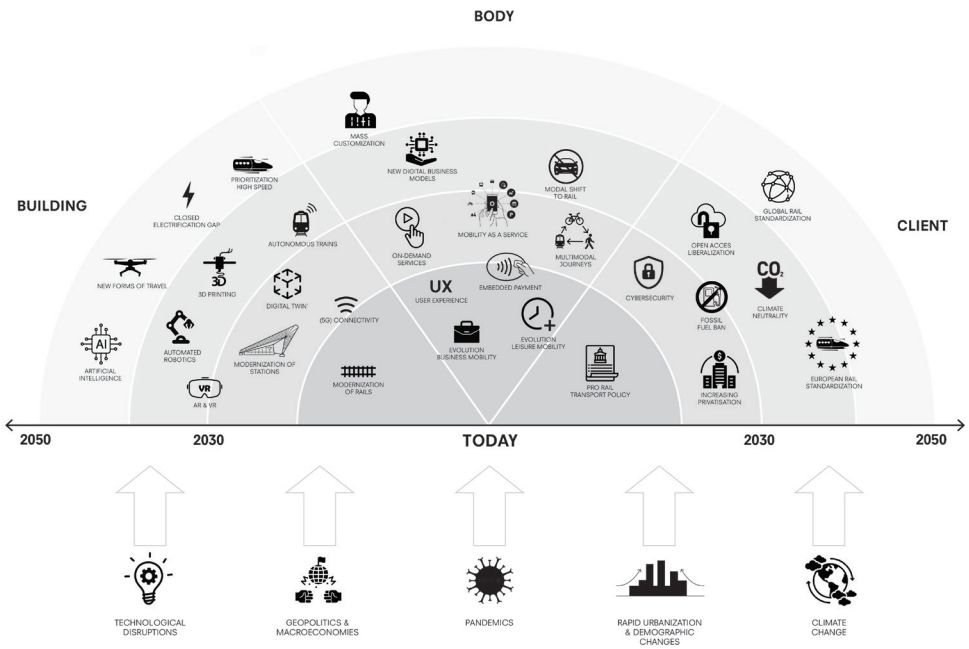

NO LONGER BEST OF CLASS
ÖBB
SNCF
SJ
DB

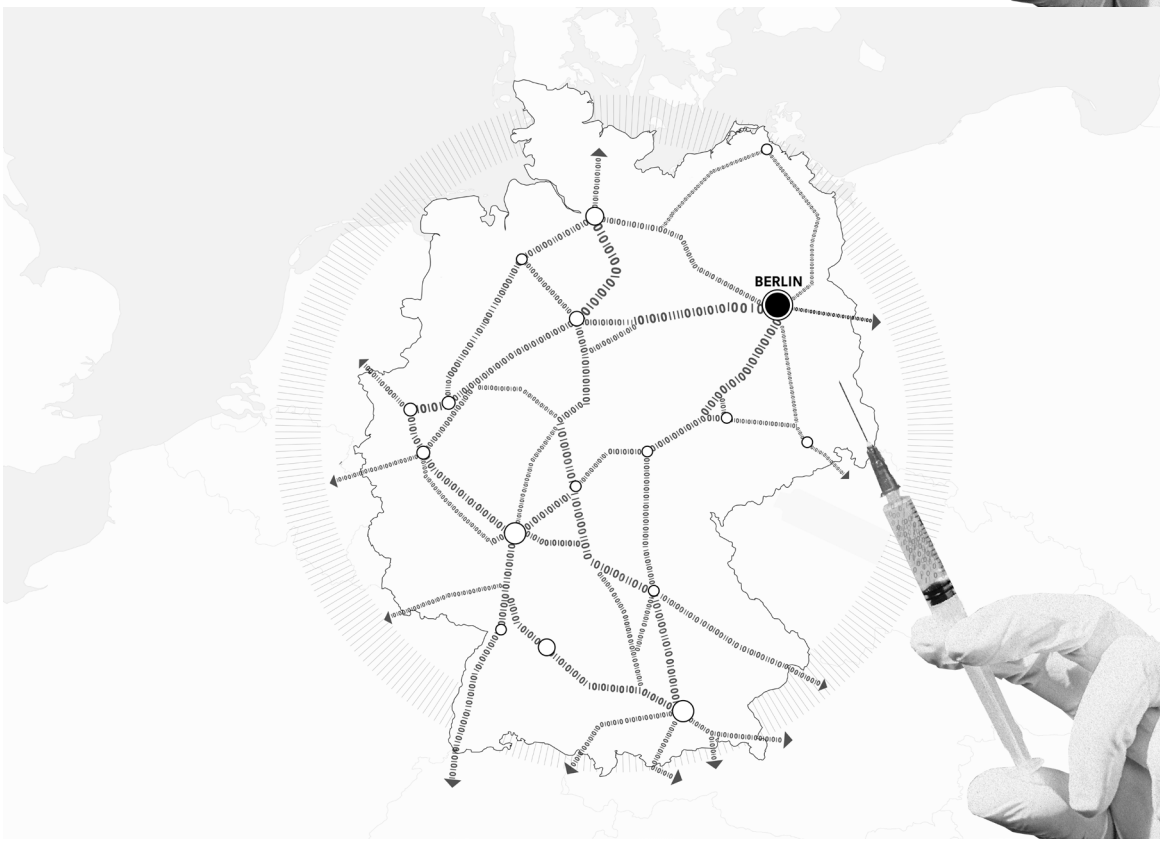

Bundesministerium
für Digitales
und Verkehr
"The rail infrastructure has been neglected for decades and brought to its absolute limits. This is no longer acceptable and unworthy of modern economy"
Volker Wissing, German Minister of Digital and Transport (2023)

Digital Rail for Germany and Berlin

The Ministry of Digital and Transport uses digitalization as the main strategy to modernize infrastructure. Smart integration between digital and rail infrastructure creates numerous opportunities. Establishing digital transport nodes enhances accessibility for the urban area and the public buildings around stations (also the CP projects).

Digitalization affects both users (individuals) and the stations themselves (structures). The significant investment in rail aligns with ambitious climate goals set by the German government and the EU. There is a global trend of pro-transport policies, shifting away from car and plane traffic with larger carbon footprints.

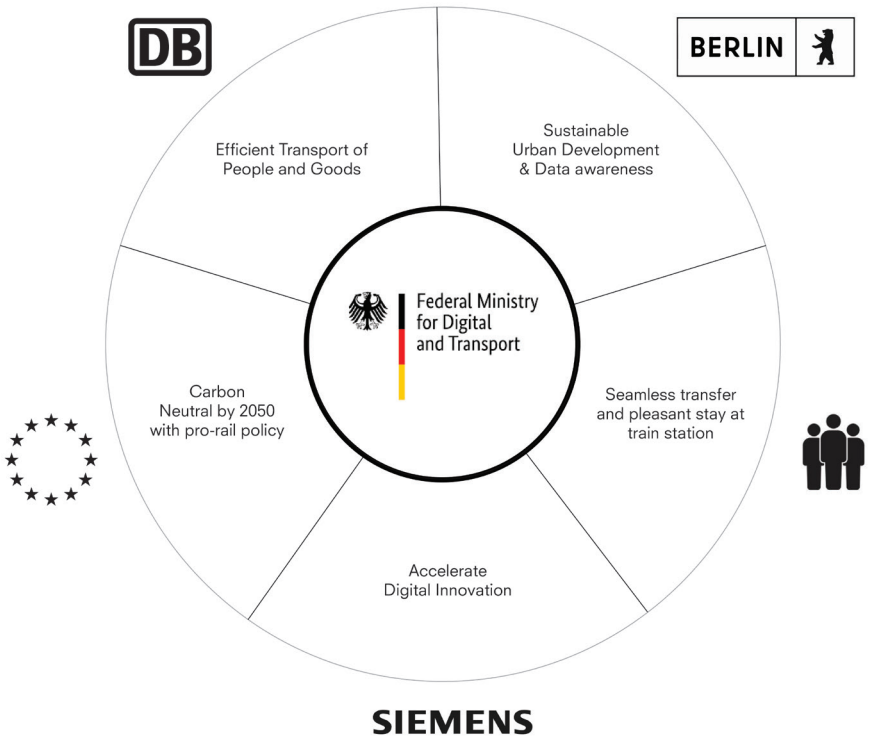


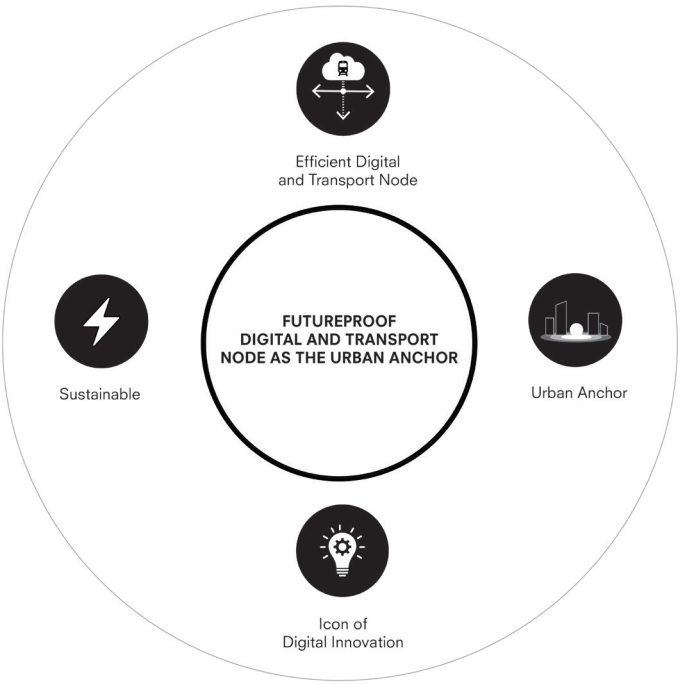

BERLIN

Client Ambitions

The Federal Ministry of Digital is the core client, funding the majority of the new station building. DB represent the main functionality of the train station by aiming for highly efficient transport of people and goods. Alongside, key stakeholders include Siemens, serving as the ideal private tech partner with expertise in digital innovation within the transport and logistics industry. Also the Berlin Municipality is highly interested in the project, aiming to promote sustainable urban development with robust public transport accessibility. Data awareness is a central ambition.

By aligning the individual ambitions of all stakeholders, the overarching goal is to create a future-proof digital and transport node, serving as the urban anchor in Berlin. This station will be integrated into a broader transport and digital network, attracting the public and contributing to an innovative society.


DB
BERLIN
Efficient Transport of People and Goods
Sustainable Urban Development & Data awareness
Federal Ministry for Digital and Transport
Carbon Neutral by 2050 with pro-rail policy
Seamless transfer and pleasant stay at train station
Accelerate Digital Innovation
SIEMENS


Efficient Digital and Transport Node
Sustainable
FUTUREPROOF DIGITAL AND TRANSPORT NODE AS THE URBAN ANCHOR
Urban Anchor
Icon of Digital Innovation

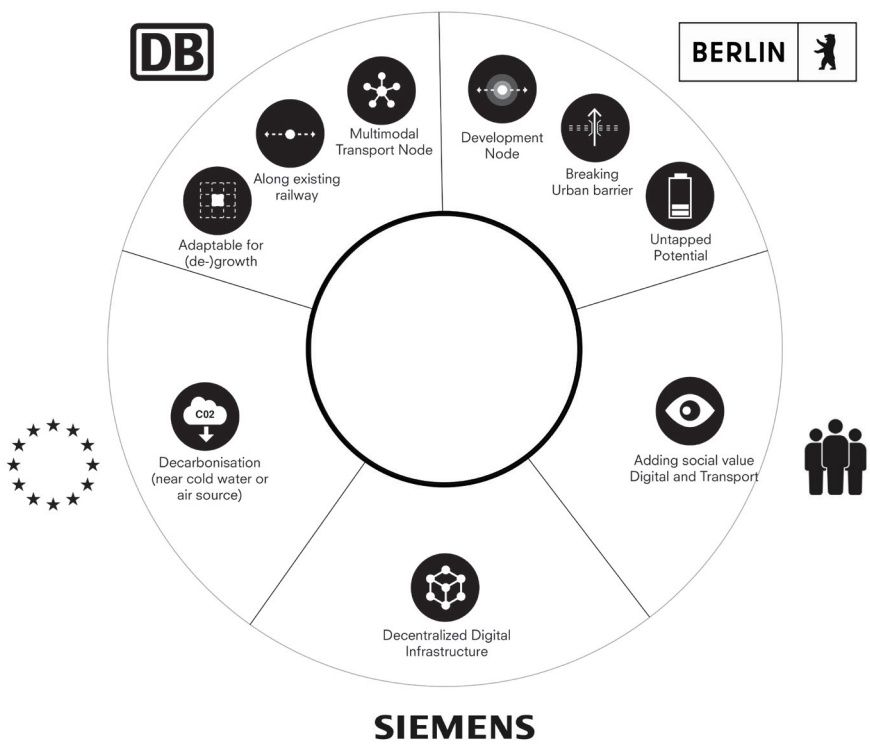

603

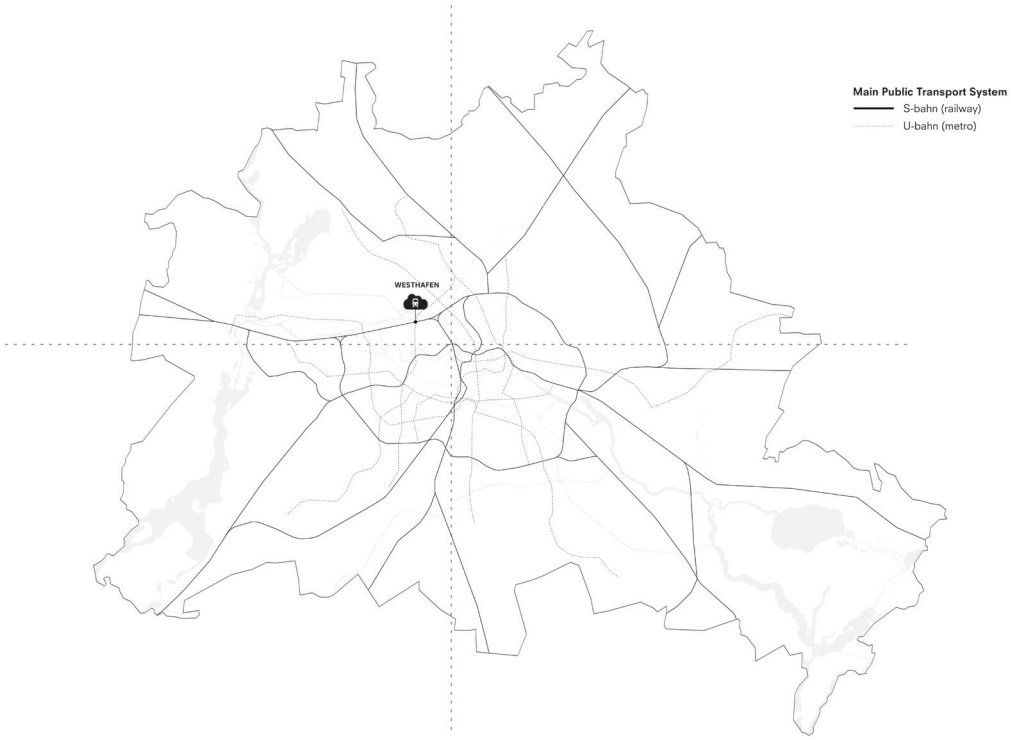

B
DB
08:00

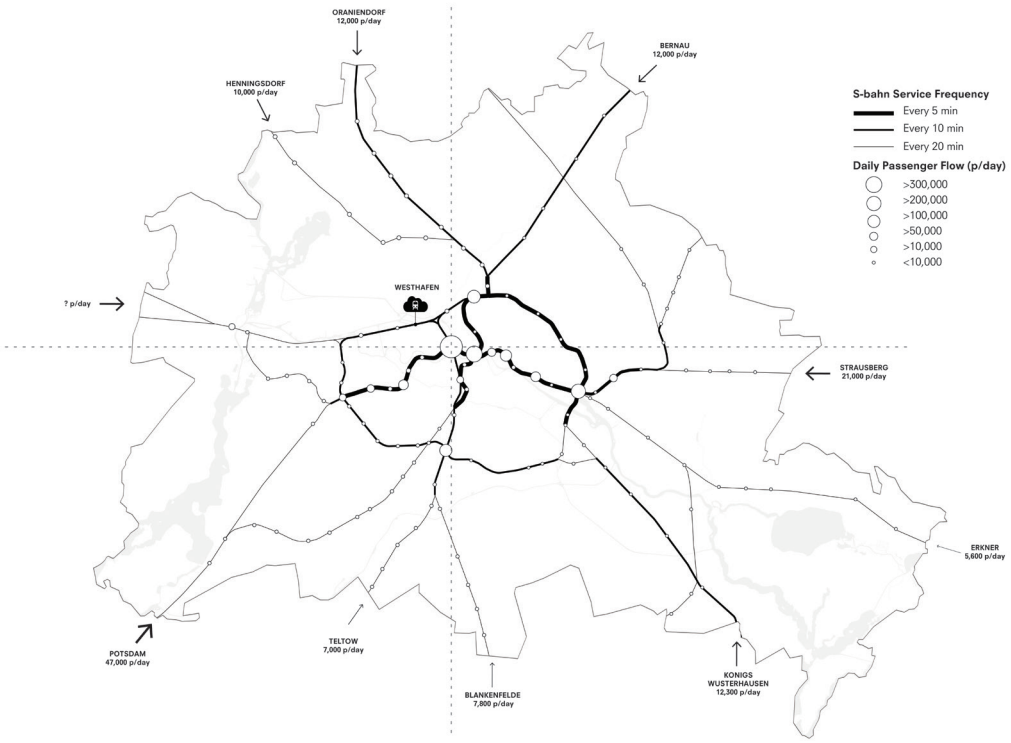
3.2 SITE RESEARCH

Site Selection Berlin Westhafen

Responding to the site criteria of each stakeholder, Westhafen has been selected as the most suitable location. It aligns with the model of becoming an urban anchor, initiating urban development for a new polycentre and alleviating pressure on the rest of Berlin's rail infrastructure. The dominant criteria for selecting the site include both train station typology and urban considerations. Also Westhafen suits a digital node by being close to water for natural cooling and decentralized from other digital nodes (data centres).




Main Public Transport System
S-bahn (railway)
U-bahn (metro)
WESTHAFEN


ORANIENDORF
12,000 p/day
BERNAU
12,000 p/day
HENNINGSDORF
10,000 p/day
S-bahn Service Frequency
Every 5 min
Every 10 min
Every 20 min
Daily Passenger Flow (p/day)
>300,000
>200,000
>100,000
>50,000
>10,000
<10,000
WESTHAFEN
? p/day
STRAUSBERG
21,000 p/day
ERKNER
5,600 p/day
POTSDAM
47,000 p/day
TELTOW
7,000 p/day
BLANKENFELDE
7,800 p/day
KONIGS
WUSTERHAUSEN
12,300 p/day

Gateway of Innovation Ecosystem

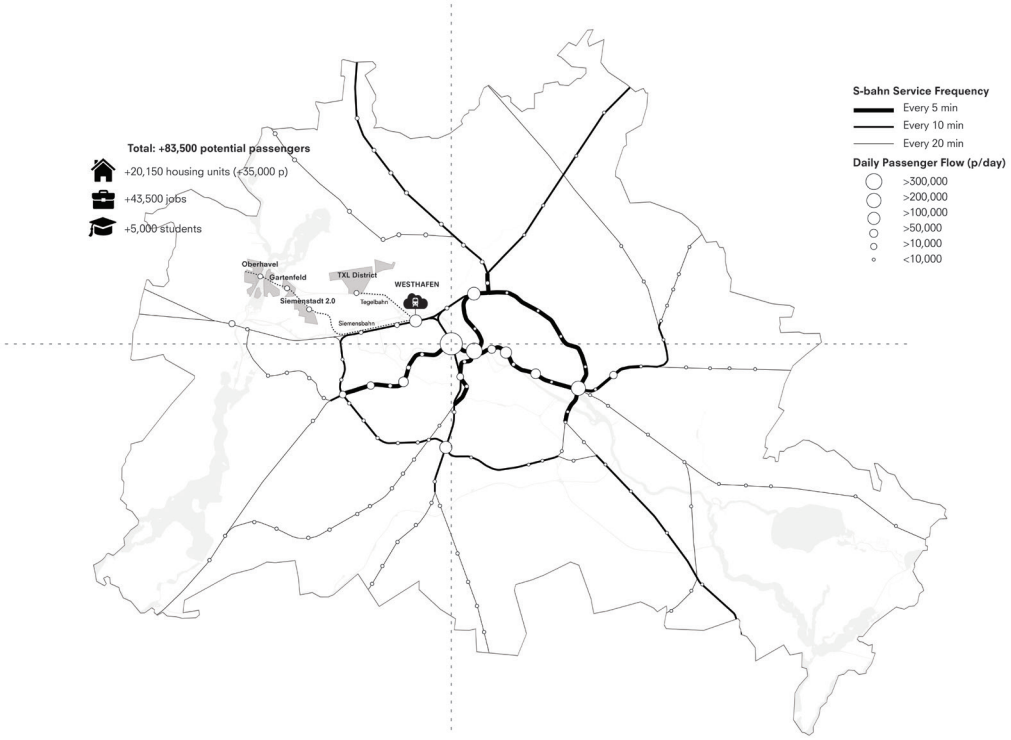
The chosen site is in Westhafen, Berlin's largest urban port. The current station has below 10,000 p/day due to lack of urban density around. Positioned as an isolated site, it acts as a barrier between the City Centre and upcoming tech development areas like Siemenstadt and TXL Urban Tech Republic. The development anticipates attracting over 85,000 new jobs, homes, and students. The prospective new station holds the potential to serve as a gateway seamlessly integrating the flow of people, goods, and data. Beyond its local prominence, the station also has the opportunity to become an international gateway, linked to international corridors. Over time, Westhafen's status as a place and node could evolve into a densely populated urban innovation district, catalyzing digital innovation in the mobility and logistics sector.

2030 2045 2060


BERLIN-TEGEL


Gartenfield
Hamburg
Amsterdam
Siemenstadt 2.0
TXL District
Urban Tech Republic
Westhafen
TU Berlin
Campus
Moabit
Hauptbanhof &
Europacity


S-bahn Service Frequency
Every 5 min
Every 10 min
Every 20 min
Daily Passenger Flow (p/day)
>300,000
>200,000
>100,000
>50,000
>10,000
<10,000
Urban Density (FSI)
14
0
WESTHAFEN

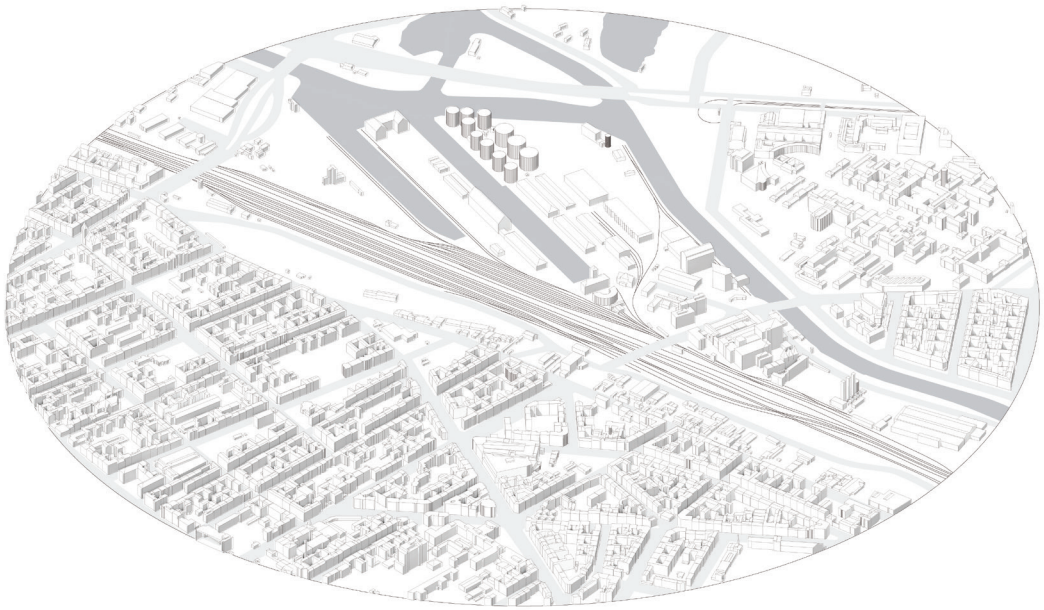

Total: +83,500 potential passengers
+20,150 housing units (+35,000 p)
+43,500 jobs
+5,000 students
Oberhavel
Gartenfeld
TXL District
Siemensstadt 2.0
Tegelbahn
Siemensbahn
WESTHAFEN
S-bahn Service Frequency
Every 5 min
Every 10 min
Every 20 min
Daily Passenger Flow (p/day)
>300,000
>200,000
>100,000
>50,000
>10,000
<10,000

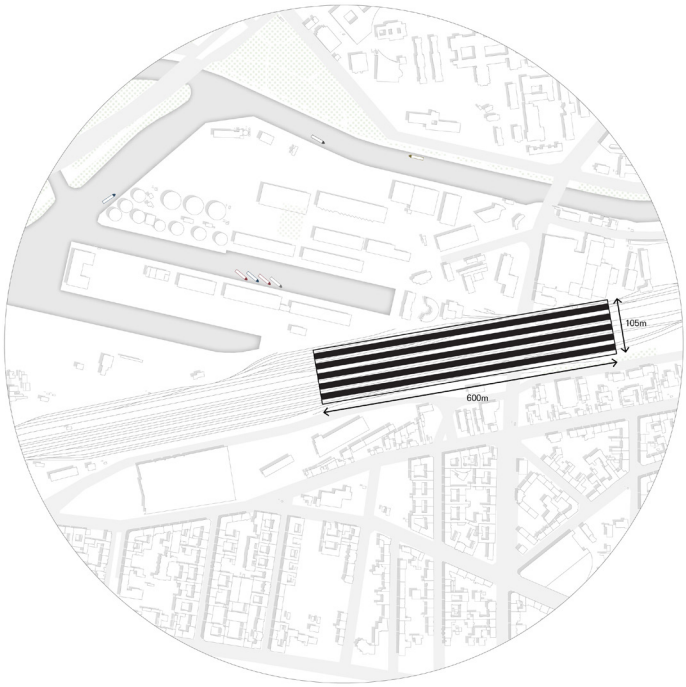

Main Public Transport System
S-bahn (railway)
U-bahn (metro)
WESTHAFEN
FUTURE TECH DEVELOPMENT
CITY CENTRE


(Inter)national transport system
IC corridor
Existing IC Station
Nightrain Station
STRALSUND
WESTHAFEN
FUTURE TECH DEVELOPMENT
HAMBURG
HANNOVER
AMSTERDAM
FRANKFURT
STUTGART
BASEL
CITY CENTRE
WARSAW
MOSCOW
LEIPZIG
DRESDEN
MUNICH
PRAGUE

Site Analysis

Today Westhafen is characterized by its logistical nature, having limited relationship with the city. However, it holds significant potential in entering the digital era, enabling smarter integration of logistics and making the harbor a more livable place. The site proves to have ideal conditions for a large new station, featuring a broad rail corridor and space to accommodate 10-12 platforms, with the capacity to host up to 200,000 people per day in the future.



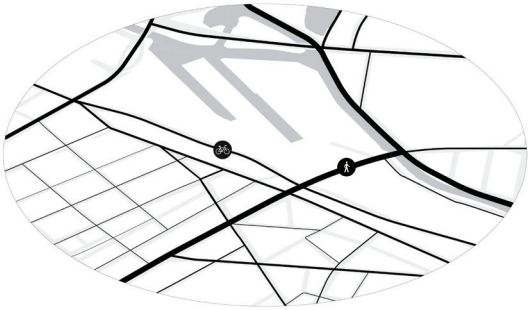


Max. Platform Capacity = 10-12 Platforms

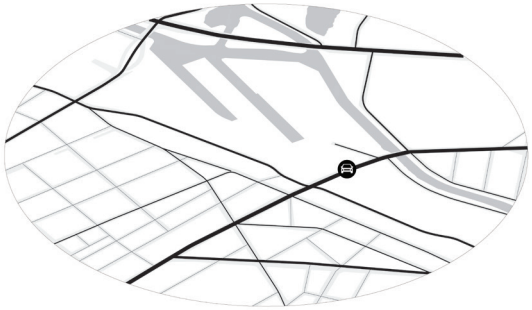
Max. 200,000-275,000 p/day possible within existing site boundaries.
Ideally 90,000-155,000 p/day based on own case-study data

Transport Flows

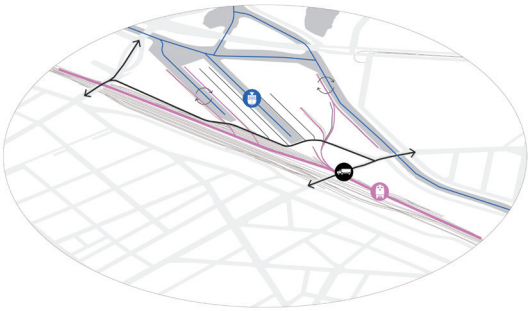
Presently, Westhafen has a compact S&U-bahn (local rail and metro) station with two platforms, each operating at a low frequency. The station lacks prominence, and their entrances are uninviting, resembling non-places. The S-bahn platform is positioned at +0, connected to the U-bahn platform at -1. The primary flow of local transport and people passes the site on the Putlizstrasse bridge. Westhafen is predominantly characterized by logistic routes for HVG, cargo trains, and cargo ships.



Slow Mobility



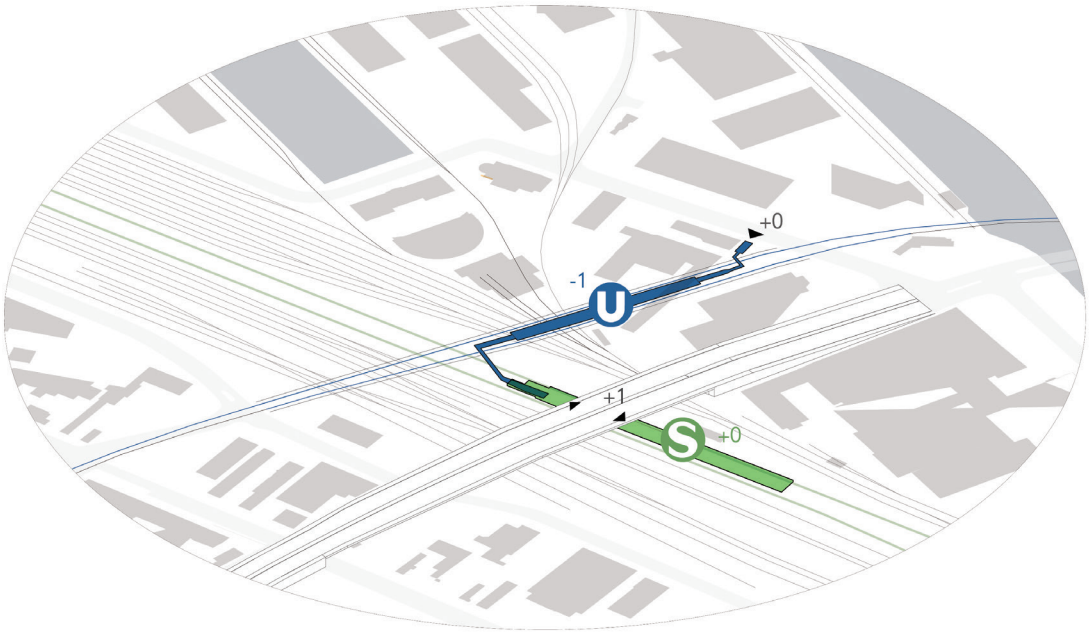
Motorized Vehicles



Industrial Logistics

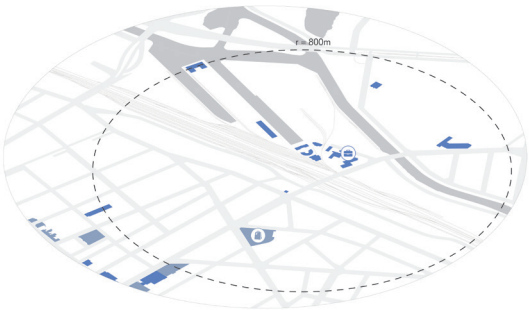
Public Transport


Westhafen

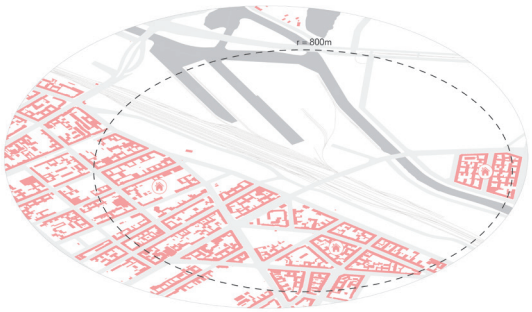

+0
-1
+1
+0

Urban Program and Catchment Area

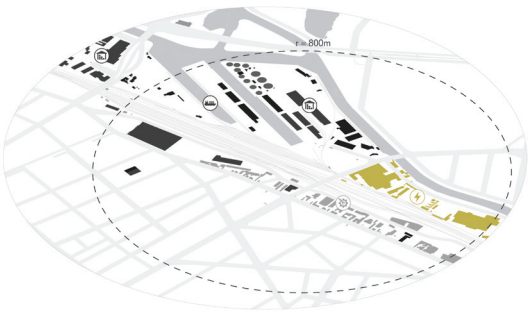
Within an 800m walking distance catchment area of the train station, there is a significant residential area in the Moabit district, along with industrial facilities in the harbour and a large scale university hospital, Charite. The new station must take into account the residents within this area as both origins and destinations for travel.



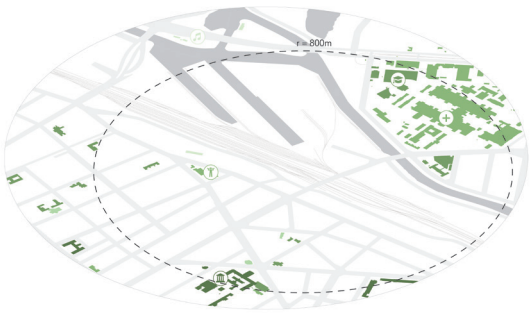
Commercial



Residential



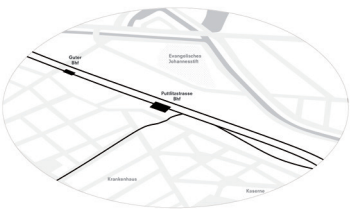
Industrial

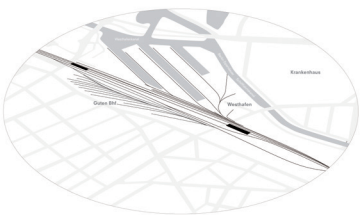


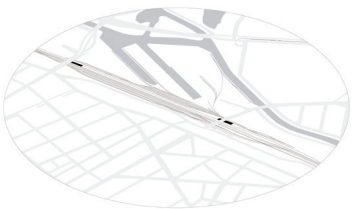
Civic

Site History

The site has a rich history as a former centreof a Protestant religious community. In the 20th century, it was relocated to make way for a harbour, which remains fully operational today. However, one basin has transitioned to accommodate office programs due to the outdated warehouses no longer meeting modern logistic requirements.







19th Century

Protestant institution

20th Century

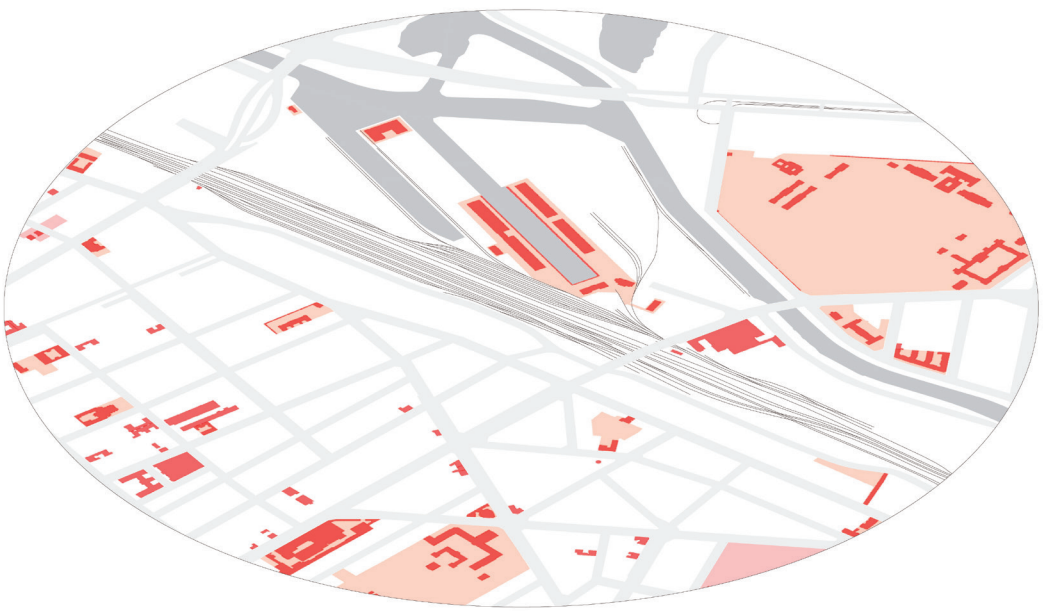
Industrial Port

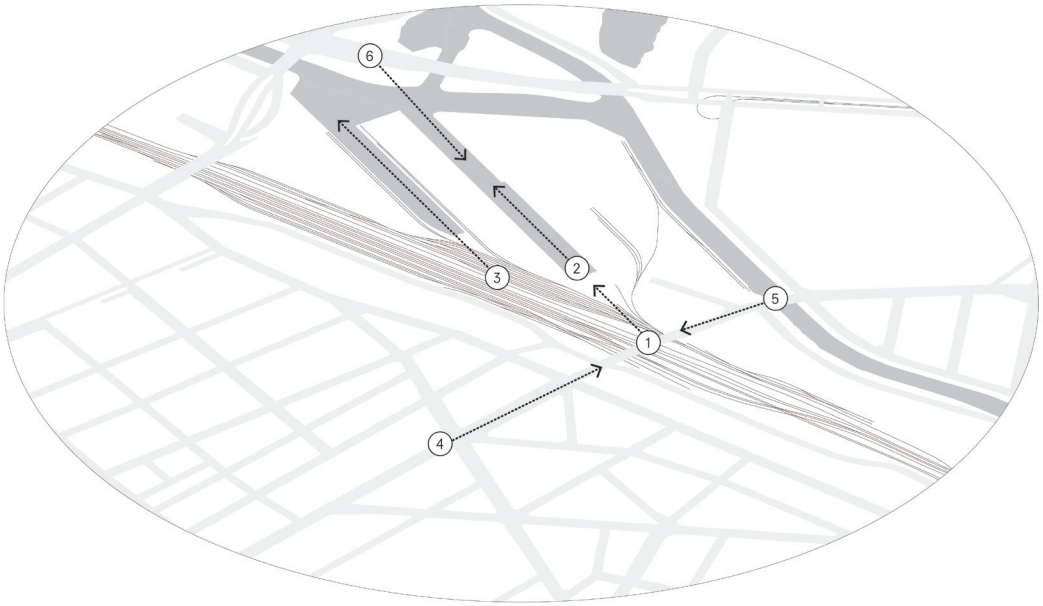
21st Century

Mixed-Used
Innovation District?

Protected Monument and Key Views

Due to its history, the site is filled with monumental buildings, providing the place with a distinct identity that should be cherished. Offering a contextual response is a crucial opportunity to showcase Westhafen to the public. As the station is also a landmark, key views into and from the building have been studied. The view of the existing port building with its iconic clocktower is particularly appealing.





INSIDE OUT

1

2

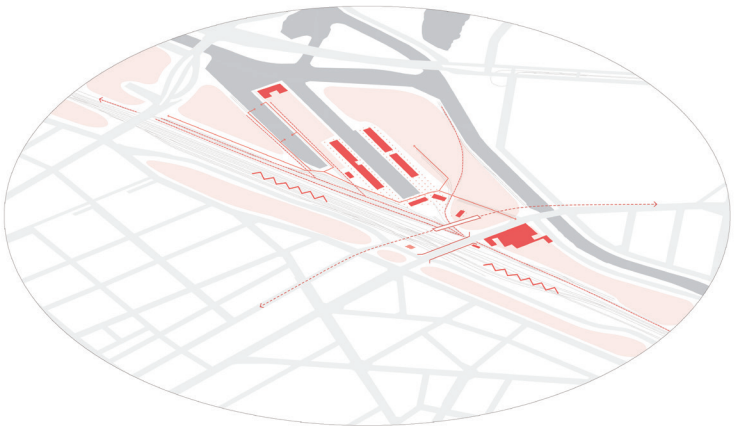
3

OUTSIDE IN

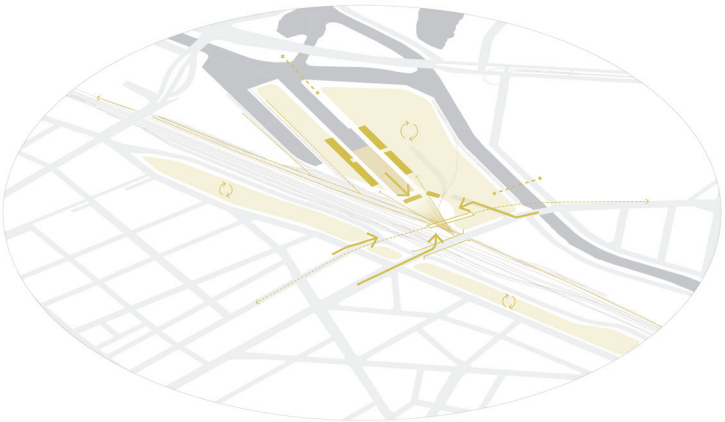
4

5

6



Protected Buildings
Protected Area
Industrial Area (in operation)
Logistic route (HGVs)
Freight yard (cargo trains)
Railway barrier
Traffic bridge
U-bahn route
U-bahn station
Energy Substation Railway



Monumental Buildings
Key view to historic clock tower
Potential Urban Development
Freight yard (cargo trains)
Traffic bridge
U-bahn route
U-bahn station
Potential Access Points
Potential Urban Connections
Water basin as square + Data Centre

Constraints and Opportunities Summary

The site analysis is summarized in a constraints and opportunities maps. The two primary constraints are the spatial barrier created by the rail between the city, tech development area, and Westhafen, and the continued dominance of heavy harbour logistics on the site. On the bright side, the two key opportunities lie in the station's potential to enhance urban connectivity through multiple access points and the potential for development of the harbour into a livable station area with a mixed-use program.

Site Ambitions Overview

Public Gateway Acces to Westhafen site

Overcome Urban Spatial Railway Line

Short distances between various modes of transport

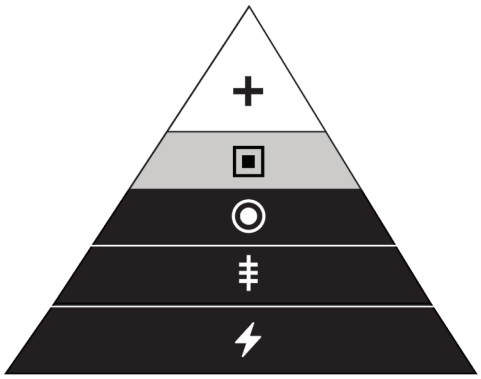
Main entrance easily seen at eye-level from far distance

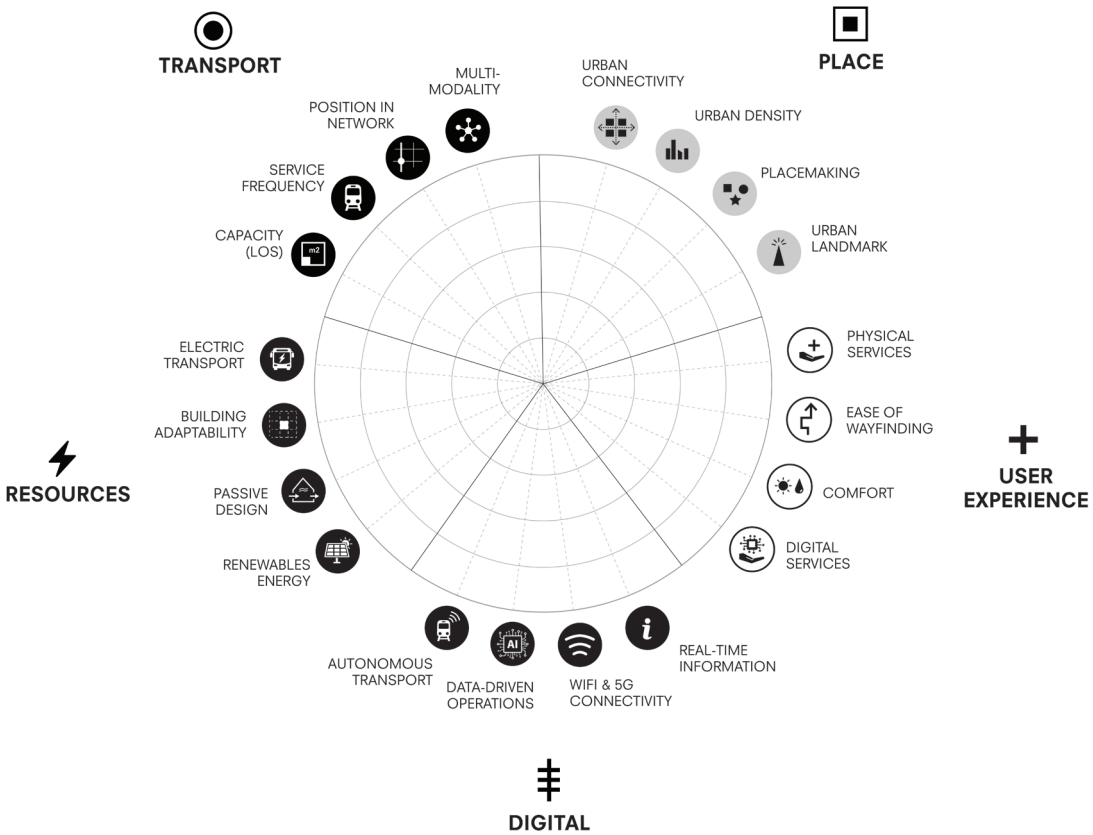

9B
8B

3.3 PROGRAM RESEARCH

Specific vs Generic

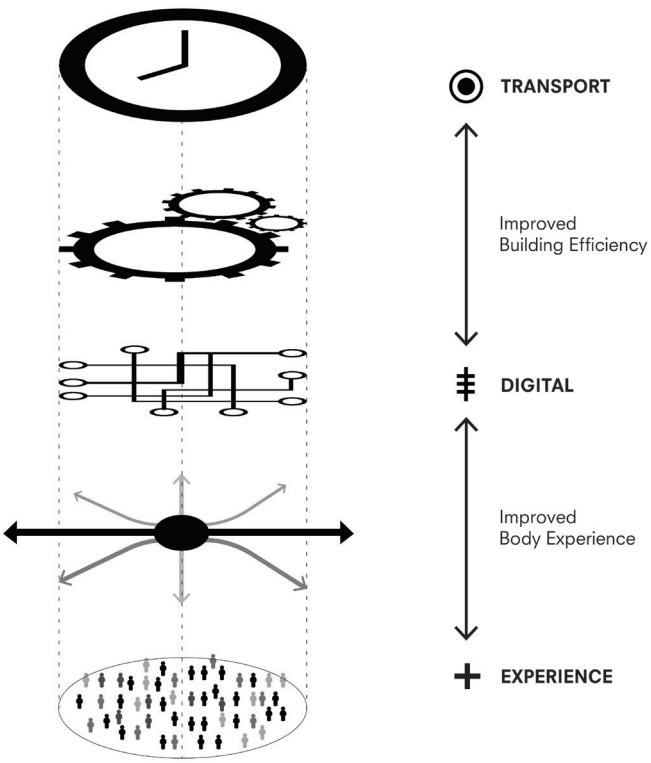
To gain a better understanding of which program aspects are essential for the building typology, the building's functionalities have been ranked in a pyramid based on dependency. Traditionally, an urban area cannot develop without being connected to a transport system, serving as the core functionality. Similarly, without an origin or destination in proximity to the station, there are no users for experiences such as commercial program associated with the train station. Therefore experience can be regarded as additional program.

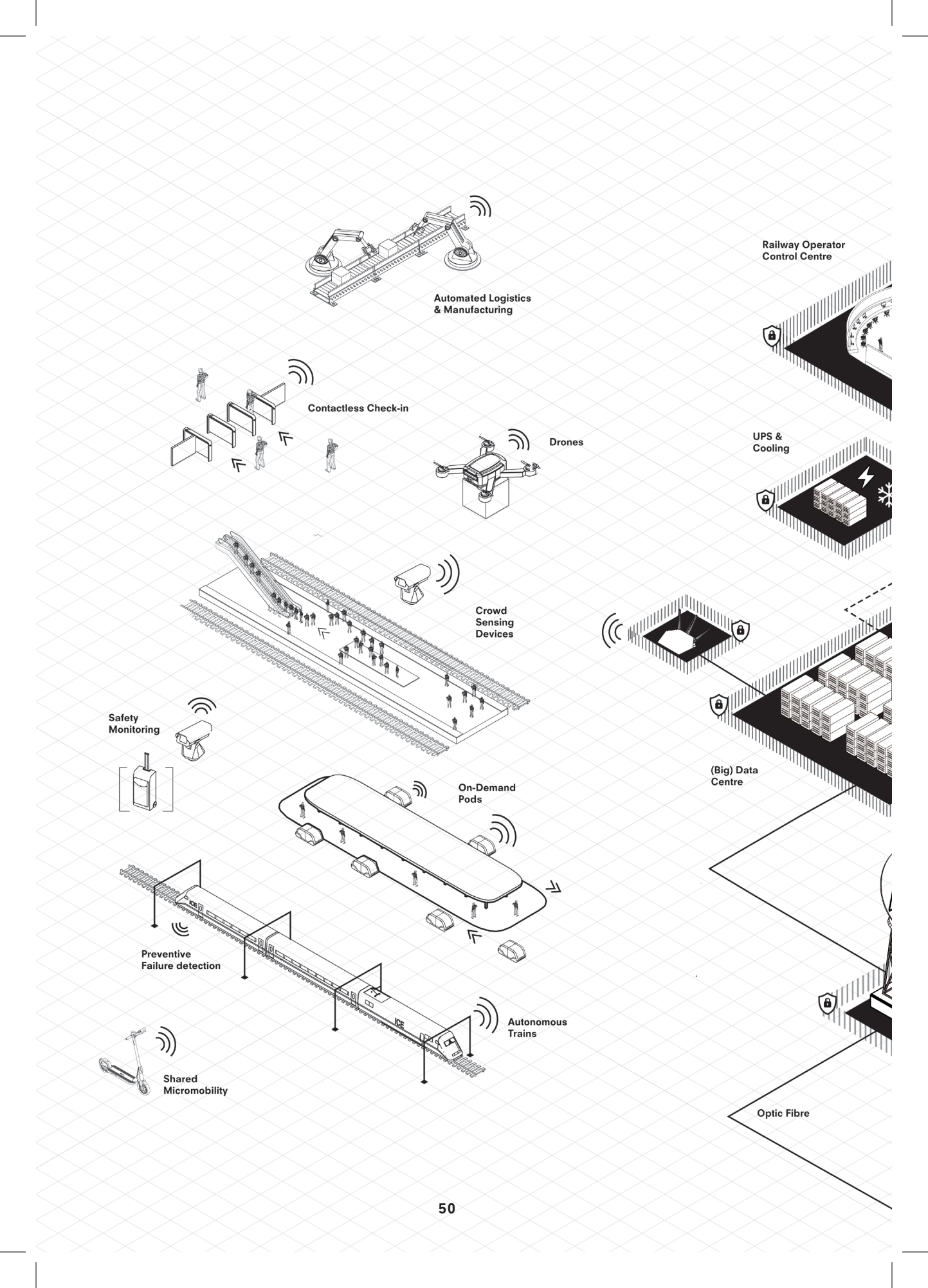


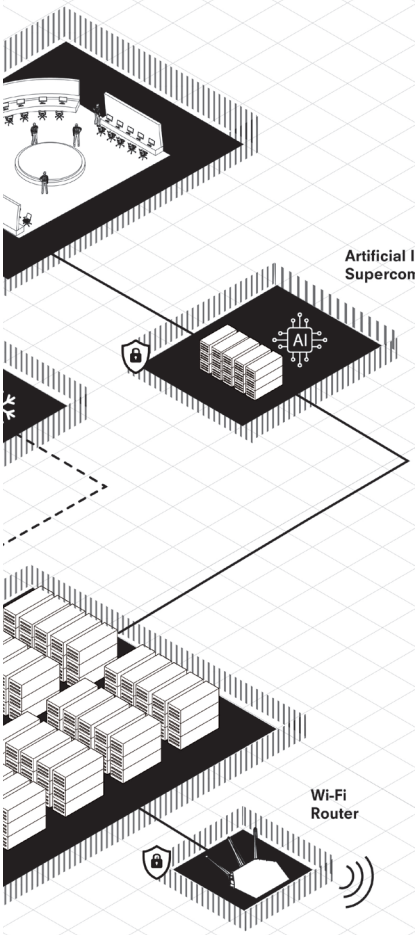


Digital Infrastructure is backbone of future train station

As a research hypothesis, the digital infrastructure is considered the backbone of the train station. This digital infrastructure enables the efficient flow of data to optimize both the building's transport efficiency and user experience. Information collected from users and connected devices is gathered in data centers, resulting in physical or digital responses. Furthermore, without resources such as an energy supply, there is no flow of data in digital format. Therefore, it will be crucial for the new station to have an uninterrupted power supply, potentially through energy batteries in case of a power failure.

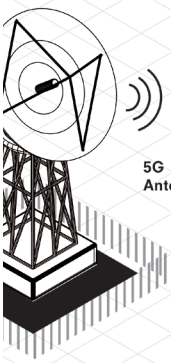



Automated Logistics
& Manufacturing
Railway Operator
Control Centre
Contactless Check-in
Drones
UPS &
Cooling
Crowd
Sensing
Devices
Safety
Monitoring
(Big) Data
Centre
On-Demand
Pods
Preventive
Failure detection
Autonomous
Trains
Shared
Micromobility
Optic Fibre

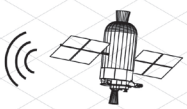


Artificial Intelligence
Supercomputer

Wi-Fi
Router



5G
Antenna

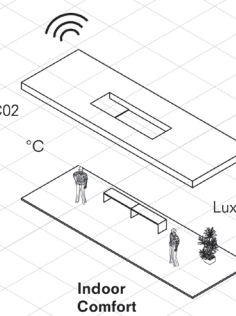


GPS Tracking

Delivery
Pick-up points

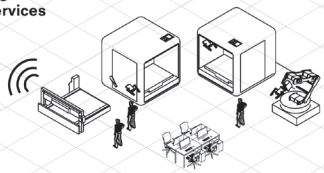
Smart Ticketing &
Self-Service

High-Speed
Connectivity

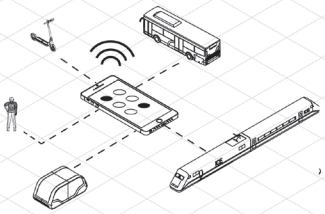


Indoor
Comfort

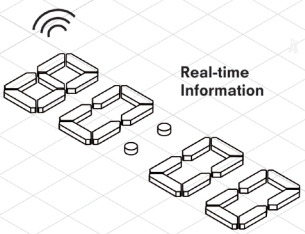
Digital
Services



Digital Infotainment /
Wayfinfing



MaaS



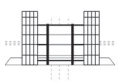
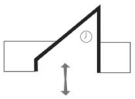
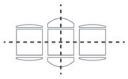
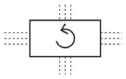
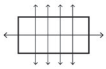
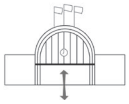
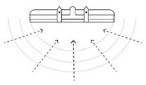
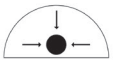
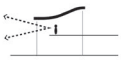
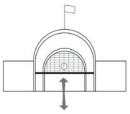
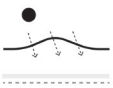
Real-time
Information

Station Database

Data can also have an impact on the design of a train station during the design process by constructing a knowledge base to predict program requirements. A total of 16 station case studies have been studied across Germany, the Netherlands, and internationally. These buildings serve as benchmarks, illustrating how digitalization can transform them. The programmatic division, user flows, typology, and transport capacities have all been thoroughly examined to gain a deep understanding for setting up the design brief.

Key Building Concepts

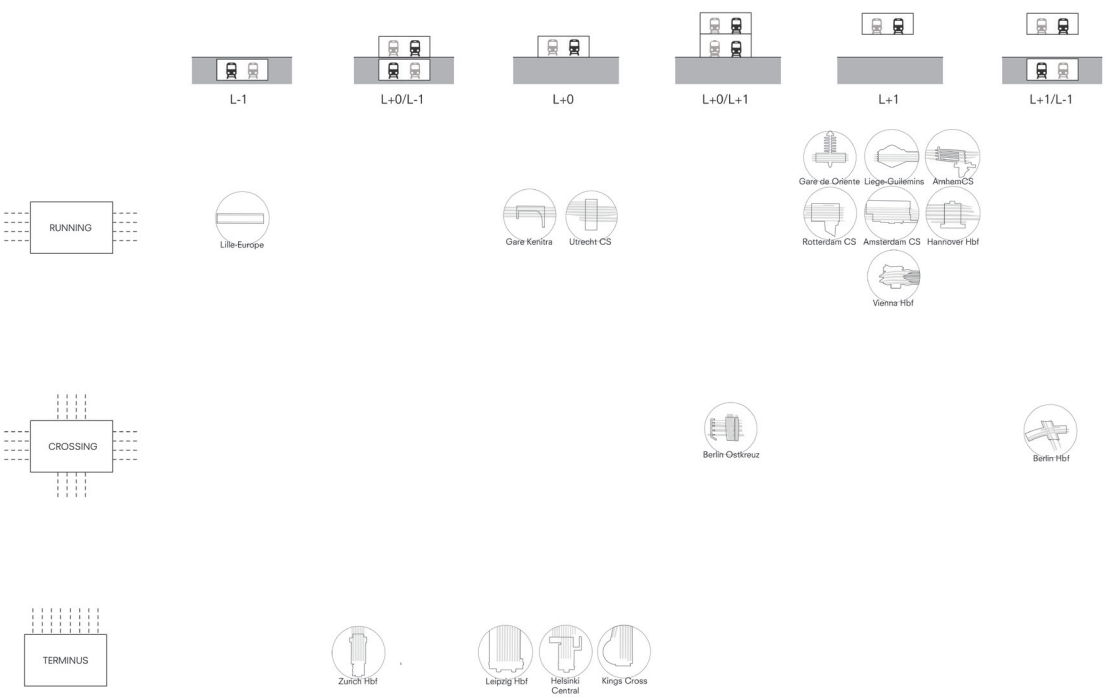
Each case study station has its own key concept, embodying distinct qualities that characterize the building. While some stations prioritize pure transport efficiency, others are strongly connected with the city and serve as a place. The architecture often reflects the ambitions of the clients and the era in which it was built. Common concepts include the station as a gateway, symmetry, and transparency. These softer qualities can also be incorporated into the design brief.

GERMAN	DUTCH	INTERNATIONAL CENTRAL	INTERNATIONAL HIGH SPEED
 BERLIN HBF	 ROTTERDAM CS	 VIENNA HBF	 GARE DO ORIENTE
 BERLIN OSTKREUZ	 UTRECHT CS	 ZURICH HBF	 GARE KENITRA
 LEIPZIG HBF	 AMSTERDAM CS	 LONDON KINGS CROSS	 GARE LILLE-EUROPE
 HANNOVER HBF	 ARNHEM CS	 HELSINKI CENTRAL	 LIEGE-GUILLEMINS

GERMAN	DUTCH	INTERNATIONAL CENTRAL	INTERNATIONAL HIGH SPEED
 BERLIN HBF	 ROTTERDAM CS	 VIENNA HBF	 GARE DO ORIENTE
 BERLIN OSTKREUZ	 UTRECHT CS	 ZURICH HBF	 GARE KENITRA
 LEIPZIG HBF	 AMSTERDAM CS	 LONDON KINGS CROSS	 GARE LILLE-EUROPE
 HANNOVER HBF	 ARNHEM CS	 HELSINKI CENTRAL	 LIEGE-GUILLEMINS

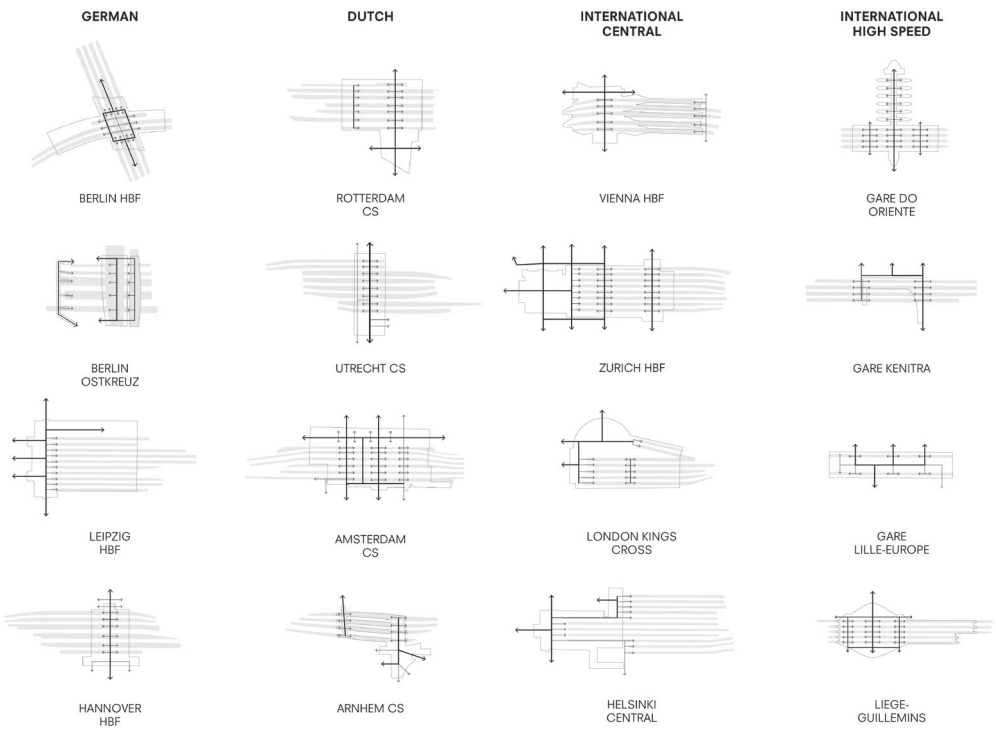
Typology

Stations can be categorized based on track configuration. The most common type is a running track station with the rails on level +1, and a passage on +0, creating minimal spatial barriers for pedestrians from the urban surroundings. Following this is the terminus station on L+0, which occupies a significant space and limits the flow, often found in central stations. Another type is the running station with tracks on L+1, where the passage can either be above or below the rails. The typology of the new train station heavily depends on the existing situation as altering the placement of tracks is costly. Additionally, during the construction of the station, the railway system must remain in full operation.



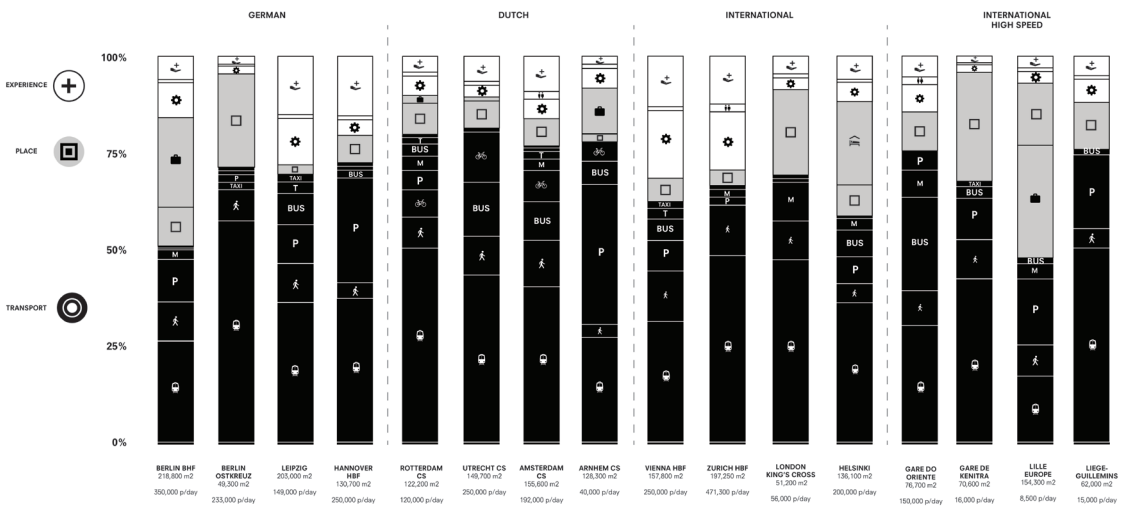
User Flows

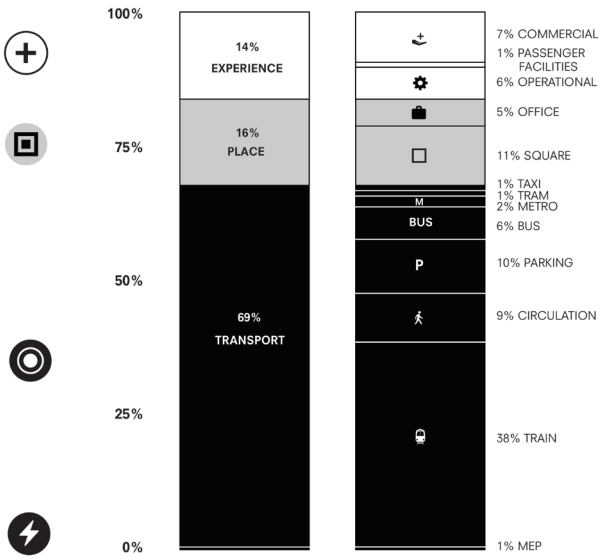
Analysing user flows reveals that the routing is straightforward for wayfinding, offering a direct route from the main entrance to the train platform with a maximum of two turns. The station should be accessible from both sides of the track. A simple and concise wayfinding approach helps enhance flow efficiency and the overall experience. Some stations have more than one passage connected to the platform to facilitate quicker transfers and an even distribution across the platform area, linking to at least two main entrances.

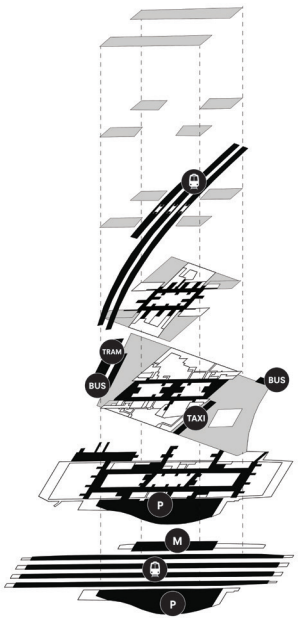


Programmatic Division

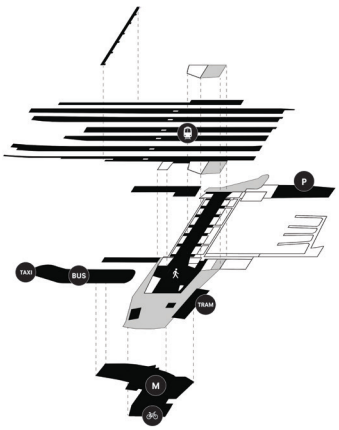
The programmatic division of all studies has been outlined. Based on the program framework, the main classifications are Transport (black and generic), Place (grey and semi-generic), and Experience (white and specific). Data indicates that the transport program is the most dominant, constituting around 69% of the total GFA. Place is primarily represented by the station square, with the inclusion of office space to attract more local activity throughout the day. Experience is mainly characterised by commercial programs involving retail and food & drinks. The case study examples of Berlin Hbf, Vienna Hbf, and Rotterdam CS illustrate how stations revolve around circulation between various modes of transport, including buses, metro, parking, etc.



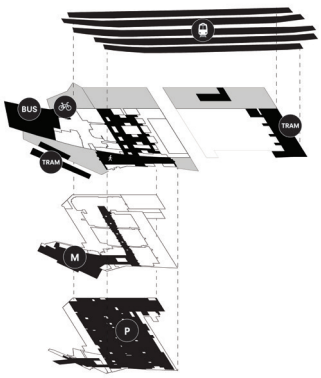




Berlin Hbf



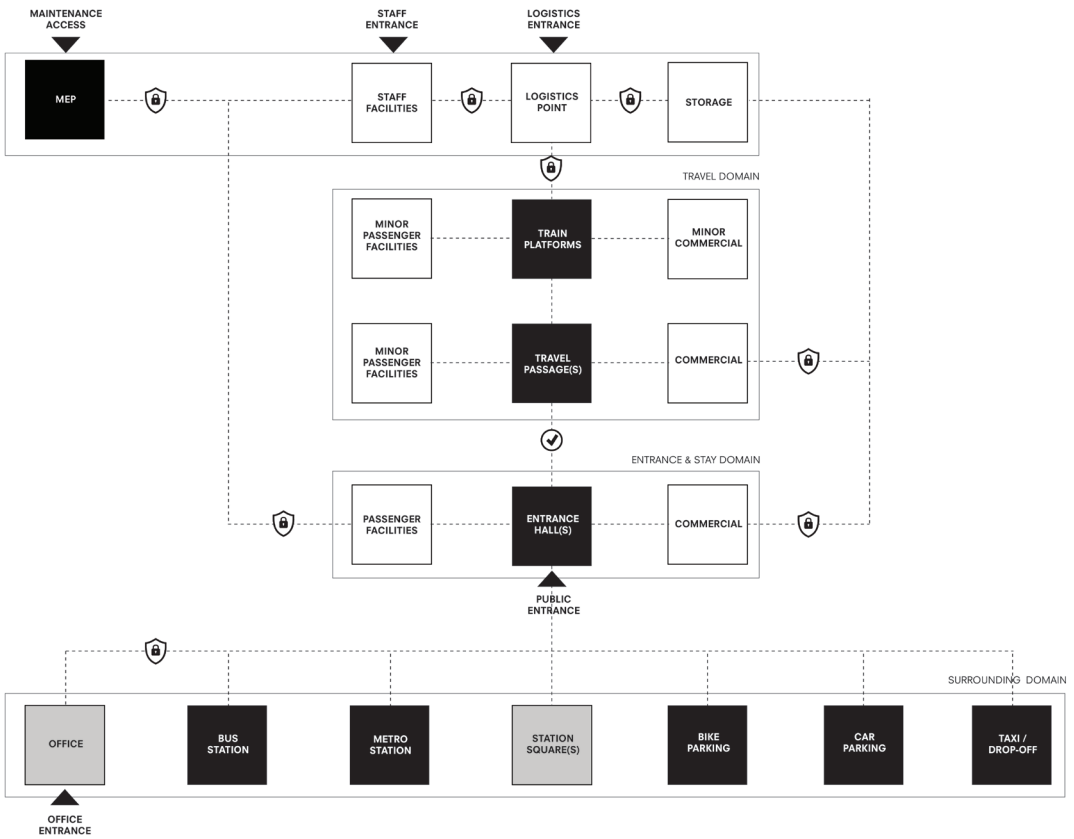
Vienna Hbf



Rotterdam CS

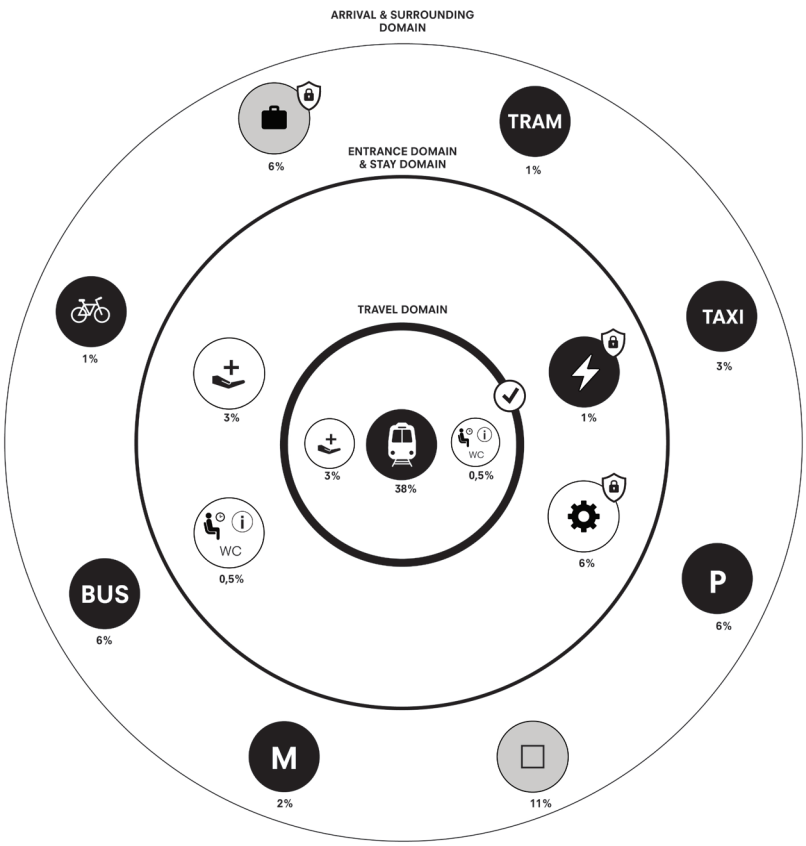
Relation Scheme

A traditional relation scheme diagram has been created by studying spatial connections between the main spaces in the building. Typically, the primary sequence of spaces is from the station square to the entrance hall, then to the passage, and finally to the platform for boarding the train. Some programmatic elements are situated behind the scenes and are not accessible to the public, being secured. The station staff and logistics personnel have their separate entrance.



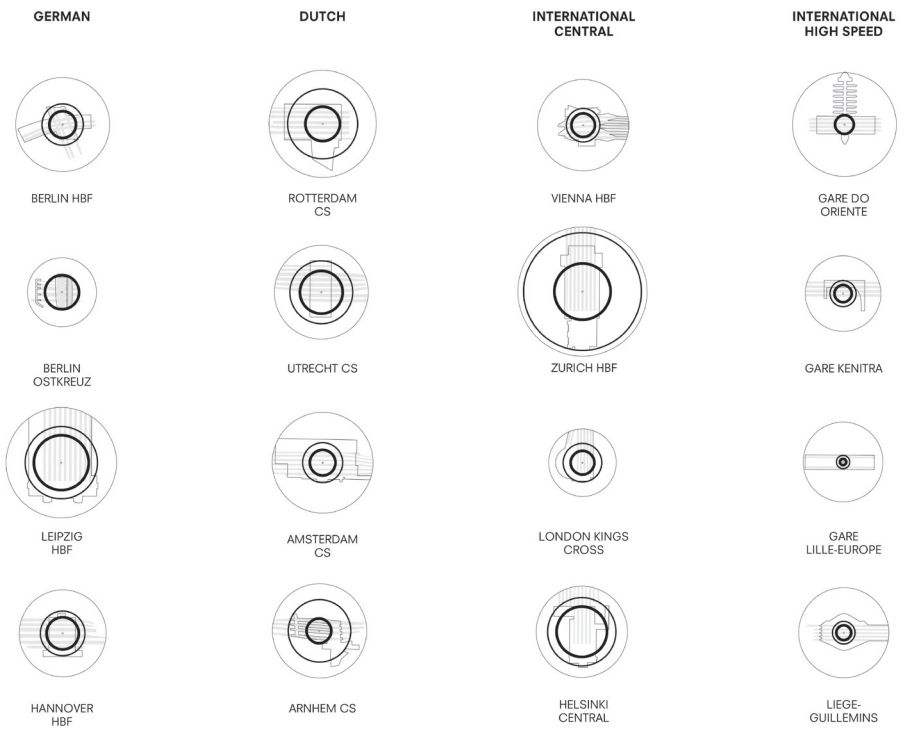
Domains

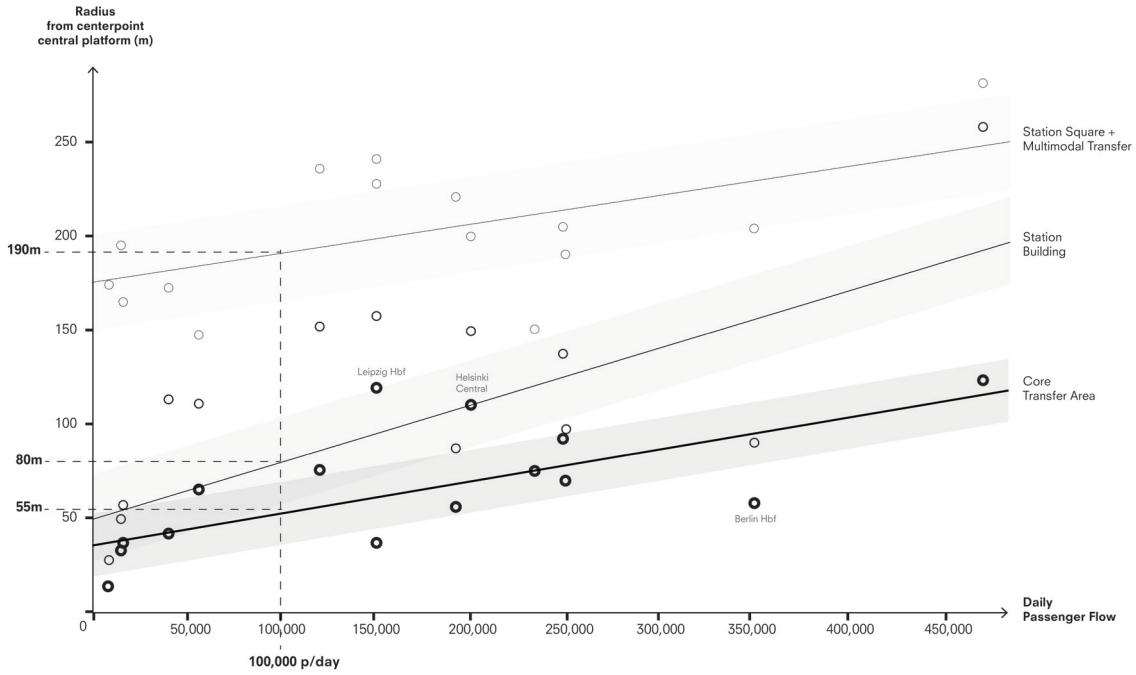
The station can be viewed as a union with functional layers. At the core, there is a travel domain for the train platform and passage, along with minor commercial and passenger facilities for waiting passengers. Then there is the stay and entrance domain with additional services and commercial, including the necessary operational components. Beyond the public entrance hall, there is the surrounding and arrival domain where the square is located, providing access to other modes of transport such as buses.



Domain ranges

The extents of these functional layers were examined for the case study station to comprehend their correlation with the daily passenger flow. The outcome indicates that the larger the station, the greater the range; however, the proportion between the layers remains relatively constant. Particularly, international high-speed train stations exhibit a noticeable compact building compared to the size of the station square and connections to other modes.

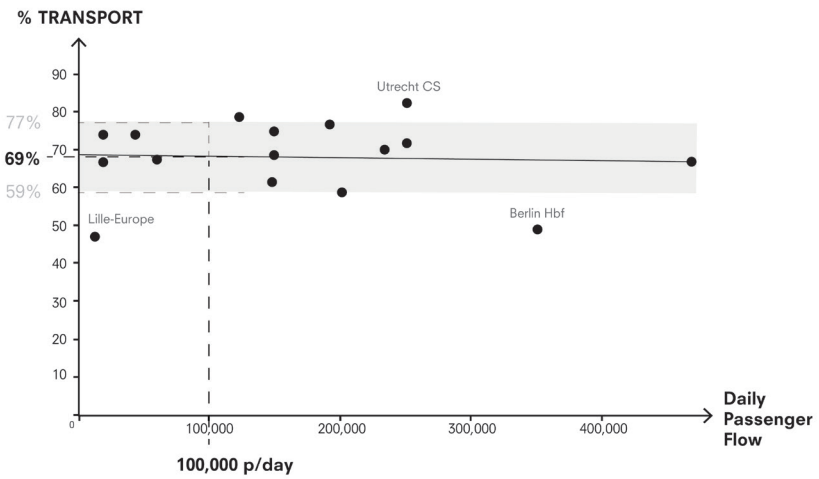


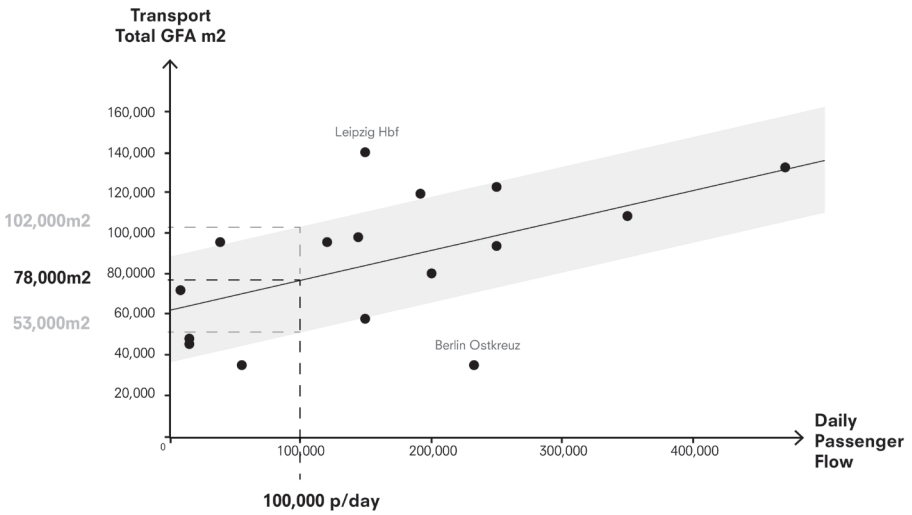

Radius
from centerpoint
central platform (m)
250
200
190m
150
100
80m
55m
50
0
50,000
100,000
150,000
200,000
250,000
300,000
350,000
400,000
450,000
100,000 p/day
Daily
Passenger Flow
Station Square +
Multimodal Transfer
Station
Building
Core
Transfer Area
Leipzig Hbf
Helsinki
Central
Berlin Hbf

Transport Capacity

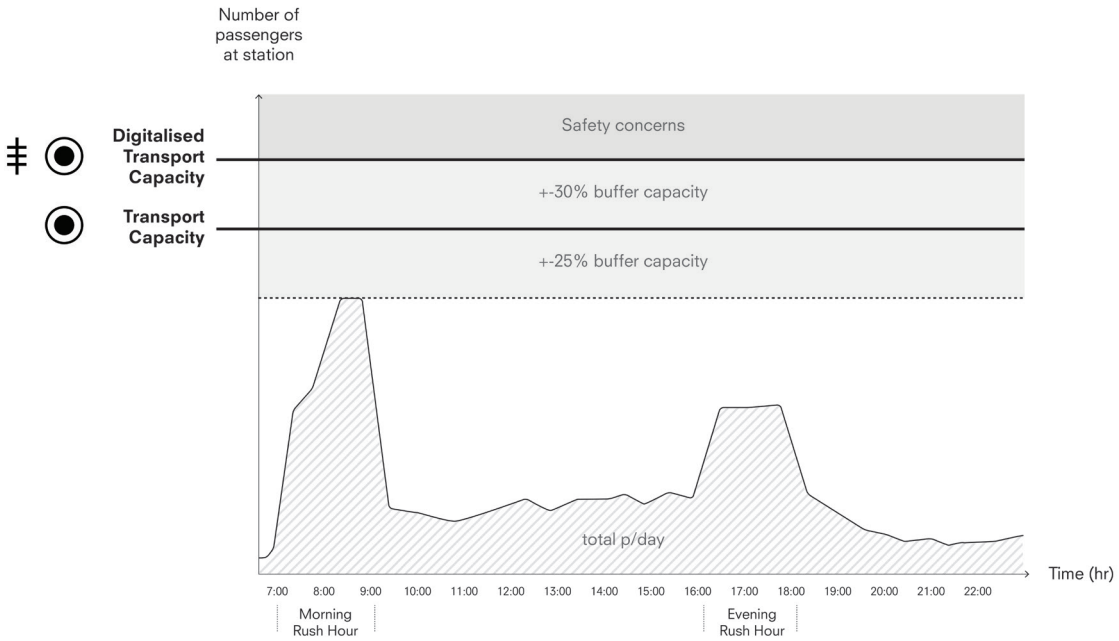
Similar to the domain ranges, the volume of the transport program GFA is also proportionate to the daily passenger flow. Knowing the predicted daily passenger volume enables the prediction of the required transport area, maintaining a similar capacity in terms of square meters per person to ensure efficient flow and reduce overcrowding. Regardless of the station building's size, the transport program predominantly represents between 59% and 77% of the total GFA.

The transport capacity is directly proportional to the daily passenger flow, but the primary purpose of this capacity is to accommodate the demand during rush hour peak flows. Sufficient capacity should be calculated, including a 25% buffer, to prevent overcrowding and obstructions. Safety and reliability of the transport network are fundamentally crucial. With the increasing pressure on existing stations to expand due to growing passenger flows and spatial constraints, digitisation can enhance capacity





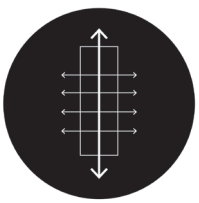
by adding around 30%. Digitisation of the infrastructure results in more punctual and optimised timetabling. At the station, it aids in crowd control, addressing the common issue of delays often caused during the boarding of trains.



Program Ambitions

Building size proportional to daily passenger (peak) flow

Transport is core functionality



Simplicity is key for Wayfinding

Digital infrastructure to improve transport efficiency and user experience

DESIGN BRIEF

04

Project Ambition

The design brief is the result of a thorough analysis of the client, site, and program, translating a set of ambitions into design requirements. The proposed new station, situated in Berlin's Westhafen with a total area of approximately 113,000m², aims to be a comprehensive facility, integrating a data centre. The primary clients, including the Ministry of Digital and Transport, the main funder, and Deutsche Bahn, the German railway operator and owner of the station building, align with the ambition to construct a future-proof digital and transport node serving as the urban anchor.

Westhafen is selected as the most suitable site, meeting the client's criteria. The main ambitions involve creating a future innovation district in Westhafen, transforming the flow of people, goods, and data to enhance transport efficiency and experience. The building must also be adaptable to future rush hour scenarios. Located in the Moabit district, Westhafen lies between the city centre and a tech development on the outskirts, attracting local commuters, tech workers, and TU Berlin students who can benefit from digital accessibility, contributing to the acceleration of digital innovation.

WHAT?

Train station with
integrated data centre

Total GFA 113,000 m2

WHERE?

Berlin Westhafen

FOR WHO?

Federal Ministry of Digital and
Transport

Deutsche Bahn

Local daily commuter

Tech worker and student

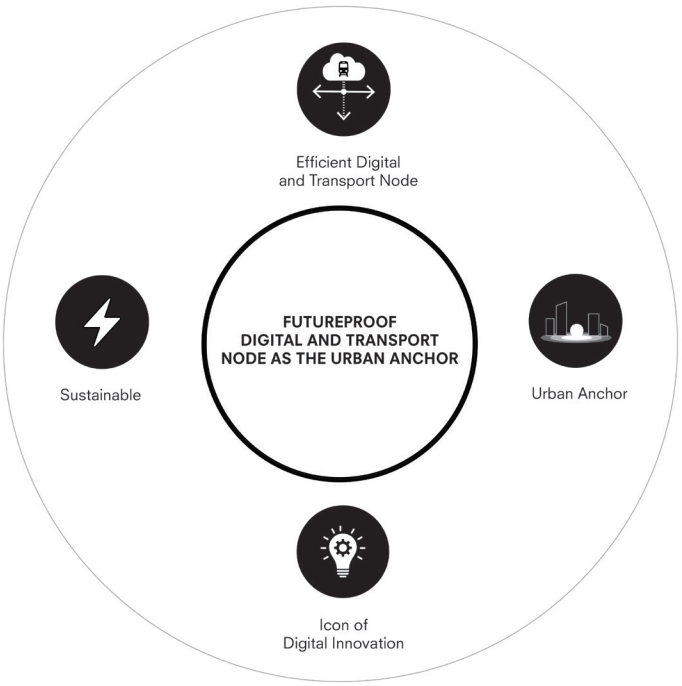
Operational staff

Berliner

4.1 CLIENT REQUIREMENTS

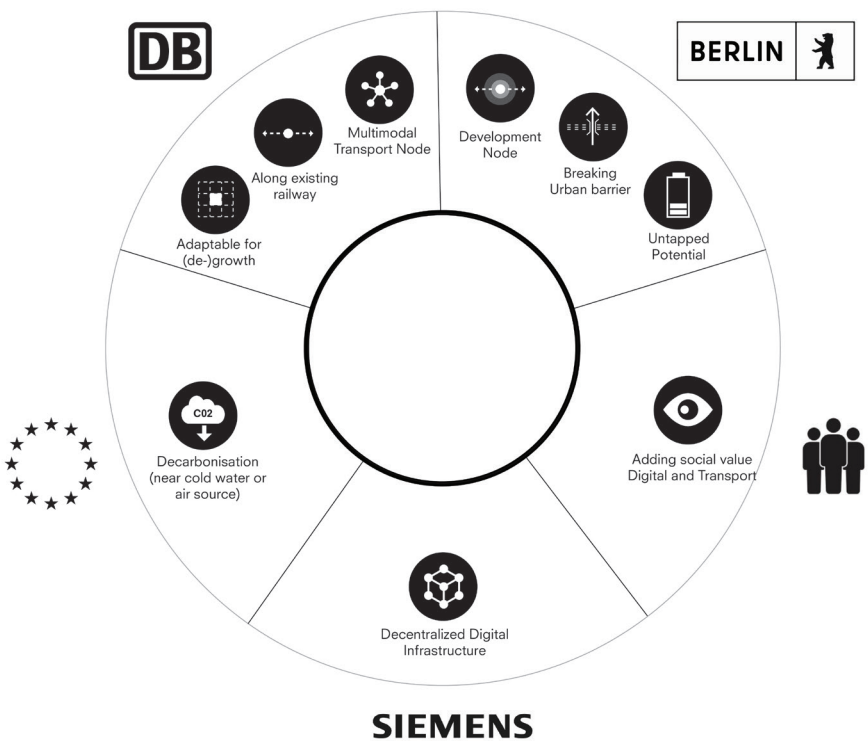
Future Digital and Transport Node

The diverse client ambitions have been aligned and formulated into a concrete project ambition: a Future-proof digital and transport node as the urban anchor. The primary focus is on delivering highly efficient transport with data integration, creating conditions for redeveloping the surrounding area into an innovative hotspot. Additionally, there is a requirement for environmental sustainability and serving as a representation of a digital icon—a sign of modernity for Germany and its infrastructure.



Site Selection Requirement

Each involved client has distinct site selection criteria determining the ideal location for the building. While Deutsche Bahn prioritizes station typology, considering factors like proximity to existing rail and multimodal transportation, Berlin's ambition is to establish a development node, seeking a location with untapped potential.



4.2 PROGRAM REQUIREMENTS

Transport Capacity

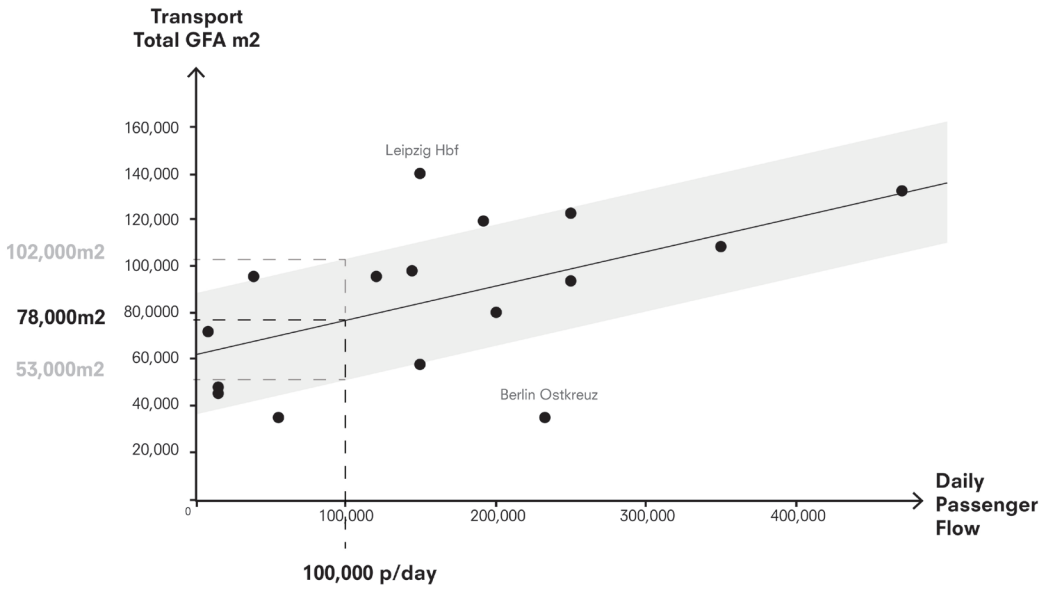
As found out in the program research, a station is mainly based on its core functionality transport which is proportional to the daily passnger flow and peak rush hour demand to avoit overcrowding and unsafe situations. There for the total transport capacity is based on the guesstimated prognosed future capacity of 100,000 people/day in 2050. Base on this, the total area for transport should be around 78,000m2.

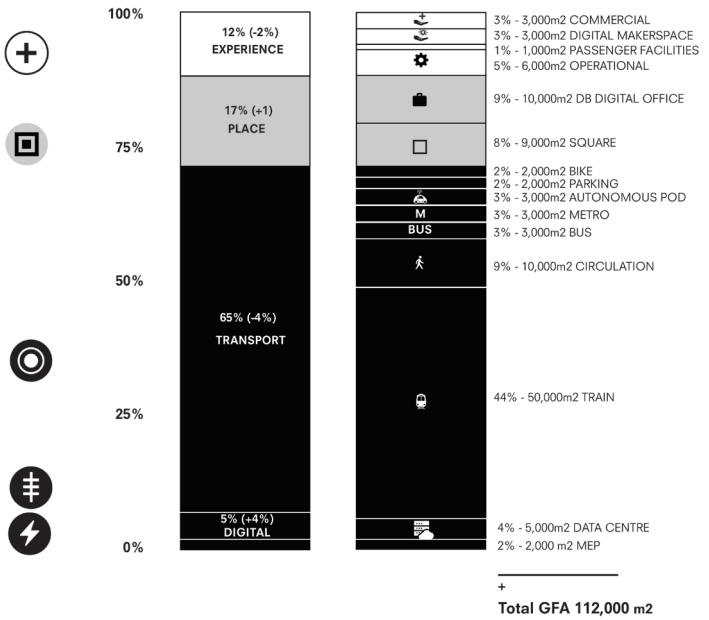
Programmatic Division

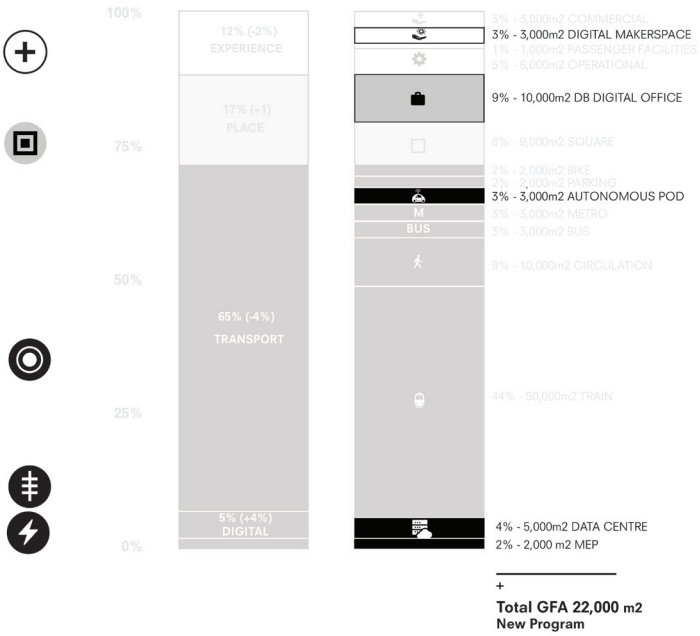
By determining the transport capacity requirement, other programs can be added proportionally based on benchmarking studies and the lens of digitalisation. A total GFA of 113,000m² is proposed, aligning with the digitally oriented client's ambition, where a new program is proposed for each functional category.

The primary impact of digitalisation involves adding a 5,000m² data centre, recognizing digital infrastructure as the backbone of the future train station. A 3,000m² autonomous pods station will be incorporated as a new and highly efficient form of autonomous transport, depending on data. A 1,000m² energy battery is proposed for an uninterrupted energy supply to the data centre and station operations. A DB digital office of 10,000m² has been added as a statement of urban redevelopment, attracting the first wave of investors.

In terms of user experience, a 3,000m² digital makerspace bridges the gap between the public and private tech sectors to accelerate innovation. Therefore, the station will also be a pleasant place to stay.

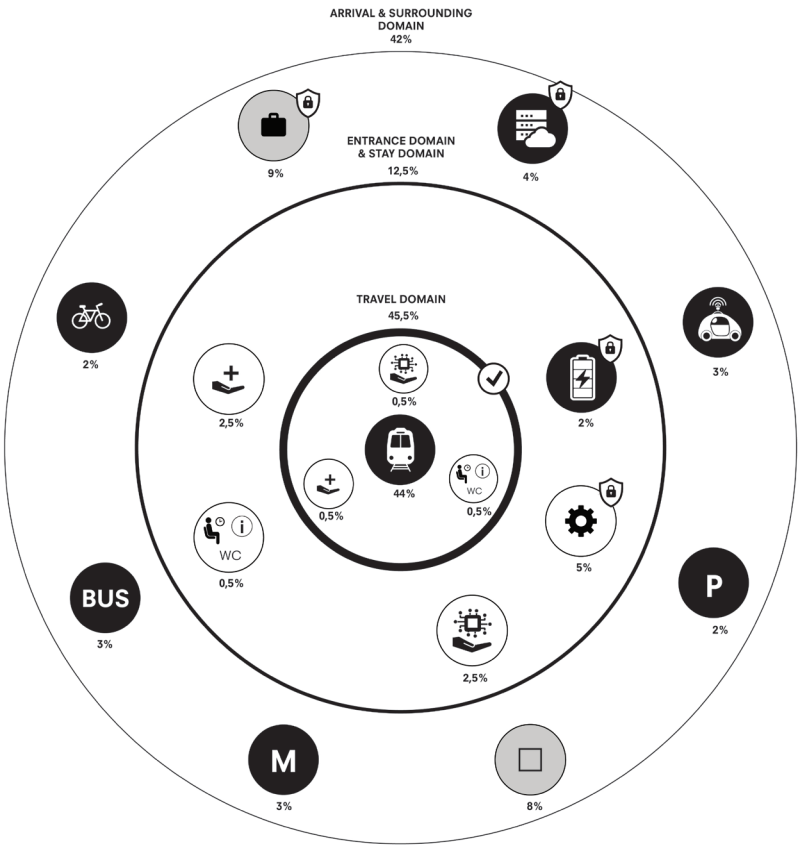



100%
75%
50%
25%
0%
12% (-2%)
EXPERIENCE
17% (+1)
PLACE
65% (-4%)
TRANSPORT
5% (+4%)
DIGITAL
3% - 3,000m2 COMMERCIAL
3% - 3,000m2 DIGITAL MAKERSPACE
1% - 1,000m2 PASSENGER FACILITIES
5% - 6,000m2 OPERATIONAL
9% - 10,000m2 DB DIGITAL OFFICE
8% - 9,000m2 SQUARE
2% - 2,000m2 BIKE
2% - 2,000m2 PARKING
3% - 3,000m2 AUTONOMOUS POD
M
3% - 3,000m2 METRO
BUS
3% - 3,000m2 BUS
9% - 10,000m2 CIRCULATION
44% - 50,000m2 TRAIN
4% - 5,000m2 DATA CENTRE
2% - 2,000 m2 MEP
+
Total GFA 112,000 m2


100%
75%
50%
25%
0%
12% (-2%)
EXPERIENCE
17% (+1)
PLACE
65% (-4%)
TRANSPORT
5% (+4%)
DIGITAL
3% - 3,000m2 DIGITAL MAKERSPACE
9% - 10,000m2 DB DIGITAL OFFICE
3% - 3,000m2 AUTONOMOUS POD
4% - 5,000m2 DATA CENTRE
2% - 2,000 m2 MEP
+
Total GFA 22,000 m2
New Program

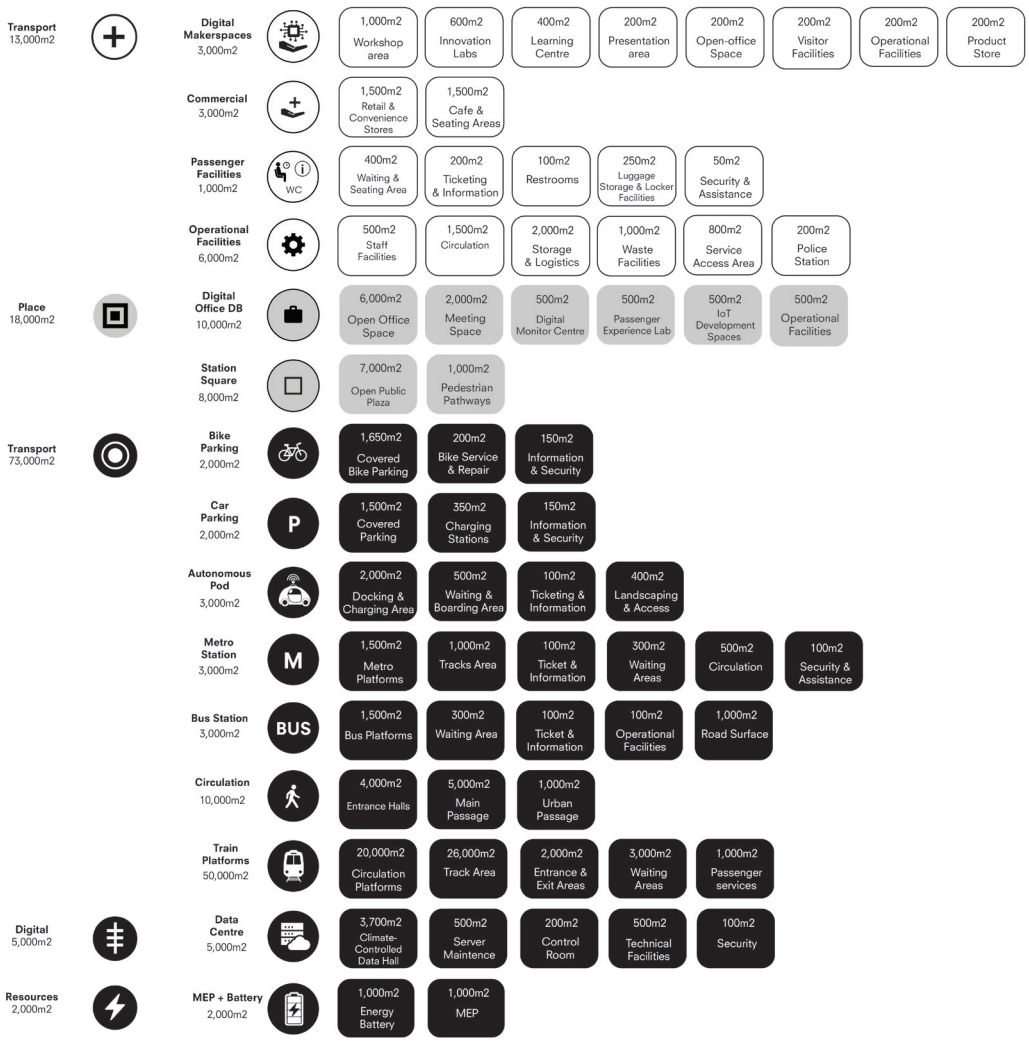
Domains

Based on benchmarking a database of other stations, the programmatic elements should be situated within three main domains: 1. the travel domain, including the train platforms and passage; 2. the entrance and stay domain for main passenger facilities and commercial spaces; and 3. the surrounding and arrival domain, where the square and other modes of transport are located. The maximum radii to reach these domains, taken from the centerline of the middle train platform, are based on the case studies. They are, respectively, 70m, 105m, and 205m.



Program Specifics

The proposed program can be further specified into sub-programmatic spatial requirements. For instance, the 2,000m² bike parking area necessitates space for double-stacked covered bicycle racks, circulation space, and a bike repair/rental service.

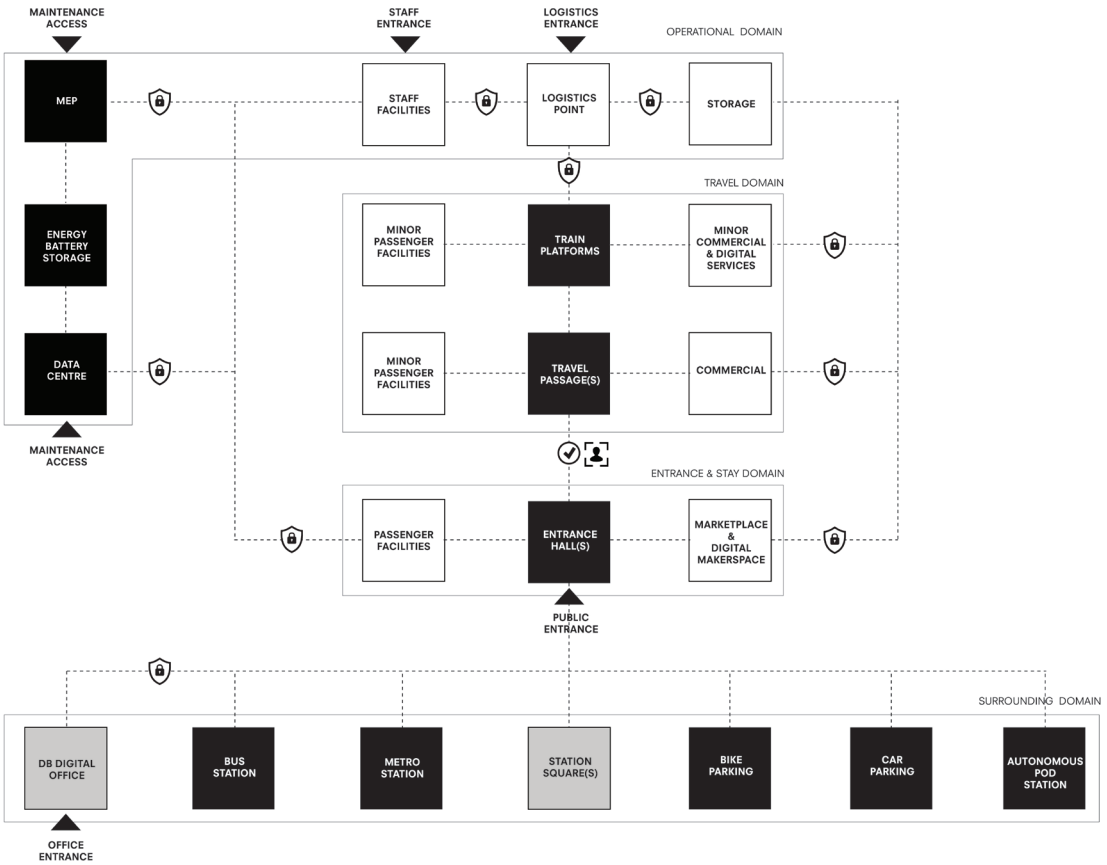


Relation Scheme

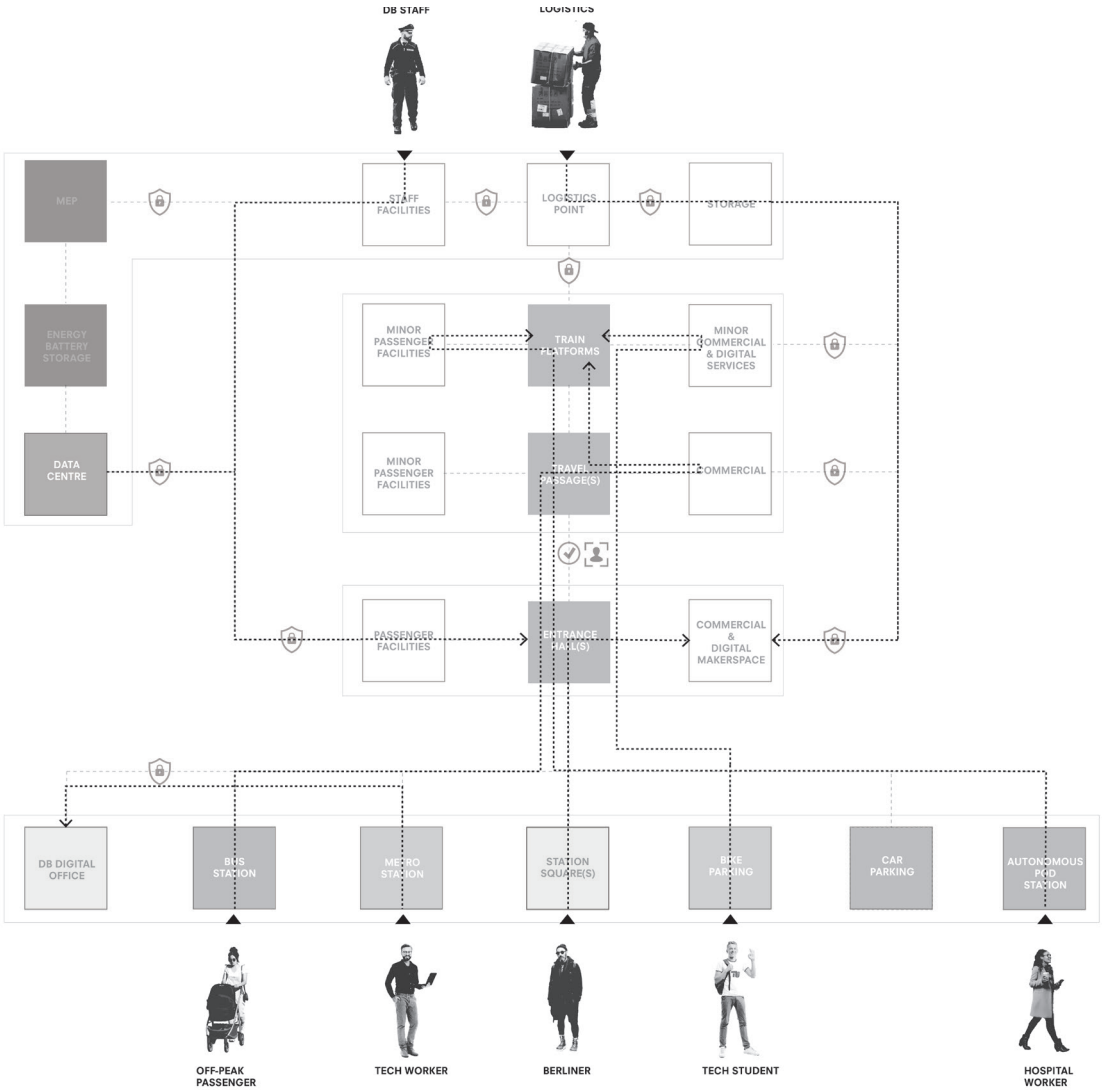
The relationship between programmatic elements primarily relies on benchmarking traditional stations, with minor modifications made by incorporating additional digital-oriented programs. The Data Centre and battery storage are positioned in the back-of-house area with high security. The autonomous pod station and office are situated in the surrounding domain. The Makerspace is in a public area next to the entrance hall and connected to the building's back-of-house logistics.

Users

The users encompass both generic and specific groups, including DB staff, logistics workers, regular commuters, tech workers, and students, influenced by the site context. The station caters to a diverse range of individuals, such as international business travellers, families, and local Berliners, especially during off-peak hours. Each user has distinct travel patterns and navigates through the building based on their purpose and needs.

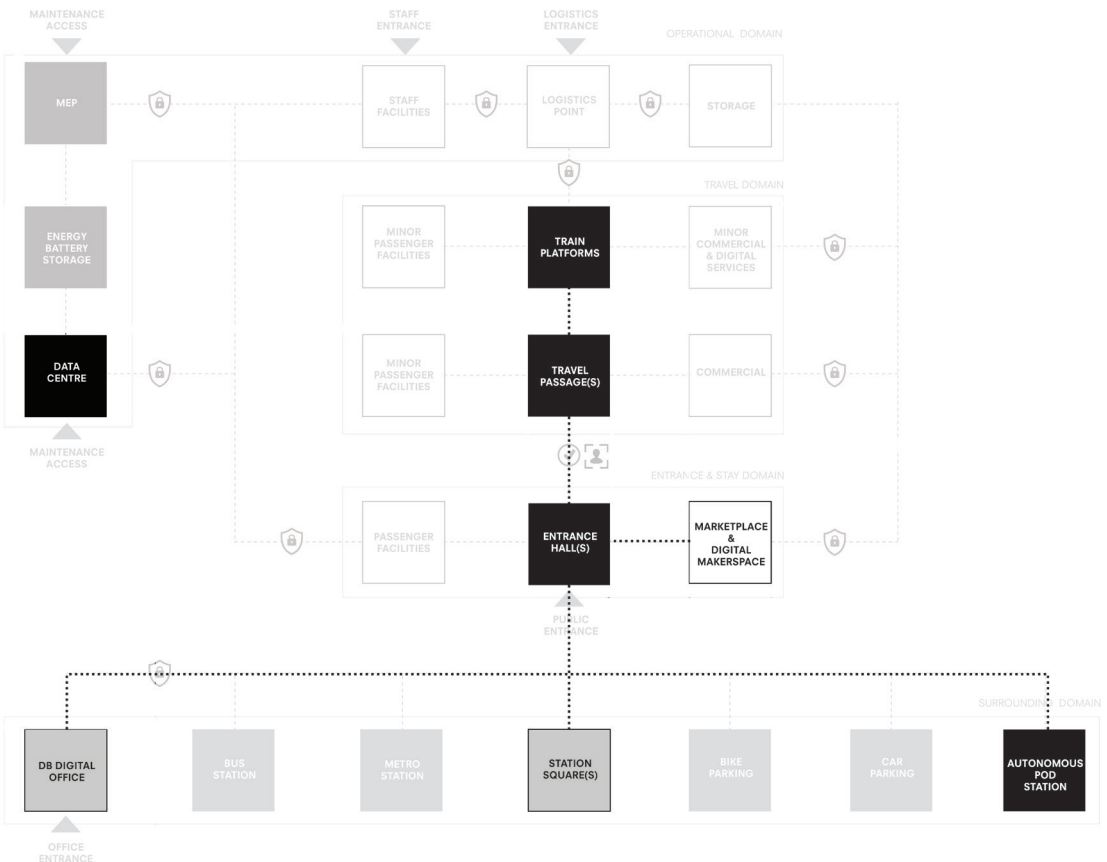



TRAIN STATION STAFF
RUSH HOUR PASSENGERS
OFF-PEAK PASSENGERS
NON-PASSENGERS
BACK OF HOUSE STAFF
FRONT OF HOUSE STAFF
HOSPITAL WORKER
TECH WORKER
TECH STUDENT
INTERNATIONAL BUSINESS
FAMILIES
BERLINER


DB STAFF
LOGISTICS
MEP
STAFF FACILITIES
LOGISTICS POINT
STORAGE
ENERGY BATTERY STORAGE
MINOR PASSENGER FACILITIES
TRAIN PLATFORMS
MINOR COMMERCIAL & DIGITAL SERVICES
DATA CENTRE
MINOR PASSENGER FACILITIES
TRAVELLER PASSAGE(S)
COMMERCIAL
PASSENGER FACILITIES
ENTRANCE HALL(S)
COMMERCIAL & DIGITAL MAKERSPACE
DB DIGITAL OFFICE
BUS STATION
METRO STATION
STATION SQUARE(S)
BIKE PARKING
CAR PARKING
AUTONOMOUS POD STATION
OFF-PEAK PASSENGER
TECH WORKER
BERLINER
TECH STUDENT
HOSPITAL WORKER

Key Spaces

The design brief encompasses key spaces that require further explanation and supporting guidelines. Traditional key areas include the square, entrance hall, passage, and train platform. Additional programs, such as the data centre, autonomous pods station, DB digital office, and digital makerspace, will be elaborated upon, along with providing atmospheric impressions.



Data Centre

The Data Centre serves as the brain of the station's digital infrastructure. In addition to storing data on racks, it houses an artificial intelligence supercomputer that processes big data into valuable information and provides automated feedback to devices. Ensuring an uninterrupted power supply, the data centre is connected to an energy battery. Releasing a significant amount of excess heat, the data centre requires technical cooling equipment and is strategically placed near water for natural cooling. Due to its sensitivity, the infrastructure demands robust security measures. Furthermore, the client aspires to enhance data awareness and add public value to traditionally black boxes.

Spatial requirements

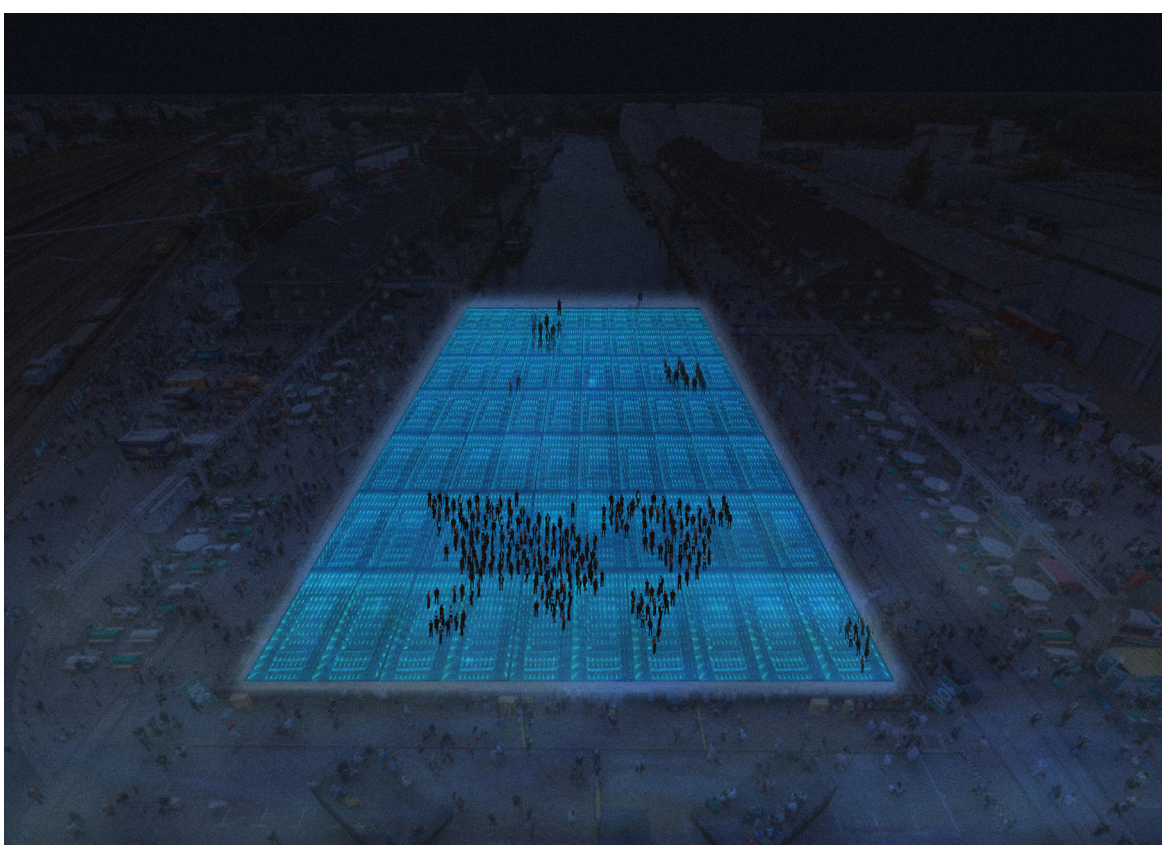
- Hot Isle width > 1.2m
- Hot Isle width > 0.7m
- Clear Height > 3.5m
- Rack size = 0.6x1.2x(multiple of 0.42)
- Total GFA 5,000m2

Additional Requirements

- Public Value
- Well Secured
- Visible element of building

Adjacency

- Energy Battery Storage
- MEP
- Staff facilities
- Security Room



Train Platform

The train platform is considered the focal point of the transport node, serving as the central hub where passengers and goods embark and disembark from trains. During rush hour, this platform becomes the most critical space, facing a high influx of people. Hence, there are a total of 10 platforms (5 islands) planned to accommodate a future daily passenger load of 100,000. The services offered range from local (Siemensbahn) to potentially international, with flexibility to interchange services throughout the day.
Dimensional requirements are determined through benchmarking case studies and analyzing the Level of Service, considering the amount of square meters needed per passenger to facilitate efficient flow through the space and prevent congestion.

Spatial Requirements

- Number of platforms = 10 (5 islands)
- Platform length >420m
- Platform Width >10m
- Clear Height below passage > 6m
- Total GFA 50,000m2 (incl. tracks)

Platform Service

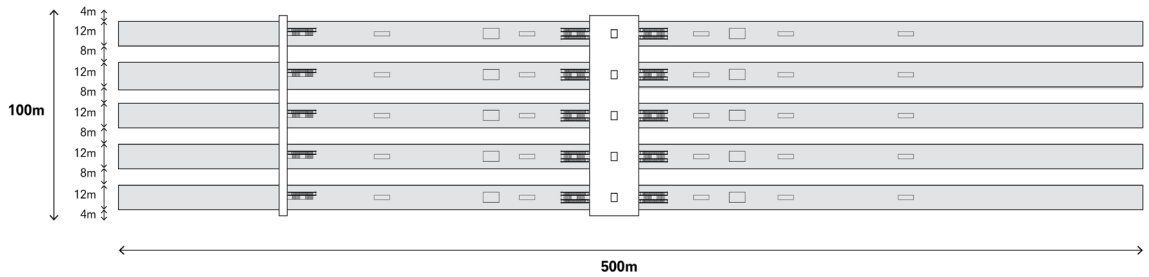
- 2x Local Siemensbahn (every 5 min)
- 2x Local S-bahn (every 10 min)
- 2x Regional RE (every 15 min)
- 2x National IC (every 30 min)
- 2x International ICE (every 2 hours)

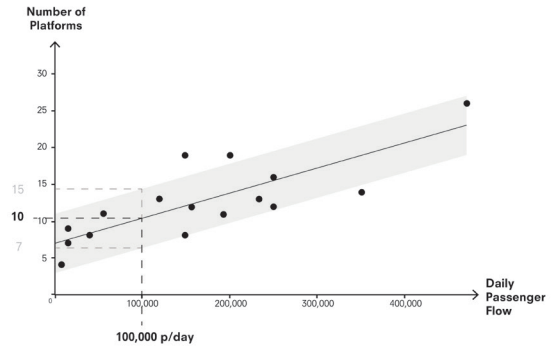
Additional Requirements

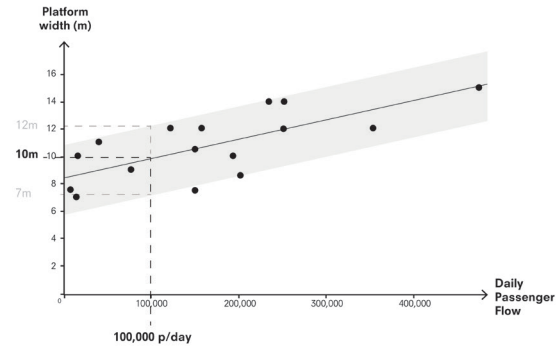
- Connected to passage(s)
- >3 escalators, >2 stairs, >1 elevator
- Canopy above platform
- Minor commercial and makerspace
- Comfort objects such as seating
- Real-time Information screens

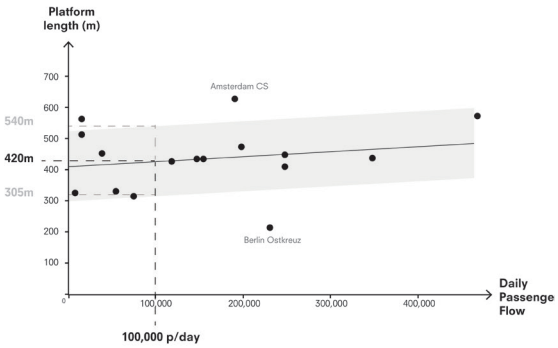
Adjacency

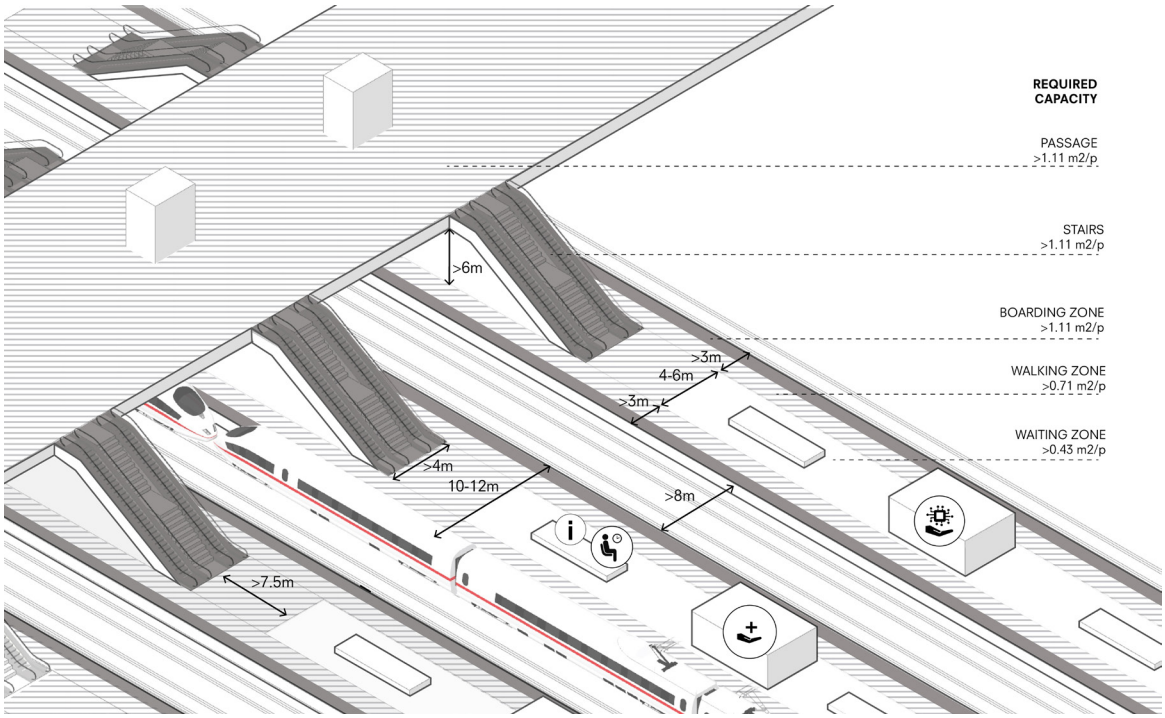
- Travel Passage
- Logistics corridor



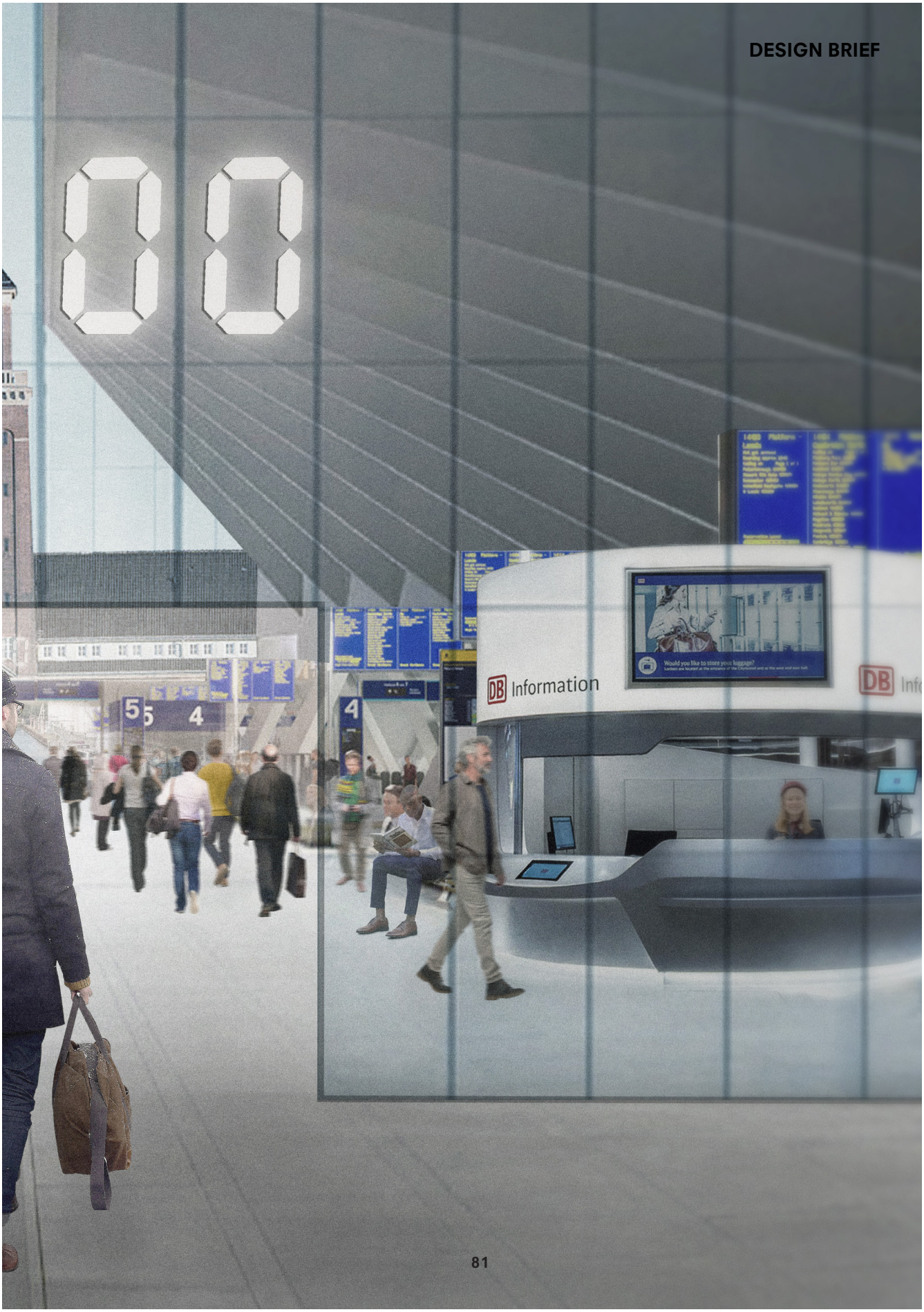

Number of Platforms
30
25
20
15
10
7
5
0
100,000
200,000
300,000
400,000
Daily Passenger Flow
100,000 p/day


Platform width (m)
16
14
12m
12
10m
10
8
7m
6
4
2
0
100,000
200,000
300,000
400,000
Daily Passenger Flow
100,000 p/day


Platform length (m)
700
600
540m
500
420m
400
305m
300
200
100
0
Amsterdam CS
Berlin Ostkreuz
100,000
200,000
300,000
400,000
Daily Passenge Flow
100,000 p/day


REQUIRED CAPACITY
PASSAGE
>1.11 m2/p
STAIRS
>1.11 m2/p
BOARDING ZONE
>1.11 m2/p
WALKING ZONE
>0.71 m2/p
WAITING ZONE
>0.43 m2/p
>6m
>3m
4-6m
>3m
>4m
10-12m
>8m
>7.5m


08
9 8
7
7 6


00
DB Information
Would you like to store your luggage?
5
4
4

Entrance Hall

The entrance serves as the central concourse where all transport flows converge. It is the front of the house where passengers and the public should experience comfort and have efficient access to information. The entrance is envisioned as a generously sized, open space. Its frontage should act as a symbolic gateway, featuring a large ceiling height and ample natural daylight. Simultaneously, it should provide a sense of shelter during the transition from outside to inside. The pathway to the travel passage should be unobstructed.

Spatial Requirements

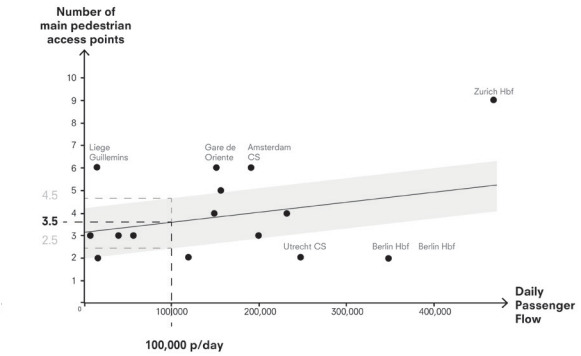
- Clear Height = +- 14m
- Total GFA = 4,000 m2 (divided across various public access points)

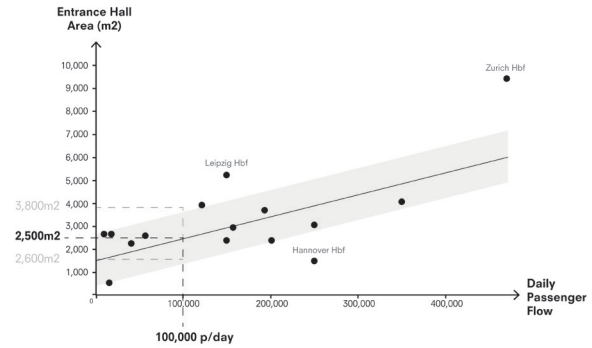
Additional Requirements

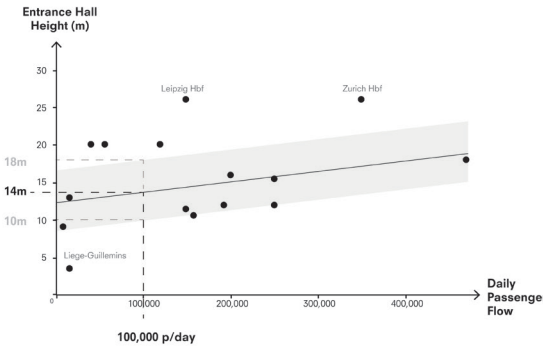
- At least 3 access points to main entrance hall(s)
- Large Digital Station Clock and Logo DB
- Focus on comfort and information services

Adjacency

- Travel passage
- Commercial
- Makerspace
- Station square
- Passenger facilities







Travel Passage

The Travel Passage facilitates access from the entrance hall to the platforms, enabling efficient transfers. Its main purpose is to guide the flow efficiently. However, it should also incorporate convenient commercial and passenger facilities for waiting. The passage should provide sufficient access to the platforms, featuring at least 3 escalators, 2 staircases, and an elevator for individuals with disabilities or those with heavy suitcases or bikes. Clear and unobstructed pathways are essential.

Spatial Requirements

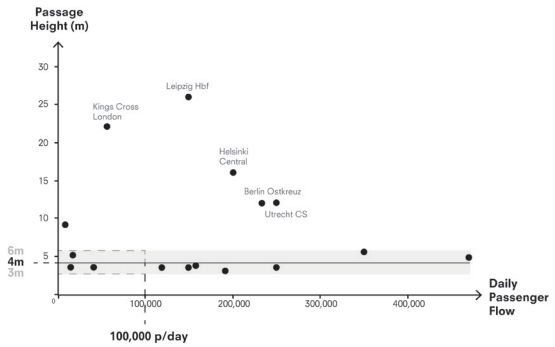
- Width = 28 m (24m main + 4m secondary)
- Length = 120 m
- Clear Height > 4m
- Total GFA 4000m2

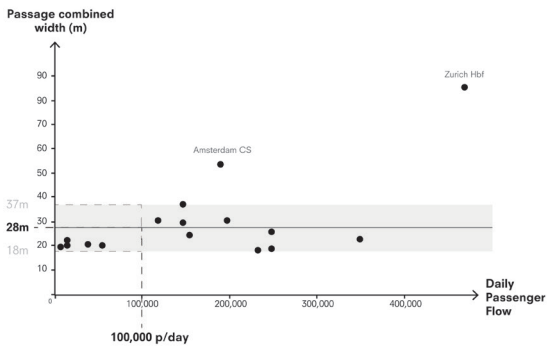
Additional Requirements

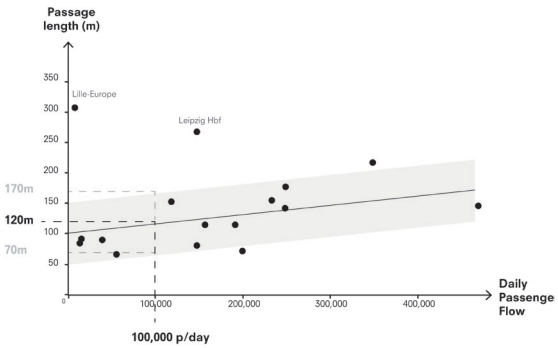
- Connected to platforms
- >3 escalators, >2 stairs, >1 elevator
- Minor Commercial
- Comfort objects such as seating
- Sufficient natural daylight but no glare
- Information services

Adjacency

- Platforms
- Entrance Hall







Autonomous Pods Station

The Autonomous Pods Station stands out as the primary transport space emphasizing digitalisation. Passengers can request an autonomous pod on-demand, which is driverless and regulated by the digital infrastructure. A spacious docking island is needed for the circulation of arriving and departing pods. The check-in process should be barrier-free, incorporating the use of biometric scanning. It should be easily accessible from the travel passage with direct routing.

Spatial Requirements

- Total GFA 3000m2
- Long streched island platfrom with many docks

Additional Requirements

- Canopy above platform

Adjacency

- Entrance Hall
- Station Square

DB Digital Office

The Deutsche Bahn digital office is established in collaboration with tech partner Siemens, serving as a statement to kickstart urban development in Westhafen. The office program is designed to be digitally oriented, featuring a control centre where processed big data is analyzed and observed for transport planning and management. Additionally, it needs to be a space for collaboration and innovation, encompassing open office areas, co-working area for start-ups, presentation rooms, and labs.

Spatial Requirements

- Total GFA 10,000 m2 (750 staff)
- Clear Height >3.5m

Additional Requirements

- Control room key space
- Generic office layout with some secluded rooms for meetings and specifics program

Adjacency

- Square
- Entrance Hall


Siemens
Xcelerator


INNOVATION

Digital Makerspace

The Digital Makerspace offers the ultimate public digital experience, aligning with the industrial context of Westhafen. It provides a large open space for co-creation with access to tech equipment such as 3D printers, robotics, and high-speed computers. The program acts as a bridge between the city center public and private tech development, run by Siemens. The main makerspace is connected to the public axis on the harbor side. However, people can also access digital services on the platform when in a rush or in the entrance hall during off-peak times. The logistics of the harbor should be automated and smartly integrated with the makerspace.
3D Files could arrive in form of data and turned into physical on the spot.

Spatial Requirements

- Clear Height >4m
- Total GFA 3,000m2 (250m2 on platforms)
- Large open space, flexible layout

Additional Requirements

- Protected Manufacturing area (3D prints, CNC milling, etc) for toxic smells
- Digital co-working space
- Logistics assimbly line connected to platform

Adjacency

- MEP
- Entrance Hall


Destination Digital
T · ·Mobile·
WELCOME TO THE END OF DATA LIMITS
NFT
WESTHALLE MARKET
DB
11:00
ACCELERATE

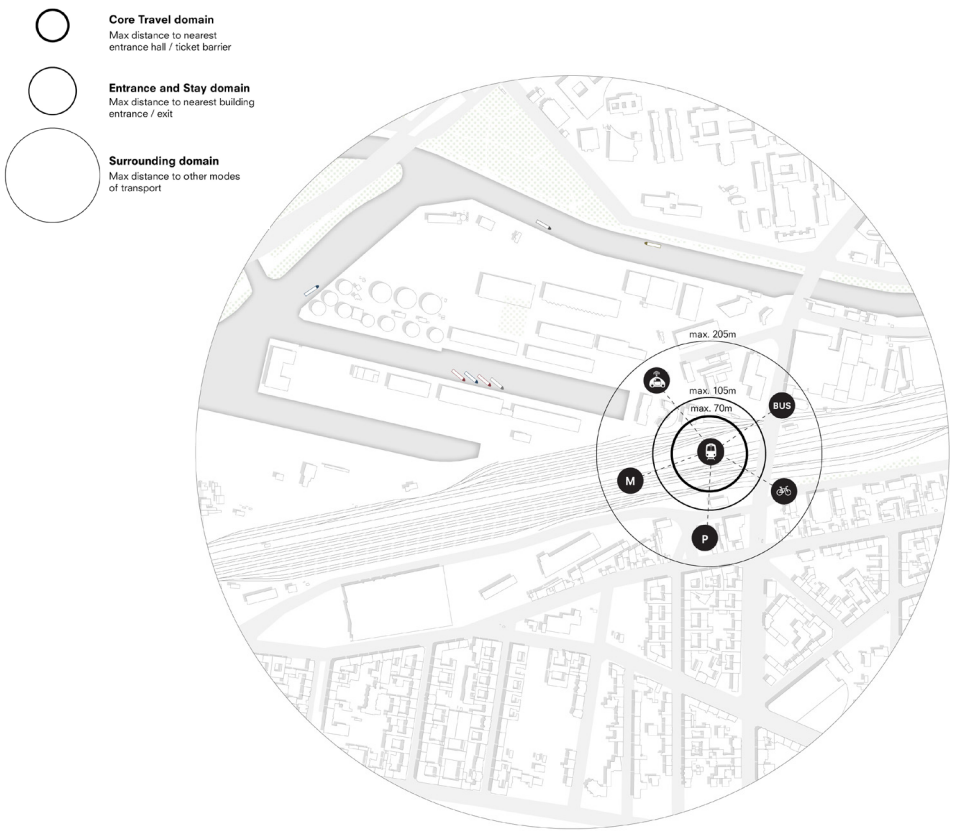
4.3 SITE REQUIREMENTS

Urban Guidelines

The complexity of the Westhafen site and the program necessitates clear urban guidelines for configuring the new station. During the optioneering phase, the massing should ideally comply with these conditions for the project to be successful and achieve a future-proof digital and transport node as an urban anchor.

Compact multimodal transport

Based on station benchmarking and the anticipated transport capacity, the walking distances from the central platform to other modes of transport should be limited to a maximum of 205m. Therefore, it is strongly recommended to align the new station with the existing metro station (U-bahn).

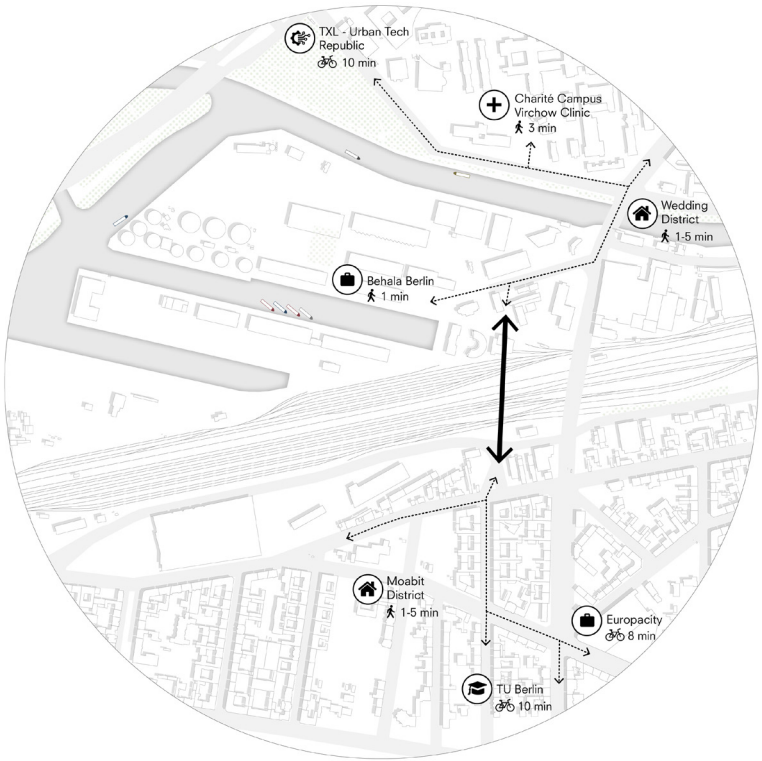


Public Gateway Acces to Westhafen site

With the ambition of serving as an urban anchor in Westhafen, the station needs to enhance urban connectivity by establishing a gateway access in the east-west direction from the main city corridor along the Putlizstrasse bridge.

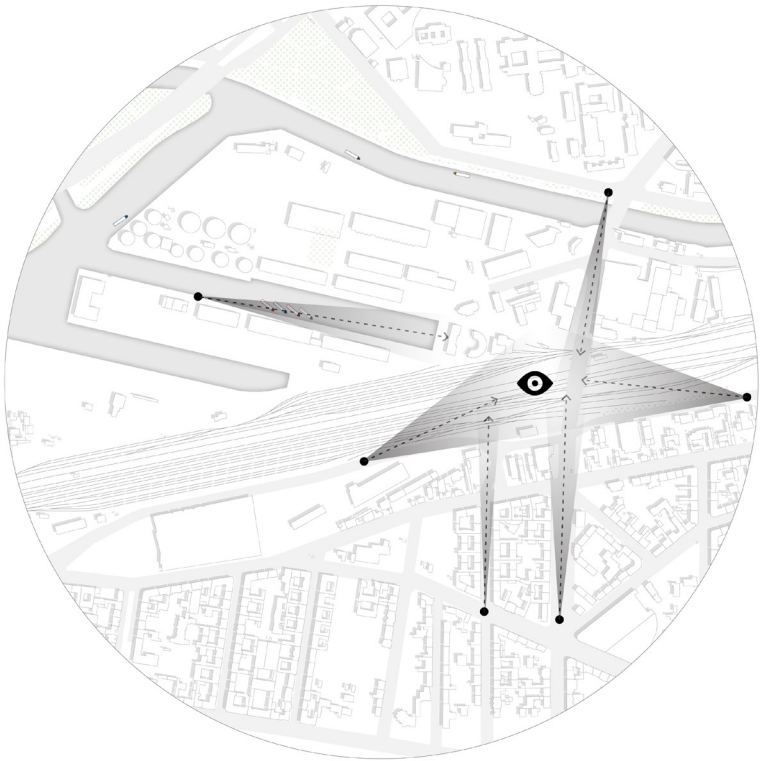
Overcome Urban Spatial Railway Line

The Municipality of Berlin has requested that the station should address a spatial barrier. Therefore, the new station should serve as a crossing in the north-south direction. The enhanced local accessibility from the nearby area will eventually also contribute to increased ridership for the main client, Deutsche Bahn.



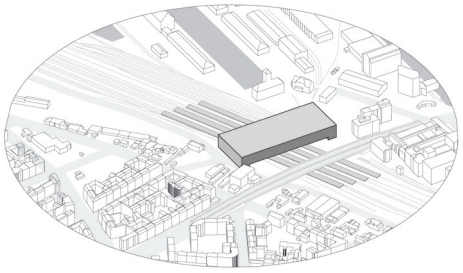
Landmark quality for people and city

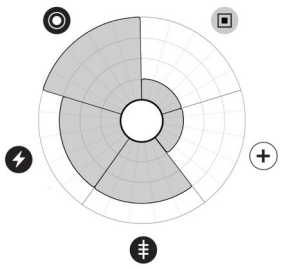
As the client requests an iconic building and passengers need a clear wayfinding experience, the building entrances should be visible from a far distance at eye level. The access points, with the help of canopies, should be clearly within the given sightlines. A high-rise is not recommended, as it may overshadow the monumental quality of the harbour clock tower.



Optioneering

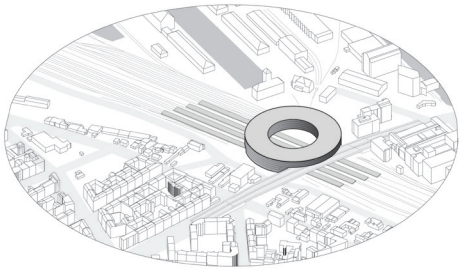
Considering all the client, program, and site requirements, three distinct massing options have been developed as a design response. One option places emphasis on a state-of-the-art compact station typology, another serves as a digital icon to represent the client's ambition, and the last one is a site-driven option that optimizes urban connectivity.

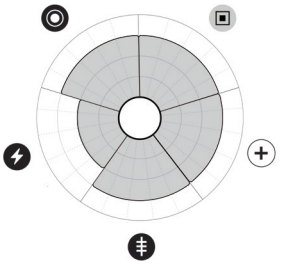




Program

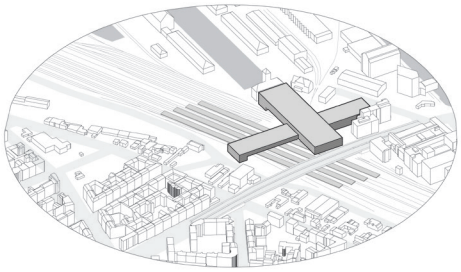
Efficient Transport

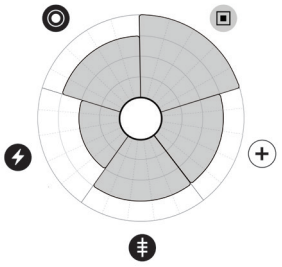




Client

Digital Icon





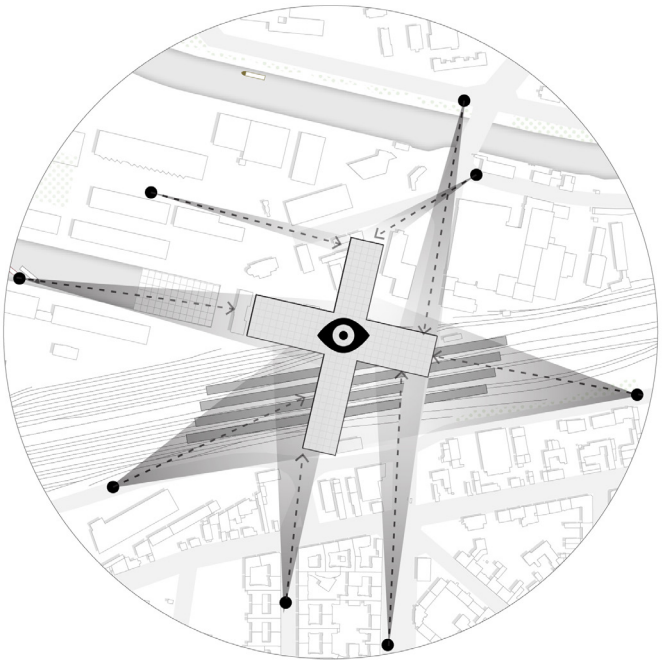
Site

Site Connectivity

Preferred Option

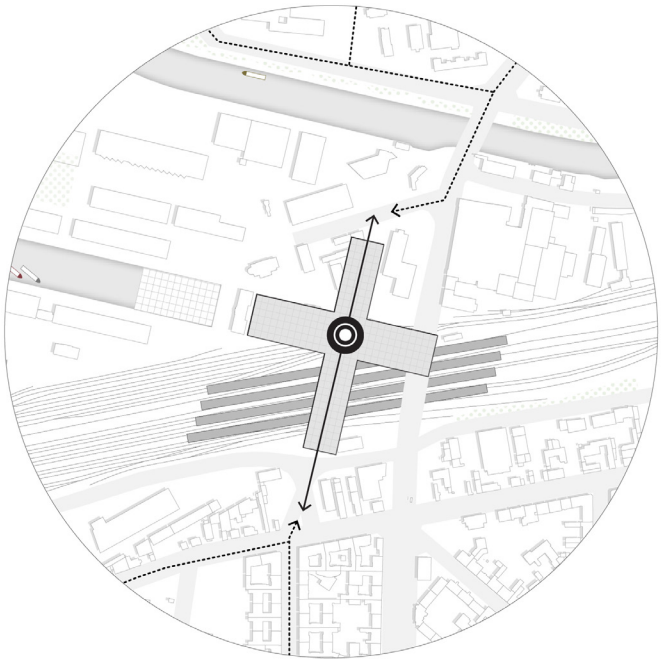
The site-driven option has been chosen as the preferred response to the design brief requirements. The complexity of site conditions necessitates a specific building response to its context. Strong urban connectivity will accelerate place development, and the cross can also symbolize digital connectivity.

The next page demonstrates how the building responds to the design brief requirements.



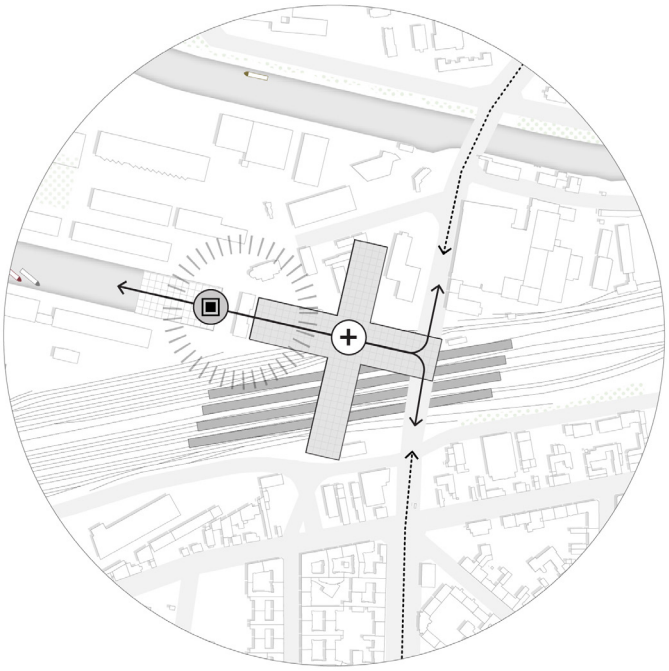
Urban Landmark of Connectivity

High visibility at eye-level from far distance with cathedral-like quality.



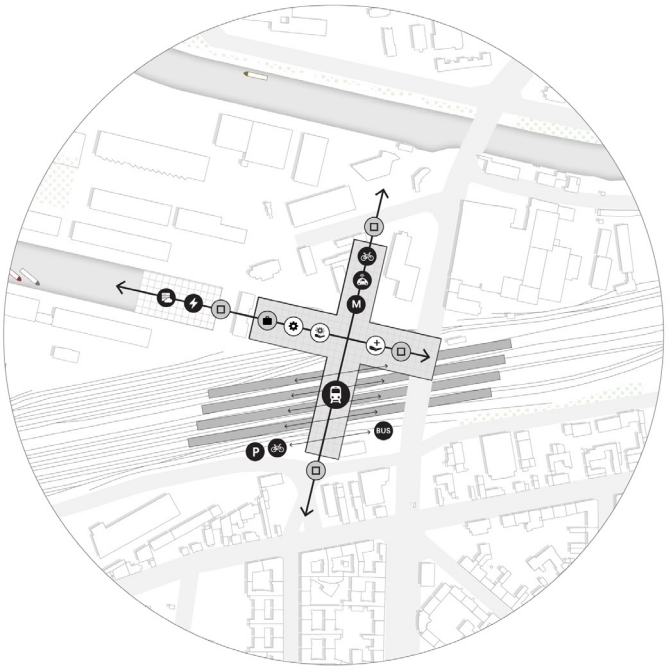
Overcome Spatial Barrier Railway Line

The Transport Axis for direct and efficient transport



Public Gateway Acces to Westhafen site

The Digital Experience and Place Axis to allow innovative urban development around the station building.



Future Digital and Transport Node Berlin Westhafen

Intersection between physical and digital flows. A building that can facilitate the future transport & digital rush hour.

Phasing Plan

As mentioned in the program ambition, the station needs to be proportional to daily passenger flow. Being an urban anchor, the surrounding area will gradually develop by being close to the digital and transport node. Over time, the station's capacity should develop simultaneously with the rate of urban development in a supply and demand cycle.

The priority lies in adding the local train platforms to the tech development and the rest of Berlin, along with building the data centre with the energy battery. This includes some makerspace program and the DB digital office. Then, over time, the larger makerspace and commercial program, autonomous pods station should be added, along with the expansion of the platforms, for example, from 6 to 10.

The phasing plan strategy suggests having a design that is adaptable. This can be achieved in various ways, including modularity.

2030 Phase 1

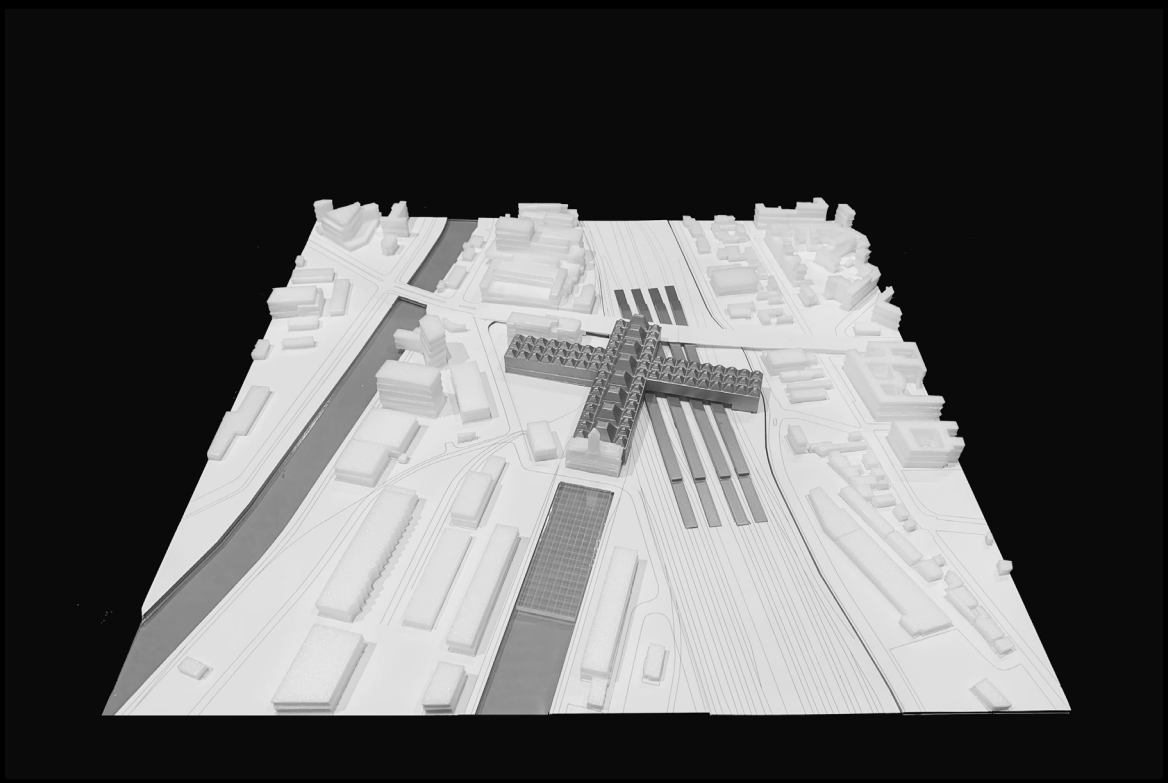
Daily passengers
30,000 p/day

2045 Phase 2

Daily passengers
50,000 p/day

2060 Phase 3

Daily passengers
100,000 p/day



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