DESIGN BRIEF

CARGO PLUS

The Cargo Terminal Design for Enhancing Working Conditions

Meng Chen

15/06/2023

INDEX

INTRODUCTION

01

Thesis Topic

In today's fast-paced and highly competitive global trade environment, cargo terminals have become crucial hubs for the transportation of goods. Germany, being the powerhouse of Europe, has a significant logistics sector, which is the third-largest sector of the economy (Schäfer, 2023). Around 8.3% of all employees work directly in this sector, with half being employed in warehousing and handling, and a quarter each in transport and delivery and administration (Schäfer, 2023). In Germany, a figure of 90,000 in air freight would correspond to approximately one tenth of the workforce (Schäfer, 2023).

However, workers in these environments often face physically demanding tasks, such as heavy lifting, awkward body postures, harmful noise, and extreme temperatures. Besides, they also mentally face the mentally demanding working conditions, resulting from the time pressure, increasing complexity of logistics systems and the integration of advanced technologies. These factors have significant implications for employee health, well-being, and productivity, which in turn affect the overall efficiency of cargo operations.

The architectural design of cargo terminals has the potential to offset these demands and address the consequences by creating environments that actively support employee well-being. By exploring innovative design strategies that consider both functionally and mentally, architecture can play a crucial role in alleviating demanding working conditions, promoting well-being, and boosting productivity within cargo terminals.

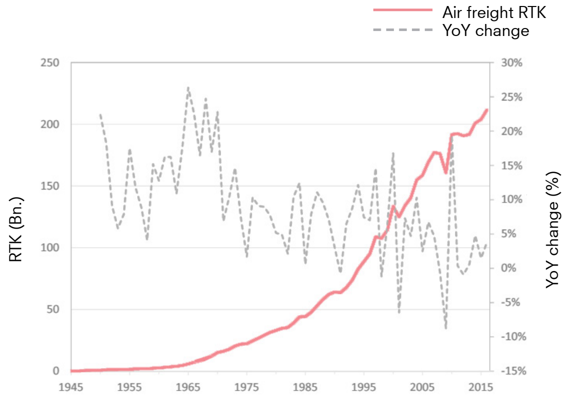

Figure 1 - Development of air freight volumes since 1945

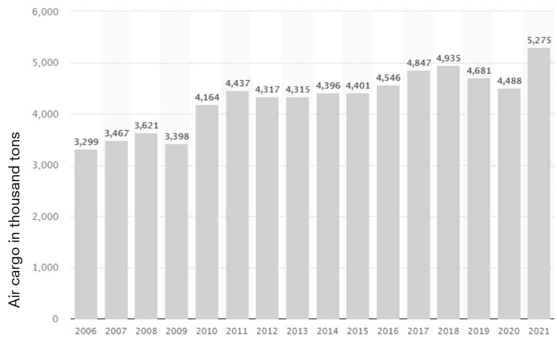

Figure 2 - Transport volume of air cargo in Germany from 2006 to 2021 (in 1,000 tons)

Problem Statement

In recent years, there has been a significant increase in exposure to demanding working conditions, with studies showing that 48% of employees experience at least one physically demanding condition and 24.8% face multiple constraints (Havet et al., 2020). A primary factor contributing to this trend is the mounting pressure to meet demands in the ever-growing global trade market (Havet et al., 2020). Workers are often required to meet tight deadlines and manage larger volumes of goods, resulting in a faster pace of physically demanding tasks and associated negative consequences.

Physically demanding working conditions encompass a variety of factors such as heavy lifting, awkward body postures, vibrations, harmful noise, and extreme temperatures (Havet & Penot, 2022). These conditions can have a detrimental impact on crew members' musculoskeletal health, potentially leading to periarticular/vibration disorders, chronic meniscus injuries, and low back pain (Havet et al., 2020). Additionally, occupational exposure inequalities disproportionately affect blue-collar workers, contributing to social disparities in health and life expectancy (Havet et al., 2020).

In addition to physically demanding working conditions, employees now face increasingly mental demands, due to the time pressure, and the rapid technological advancements in digitalization, automation, and robotics (Meyer & Hünefeld, 2018). Workers are often tasked with managing new and unlearned tasks, requiring them to adapt to new technologies and processes, handle complex decision-making, and troubleshoot problems with limited resources (Meyer & Hünefeld, 2018). This cognitive load can result in increased stress, mental fatigue, and reduced job satisfaction. As a result, it is important to explore how architectural design can support employees in managing these mental demands by creating environments that facilitate concentration, collaboration, and learning.

While architects prioritize people-centered design, there is a lack of focus on addressing demanding working conditions in the field. Buildings that house strenuous work environments, such as construction sites, warehouses, distribution centers, manufacturing plants, and transportation facilities, are typically designed with an emphasis on efficiency, often relegating worker experience and well-being to secondary importance. This can result in inadequate lighting, poor ventilation, limited access to rest areas, and a lack of spaces for social interaction, all of which can contribute to a decline in workers' well-being and productivity.

Therefore, exploring architecture's role in alleviating demanding working conditions is crucial for enhancing the overall working environment, promoting well-being, and boosting productivity. Developing innovative design strategies that consider ergonomics, acoustics, lighting, indoor air quality, and spatial layout can create healthier and more supportive workspaces. Fostering interdisciplinary collaboration between architects, occupational health professionals, and industry stakeholders can lead to a comprehensive understanding of workers' needs and effective solutions for addressing complex challenges.

Research Question

In an increasingly demanding work landscape, employees face various challenges in their daily tasks, particularly in cargo terminal environments. This study explores the research question: "**How can architecture design offset demanding working conditions, both functionally and mentally?**", which will be investigated through a cargo terminal design. The research is structured around three main sub-questions:

- What are the key factors contributing to demanding working conditions?

- How can architectural design elements and features contribute to demanding environments?

- How can technology be integrated into architecture design to improve crew working conditions?

By identifying the factors that lead to challenging work conditions and examining architectural strategies to address both functional and mental well-being aspects, this study aims to uncover innovative design solutions that alleviate the unique challenges faced by employees in cargo terminal settings.

Figure 3 - Problem statement

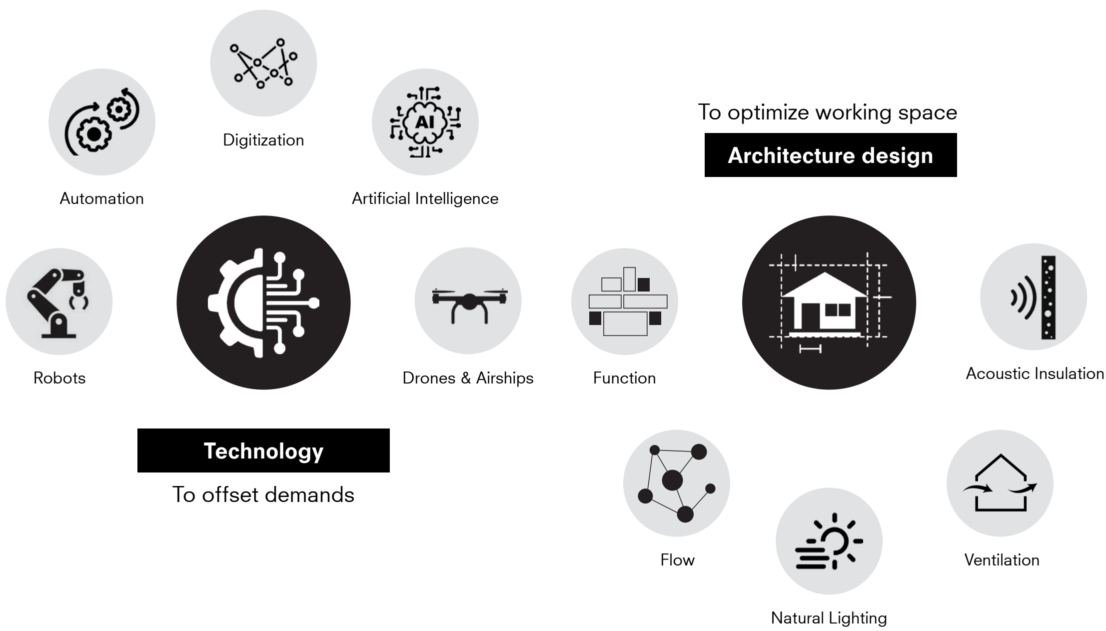

Figure 4 - Hypothesis

RESEARCH FRAMEWORK

02

Theoretical Framework

This research integrates theories and concepts from ergonomics, environmental psychology, occupational health, and human factors engineering to understand the relationship between cargo terminal design and employee well-being.

Ergonomics focuses on optimizing workspace layouts, equipment, and work processes to reduce physical strain and improve productivity (Dul et al., 2012). Incorporating ergonomic principles can minimize awkward postures, heavy lifting, and excessive force, reducing the likelihood of musculoskeletal injuries.

Environmental psychology studies the impact of physical environments on human behavior and well-being. Restorative environments promote psychological and physiological recovery from stress (Kaplan & Kaplan, 1989). Incorporating restorative elements, such as access to nature and noise control, can help mitigate mental demands and foster relaxation and focus.

Occupational health identifies and controls factors in the work environment causing illness or injury (Schulte et al., 2012). By understanding health risks associated with cargo terminal work, architects can design spaces that minimize exposure to harmful substances, noise, and extreme temperatures while promoting healthy behaviors.

Human factors engineering optimizes the interaction between humans, technology, and the environment (Salas et al., 2006). This framework investigates how architectural design can reduce physical demands and promote ergonomics and safety, enhancing the overall user experience and supporting employee well-being.

This study examines how incorporating ergonomic principles, restorative environments, occupational health strategies, and human factors engineering approaches can offset physical and mental demands faced by employees in cargo terminal settings. By doing so, this research aims to provide a holistic understanding of architectural strategies for creating healthier, more supportive workspaces.

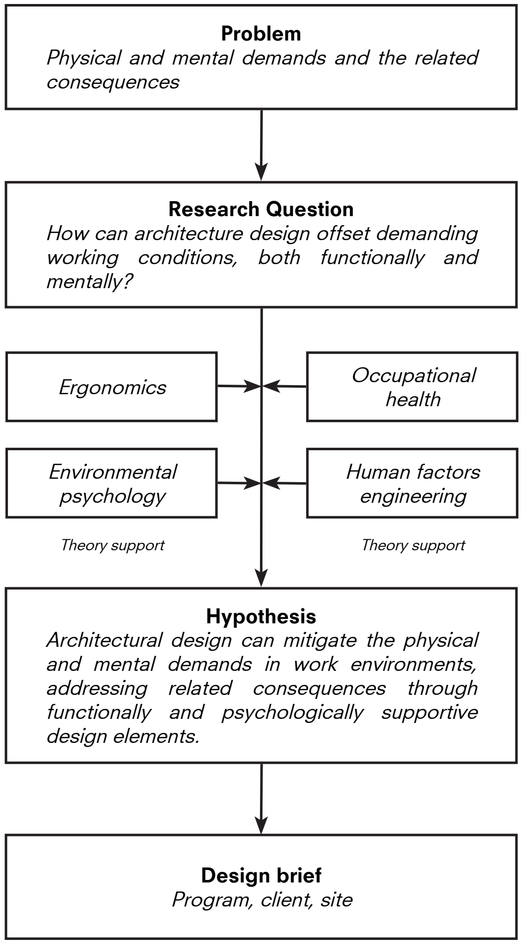

Figure 5 - Framework

Relevance

The relevance of this study is significant as it addresses working conditions, well-being, and productivity within cargo terminal environments and other demanding workplaces. The insights can impact various stakeholders, including architects, designers, operators, policymakers, and employees.

Architectural Implications
This research offers valuable insights for architects and designers to create supportive and healthier work environments, contributing to new design guidelines and best practices prioritizing employee well-being and productivity.

Industry Impact
Cargo terminal operators and similar industries can use these findings to make informed decisions on workplace design and infrastructure, resulting in increased employee satisfaction, reduced turnover, and lower healthcare costs.

Policy and Regulation
Policymakers can leverage this research to create or update policies governing workplace design and employee well-being, adopting a holistic approach to workplace safety and health.

Employee Benefits
Improved working conditions can reduce physical strain, increase mental well-being, and promote a healthier work-life balance, leading to higher job satisfaction and employee retention rates.

Cross-industry Applications
Principles and design strategies identified in this study may apply to industries like manufacturing, construction, and warehousing, promoting a broader understanding of employee well-being's role in workplace design.

In conclusion, this study's relevance extends beyond cargo terminals, illuminating architecture's role in addressing demanding working conditions and promoting employee well-being across various industries, contributing to healthier, more productive, and sustainable work environments.

RESEARCH METHODS

03

Program

To thoroughly research and develop the program, a combination of methods will be employed, primarily focusing on literature reviews, case studies, and benchmarking. These methods will be supplemented by online research, analytical diagrams, and 3D massing.

The initial task involves estimating the capacity of the cargo building, which will subsequently inform the Gross Floor Area (GFA) estimation. Capacity research will be conducted through an examination of air freight volumes at German airports and an analysis of the annual growth rate of air freight volume in Berlin. Utilizing the data on Berlin's current annual air freight volume and its growth rate, future capacity can be projected. With the estimated capacity for annual air freight volume, the GFA can be calculated based on the existing facility utilization ratio (Maynard et al., 2015).

To develop a program bar, relation scheme, and key space tailored to the specific functions of a cargo terminal, case studies and benchmarking will be utilized. First, main zoning and specific functions will be identified through case studies on existing cargo terminals. By comparing the square meters and percentage distribution of each space in these case studies, an average program structure can be established (Figure 6). Crucially, to develop a program bar for the proposed cargo terminal, adjustments will be made based on specific needs and requirements.

Following this, the relation scheme will be created through research on general cargo flow and case studies (Figure 7&8), illustrating the organization of both cargo and crew flow. Lastly, key spaces will be represented through 3D massing and references to the spatial atmosphere.

By employing this multi-faceted approach, a comprehensive and well-informed program can be developed to ensure the optimal functionality and organization of the cargo terminal.

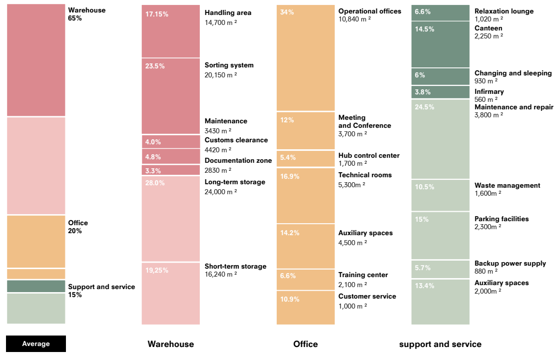

Figure 6 - Benchmarking conclusion

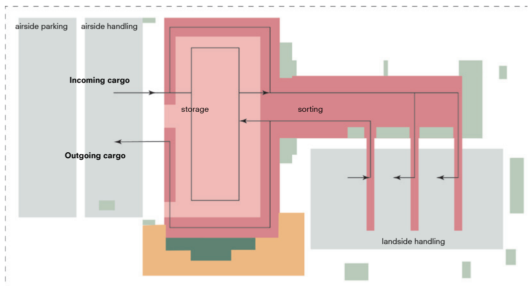

Figure 7 - Cargo flow analysis of DHL Hub Malpensa

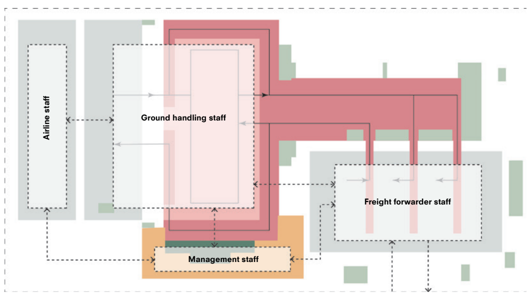

Figure 8 - Crew flow analysis of DHL Hub Malpensa

Client

The process of identifying potential clients is primarily grounded in literature reviews. Several critical factors are considered when selecting clients for the cargo terminal. These factors include the ownership structure of the cargo terminal, the various parties involved in the air cargo industry, the current trends shaping the air cargo market, and future forecasts for the industry's growth and development.

By examining these factors in detail, a comprehensive understanding of the client landscape can be established. This approach ensures that the most suitable and relevant clients are identified for the cargo terminal, fostering a strong foundation for successful operations and long-term partnerships in the evolving air cargo market.

Site

In the complex projects studio, students are divided into five groups, each focusing on a distinct topic: mobility, future, culture, environment, and economy. Our economy group established three criteria for site selection to promote economic growth. We used quantitative data collection and mapping to create a composite map identifying optimal sites economically.

These criteria serve as a foundation for site selection, with further evaluation based on cargo terminal design requirements and demanding working conditions. Once the site is determined, additional map analysis will examine the terminal's role within the airport context, its impact on surrounding urban areas, and its position in global trading routes and business locations.

Site visits and online research will assess current conditions, ensuring a well-informed decision-making process for selecting the ideal cargo terminal site.

DESIGN BRIEF

04

Designing an efficient and sustainable cargo terminal with optimal working conditions is the primary objective of this project. The design ambitions can be summarized as efficiency and sustainability, worker-centric, and urban integration. The hypothesis is that by leveraging technology and incorporating thoughtful architectural design, the working space can be optimized to address demanding conditions effectively.

Site

To identify the most suitable airport in Berlin, a comprehensive analysis was conducted on three potential options: Berlin Brandenburg Airport, Tempelhof Airport, and Tegel Airport. After careful examination, Tegel Airport was determined to be the optimal choice. The airport's transformation into the Urban Tech Republic presents numerous opportunities for the cargo terminal, including technological advancements, manufacturing capabilities, and business and trade potential.

The chosen site for the cargo terminal is strategically positioned alongside the main terminals at Tegel Airport. Originally intended for a hexagonal airport structure that was not realized, the plot's central location within the airport remains highly significant and holds immense potential for future development (Figure 9).

As Tegel transforms into the Urban Tech Republic, the surrounding areas are envisioned as tech campus zones. The campus area is accompanied by business and trade districts, as well as residential areas (Figure 10). The plot benefits from excellent transportation connectivity, situated near the main road, and with plans for a new public transportation rail line in close proximity (Figure 11). This accessibility enhances the plot's desirability.

Integrating the cargo terminal into the Urban Tech Republic poses several challenges (Figure 12). Firstly, the terminal's proximity to the TXL main terminal, a recognized landmark, necessitates a thoughtful response. Secondly, integration into the tech campus area presents additional considerations. Lastly, responding effectively to the neighboring business and trade areas is also essential.

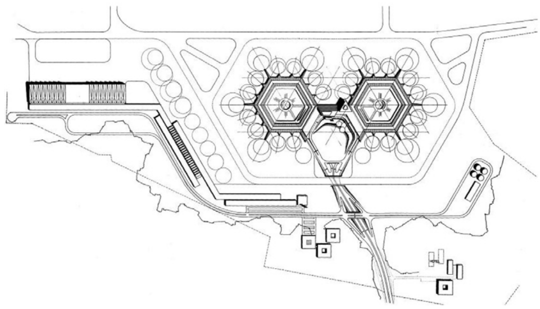

Figure 9 - Original plan for Tegel Airport

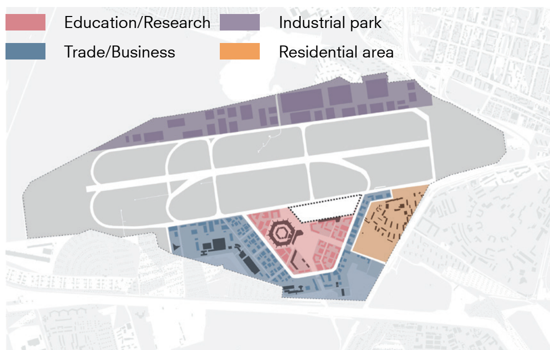

Figure 10 - Future plan for Tegel Airport

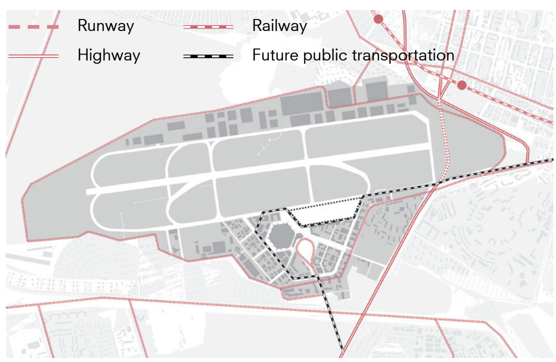

Figure 11 - Transportation

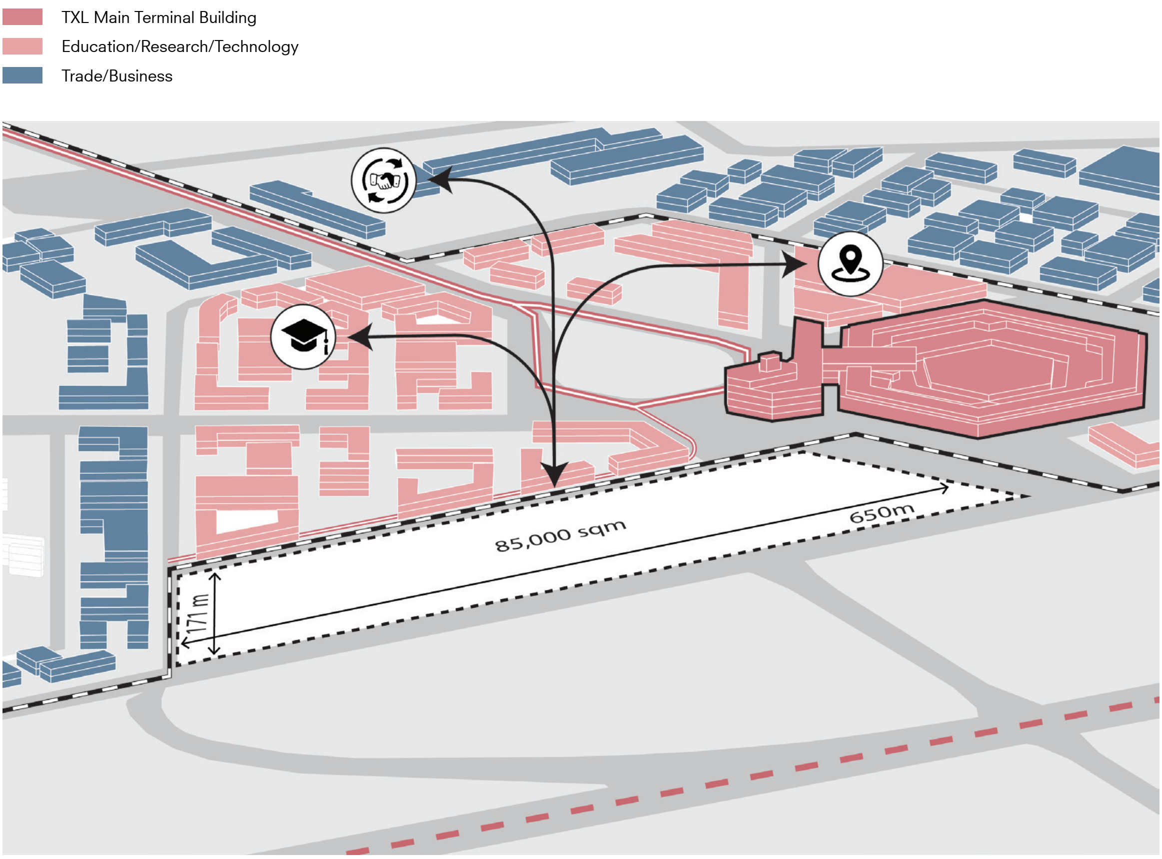

Figure 12 - Main challenge for the plot

Program

To determine the capacity and Gross Floor Area (GFA) for the proposed facility, I began by examining the air freight volume at German airports. Data showed that the current annual air freight volume in Berlin is approximately 25,000 tonnes, which is considerably lower than other German airports such as FRA - Frankfurt, LEJ - Leipzig, and CGN - Cologne. Additionally, geographic mapping of air freight volume (Figure 13) revealed that northern Germany has a lower air freight volume compared to other regions in the country, presenting a potential opportunity for further business development.

To estimate capacity, I utilized the available information on the annual growth rate (6.5%) and projected that Berlin's air freight volume would reach 330,000 tonnes annually by 2050 (Figure 14). Based on literature reviews and quantitative data collection, I determined that the current facility utilization ratio is approximately 0.14 square meters per annual tonne (Maynard et al., 2015). Consequently, I calculated the GFA of the main cargo building to be around 46,000 m².

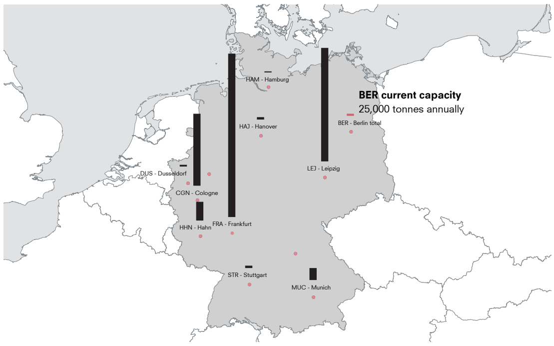

Figure 13 - Air freight volume at German airports (2020)

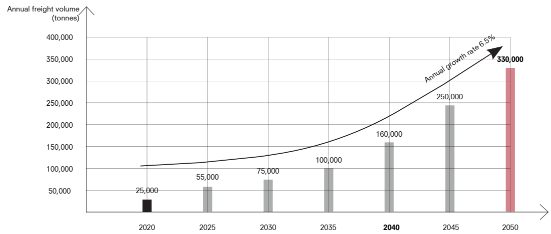

Figure 14 - Berlin's annual freight volume estimation in the future

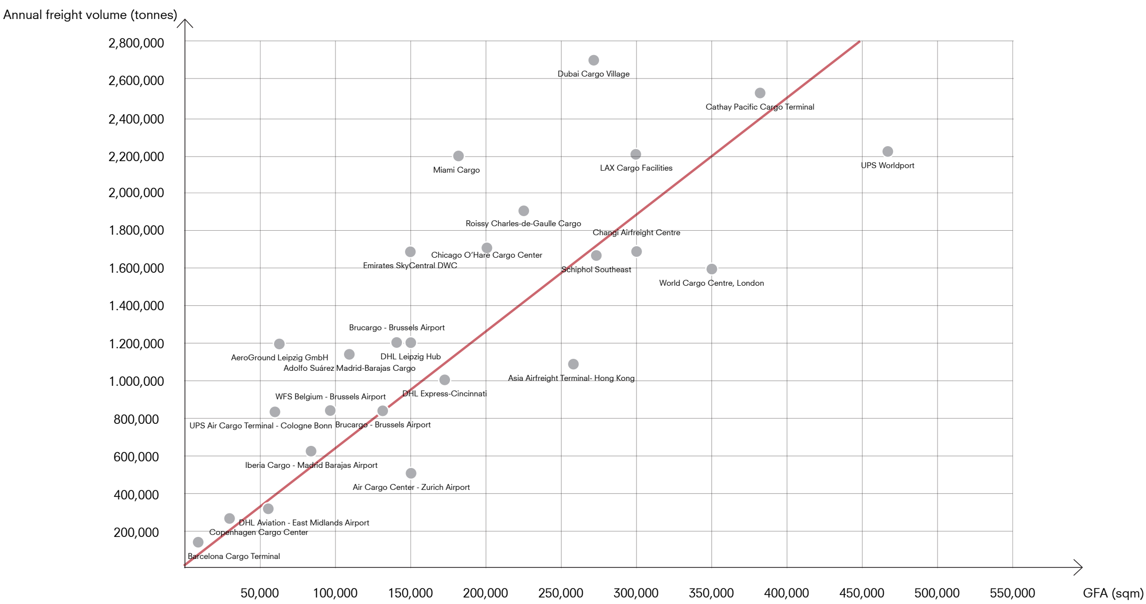

Figure 15 - The existing facility utilization ratio: 0.14 m²/t

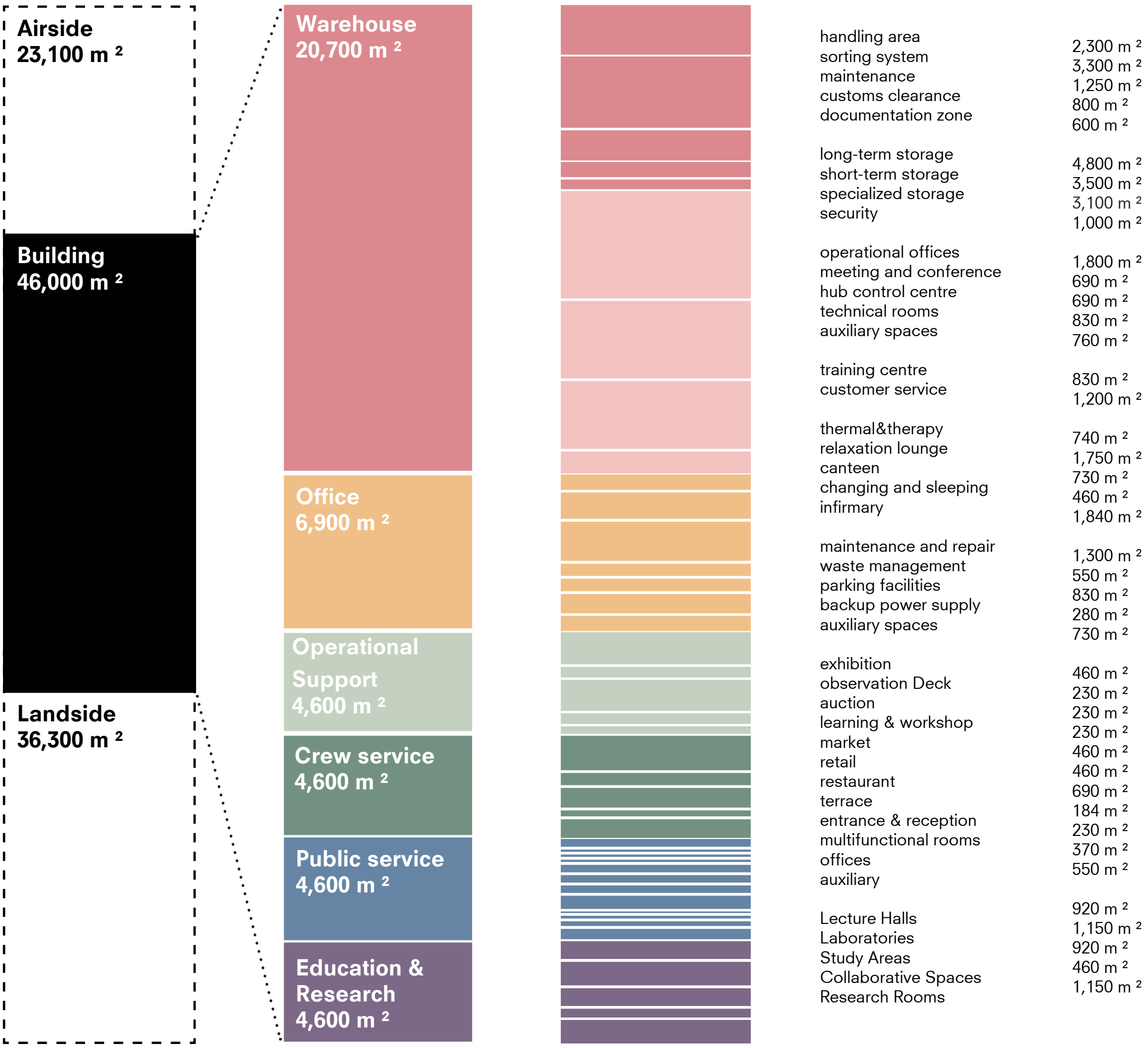

Figure 16 - Program bar

Based on benchmarking and industry standards, the general cargo terminal comprises three primary components: the warehouse, office, and operational support area. Additionally, three extra programs have been incorporated: crew service, public service, and education and research areas. The crew service spaces, including the relaxation lounge, 24/7 canteen, and thermal & therapy facilities, aim to enhance working conditions for the crew. The public service areas, such as the exhibition, auction, and restaurant & market, maximize the value of air freight while providing a welcoming space for the public and crew. The education and research spaces, featuring lecture halls, collaborative areas, and study zones, facilitate integration with the campus and contribute to technological advancements in the overall logistics sector. (Figure 16)

The design should consider the relationship between the main zoning areas (warehouse, office, operational support, crew service, public service, education and research) and the flow of cargo, crew, and public. The result of this analysis will be illustrated in a diagram (Figure 20).

The key spaces within the terminal include the efficient cargo operation area, which connects the airside and landside and ensures streamlined cargo processes (Figure 17). The public area, situated near the main cargo terminal at Tegel, features an open plinth that serves as a platform for easy public access (Figure 18). The crew service area acts as a bridge between the cargo operation area and the public area, providing convenient access for crew members returning to work or seeking entertainment after their shifts (Figure 19).

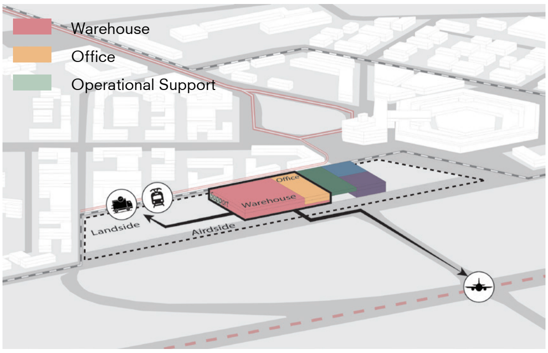

Figure 17 - Key space: cargo

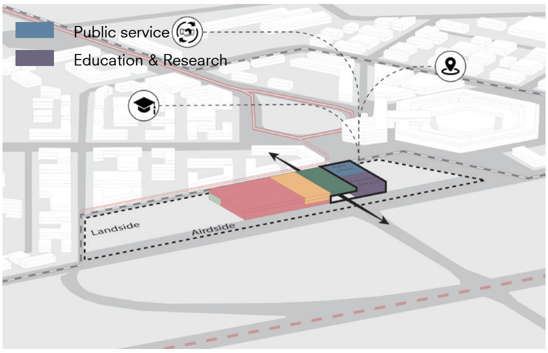

Figure 18 - Key space: Public

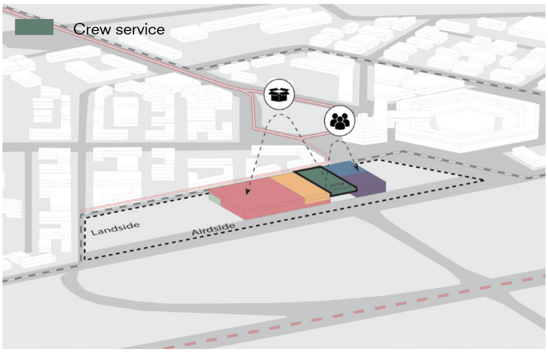

Figure 19 - Key space: Crew

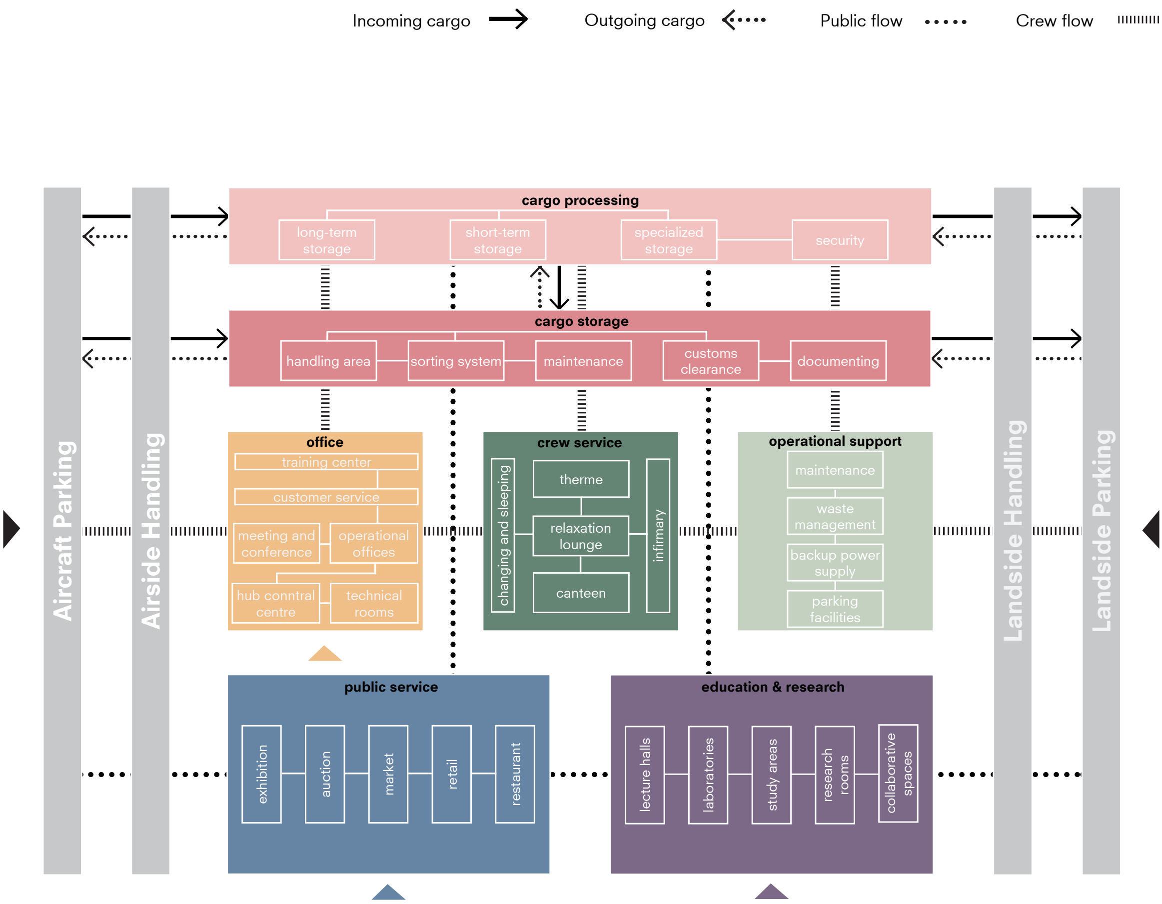

Figure 20 - Relation scheme

Client

DHL has been chosen as the primary client for the Tegel cargo terminal due to its status as a leading integrator, dominance in the EU, and German roots. This alignment allows for a strategic connection of Tegel with other DHL European hubs, potentially establishing Tegel as a future EU hub. DHL's objectives, which encompass green logistics, technology innovation, and strengthening of the supply chain, resonate well with the project's goals.

In addition to DHL, other stakeholders from EU government bodies, Urban Tech Republic and leading e-commerce players are involved, each contributing a critical piece to the project's puzzle. They bring perspectives and requirements that shape the terminal's future and contribute to its functionality and success.

This cargo terminal, designed with a multifaceted user base in mind, will serve not only as a work center for the crew, but also as a place of leisure for visitors and the community, a research and study hub for students and researchers, and a logistics resource for various industries and startups. The integration of these diverse needs is what will make the Tegel cargo terminal a dynamic, engaging, and integral part of the Urban Tech Republic and the broader Berlin area. This holistic approach ensures that the terminal's design caters to the evolving requirements of today's logistics landscape, underpinned by the values of efficiency, sustainability, and urban integration.

Figure 21 - User group

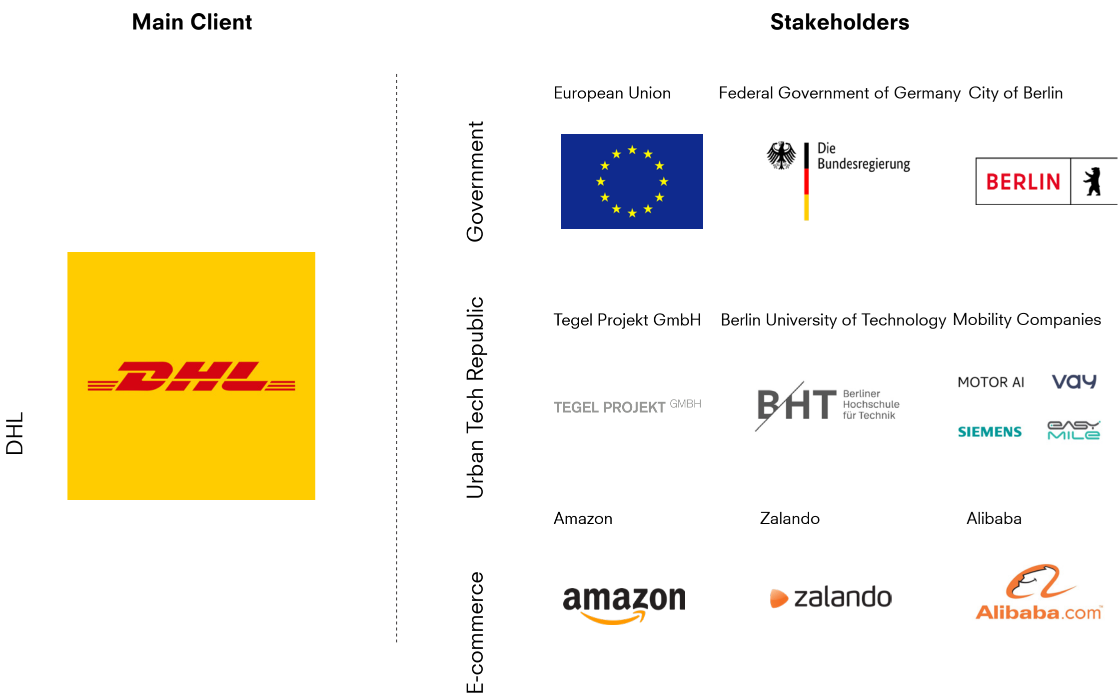

Figure 22 - Main client and stakeholders

Figure 23 - Collage


Sotheby's

BIBLIOGRAPHY

05

Bibliographical References

Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W. S., Wilson, J. R., & van der Doelen, B. (2012). A strategy for human factors/ergonomics: Developing the discipline and profession. Ergonomics, 55(4), 377–395.

Havet, N., Fournier, J., Stefanelli, J., Plantier, M., & Penot, A. (2020). Disparate exposure to physically demanding working conditions in France. Revue d'Épidémiologie et de Santé Publique, 68(6), 327–336. https://doi.org/10.1016/j.respe.2020.09.008

Havet, N., & Penot, A. (2022). Trends in exposures to physically demanding working conditions in France in 2003, 2010 and 2017. European Journal of Public Health, 32(1), 73–79. https://doi.org/10.1093/eurpub/ckab195

Kaplan, R., & Kaplan, S. (1989). The experience of nature: A psychological perspective. Cambridge university press.

Maynard, M., Clawson, D., Cocanougher, M., Walter, D., Brimble, R., Webber, M., Janisse, R., Freidheim, K., Miller, R., Airport Cooperative Research Program, Transportation Research Board, & National Academies of Sciences, Engineering, and Medicine. (2015). Air Cargo Facility Planning and Development" Final Report (p. 22094). Transportation Research Board. https://doi.org/10.17226/22094

Meyer, S.-C., & Hünefeld, L. (2018). Challenging Cognitive Demands at Work, Related Working Conditions, and Employee Well-Being. International Journal of Environmental Research and Public Health, 15(12), 2911. https://doi.org/10.3390/ijerph15122911

Salas, E., Wilson, K. A., Burke, C. S., & Wightman, D. C. (2006). Does crew resource management training work? An update, an extension, and some critical needs. Human Factors, 48(2), 392–412.

Schäfer, J. G. (2023). Air Cargo: Participants - Processes - Markets - Developments. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-38193-6

Schulte, P. A., Pandalai, S., Wulsin, V., & Chun, H. (2012). Interaction of occupational and personal risk factors in workforce health and safety. American Journal of Public Health, 102(3), 434–448.

Figures