Tampere University

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DEVELOPING AN INCLUSIVE DESIGN SYSTEM FOR AN INDUSTRIAL MACHINERY ORGANISATION

FROM THEORY TO PRACTICE

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ABSTRACT

Ngoc Nguyen: Developing an inclusive design system for an industrial machinery organisation – From theory to practice.

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The digital design world is constantly evolving, and at the forefront of this evolution is the development of inclusive design systems. At Metso, a leading industrial machinery organisation, user experience design is taken seriously. This thesis delved deep into Metso's design processes and human-machine interface products, focusing on creating an inclusive design system that benefits both primary and secondary users.

Through extensive research, this thesis explored the necessity of community and business design approaches, human-centred product development, and agile methodologies to create an engaging and efficient design system that meets the needs of all users. The development of a digital guidebook, Metso Inclusive Design, which supports integrating human diversity and control systems design into the primary style guide, was also formed as the thesis's outcome.

The literature review primarily focused on academic articles, reputable books, and credible websites. Furthermore, personal accounts and relevant blog posts related to collaborative efforts among digital product teams, design systems, diversity and inclusion in design, cross-cultural design, and human-machine interface design were duly considered. The research findings were instrumental in developing design insights to drive progress in the design process.

Through research through design, this thesis concluded that human diversity and human engineering factors in the design process can be beneficial for efficient problem-solving and concept development. Inclusive design approaches and design thinking can help develop mature concepts that generate high-performance ideas suitable for diverse users. Finally, a human-centred product development design process considers user experience, requirements, and desires through extensive research, surveys, workshops, and user evaluations, thereby making ideas concrete and visible throughout the process.

Overall, this thesis provided a comprehensive guide to developing an inclusive design system for Metso, an industrial machinery organisation, with practical insights and valuable research findings that can be applied across various organisations in the same industry on a broader scale.

KEY WORDS AND TERMS: DESIGN SYSTEM, HUMAN-MACHINE INTERFACE, INCLUSIVE DESIGN, INDUSTRIAL CONTEXT, SAFETY ASPECT.

The originality of this thesis has been checked using the Turnitin Originality Check service.

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Tampere, November 2023

Ngoc Nguyen

(Nguyễn Lê Khánh Ngọc)

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LIST OF ABBREVIATIONS AND KEY TERMS

DSUI	Design System User Interface (React component library)
HCD	Human-Centred Development
HCI	Human-Computer Interaction
HFE	Human Factors Engineering
HMI	Human-Machine Interface
KPI	Key Performance Indicator
Modes	Metso Design System
Modes UI	Metso Design System UI (Web component library)
MVP	Minimum Viable Product
P&ID	Piping and Instrumentation Diagram
PO	Product Owner
RtD	Research through Design
SIS	Safety Instrumented System
UCD	User-centred Design
UI	User Interface
UX	User Experience

Branch: Figma's branching feature allows designers to experiment without altering the main file. The changes are merged when they are ready. [1]

Brand manager: A brand manager manages the global Metso brand, develops and maintains brand guidelines and tools, and oversees brand implementation and training.

Contributor: A contributor works closely with stakeholders, Modes designers and developers to improve and produce components and guidelines that uphold design principles and best practices.

Component library: A component library is a comprehensive collection of web components, including design elements and visual standards based on the UI Kit designs [2]. These components are organised into a library to simplify their accessibility and usage for users.

Designer: In this thesis, the designer creates and executes project plans and integrates branding, design, usability, and function to enhance user experience [3].

Developer: This thesis defines a developer as a software engineer who works with designers to create applications from scratch and supervises software development [4].

End-user: An end-user utilises products designed using the design system but is not directly involved.

Human factors engineering: HFE optimises human well-being and performance through scientific study of interactions between humans and other system elements. It uses theoretical principles, data, and methods to create efficient, safe, and effective systems for diverse settings. [5, p. 14]

Instance: A principal component defines the properties of an element, while instances are copies of that component to be reused in other designs [6].

Product: The term product in this thesis refers to software products, system software, and screen configuration software running on a selected operating system [7]. It does not include hardware products.

Product owner: A product owner maximises a product's value based on the iterative and lean team's work. This responsibility falls on one individual rather than a group, and they are accountable for managing the product backlog effectively, which may involve representing the needs of multiple stakeholders. [8]

Product team: A product team is a group of individuals collaborating to create digital products. This team comprises a product owner, designers, and developers who work together to achieve the desired outcome [9]. They are responsible for creating and maintaining their products and are the primary users of a company's internal design system in the context of this thesis.

Prototype: A prototype is a preliminary product version to test a concept or process. It helps improve design accuracy before mass production and is essential in all design disciplines. [10]

Safety instrumented system: SIS is a system of safety functions that detect and address hazardous conditions in an industrial process, bringing it to a safe state [5, p. 15].

UI kit: A UI kit is a set of essential user interface components such as fonts, icons, design files, and documentation [11]. Designers utilise these components to create new templates and pages.

User: A user in this thesis refers to anyone directly using the design system, including product owners, developers, designers, and brand and communication managers [12].

Variant: A component can have multiple variants with slight differences grouped into a single container to streamline the component library. This is an approach promoted by Figma which enhances the accessibility of the library and the ease of use for all stakeholders involved. [13]

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1 Introduction

Effective collaboration among product teams is critical to establish and adhere to design systems for consistent product design, particularly for large multinational companies. However, this can be challenging because human values are varied and manifest through behaviour, which is influenced by economic, societal, and cultural factors. [14, pp. 115–117]

There has been an increased recognition within the industry regarding the advantages of integrating social dimensions into business operations [15, pp. 248–257]. In Scandinavia, implementing Corporate Social Responsibility initiatives has further strengthened the concept of *design for all*. As businesses expand and diversify globally, design systems must accurately reflect this reality. As a result, the significance of inclusivity within design systems for industrial organisations cannot be overstated.

As a company case of this thesis, Metso Corporation, a global company based in the Finnish capital, strives to expand its global footprint and emerge as a leader in designing solutions catering to diverse needs. By employing inclusive design principles, the thesis's motivation aims to create exclusive digital product solutions for Metso that enhance customer satisfaction, paving the way for its growth and success.

Eventually, this thesis also provides practical recommendations to other industrial machinery organisations to integrate inclusive design practices effectively. Beyond the business value, the thesis considers the users and environment, which aligns with the strategic objective of Metso to work towards a safer working environment for all stakeholders involved [16].

1.1 Company Case Study: Metso Corporation

Metso Corporation (Metso Finland Oy, abbreviated to **Metso**) is a company that specialises in providing sustainable technology and services for the mining and metals industries. Before the 2020 merger, Metso Corporation's predecessor consisted of two distinct heavy industrial organisations: the former Metso and Outotec. Following that integration, in May 2023, the group formed a unified Metso brand and company that promotes diversity and inclusion as one of their strategies and strong culture.

Metso is a global company with more than **16,000** employees spread across **45** countries. They offer diverse products and services in three reporting segments: aggregates, minerals, and metals [17]. Metso provides customers with comprehensive product solutions, processes, spare and wear parts, and services incorporating advanced digital solutions and machinery production lines. Each business unit has its unique offerings at a high level of complexity.

To enhance branding and consistency in Metso's digital and web applications and achieve a positive user experience, they implemented a design system, Metso Design System (**Modes**), in August 2020. It has a dedicated team to oversee the management of the system and an ecosystem with different platforms to benefit various user groups. The Modes team has three roles: product owner, designer, and developer. They offer

sufficient assets and tools to reduce design, coding, and testing time for digital product development teams while committing to optimising the diverse customer experience true to the brand across all digital touch points with Metso's products.

1.2 Method and Research Question

Inclusivity and design systems are a great combination in which usability and accessibility can be integrated seamlessly into all aspects of a design system. Inclusive design has expanded beyond its original intent of accommodating individuals with disabilities. It has evolved into an approach that incorporates creating products for all users, including *our future selves* [14, p. 112], [18]. Studies also have indicated that implementing inclusive design principles can effectively address the needs of a varied user base without the dependence on assistive technology [19, pp. 849–850].

Industry 4.0 has evaluated the effectiveness of implementing inclusive design through digitisation. Over the years, various legislation and standards have been established to provide guidelines and tools for creating inclusive workplaces for workers with diverse abilities [20]–[22]. Understanding that importance, many organisations now recognise the significance of providing *digital accessibility opportunities* for their products [23].

Nowadays, a design system is treated like a *product for products* [24]. It is changing how products are developed and marketed by offering users a more efficient and consistent experience [25]. As a standalone product, it has become increasingly complex and functional, allowing for easier creation of high-quality user experiences [24].

However, further empirical and theoretical research is necessary to understand its sufficient implementation in the industrial machinery industry. Understanding that, this thesis employed a research-through-design (RtD) methodology, utilising the inclusive design process to address under-constrained problems in the human-computer interface (HCI) context [26]. The approach incorporated information-based design research (e.g., ethnography) and inspiration-based design research (e.g., generative techniques) to produce novel solutions based on existing knowledge [27, p. 4]. Stappers and Giaccardi [28] argue that prototypes (i.e., Metso Inclusive Design), created through an RtD approach, can verify hypotheses derived from research questions. Therefore, design is considered an exploratory activity within the context of design research, and through reflection on the design process, new knowledge can be acquired. As the thesis adhered to the RtD and the principles of human-centred product development, it involved six months of user study, design, demonstration, and documentation activities. As a result, the focus of this thesis is to explore the following research question:

How to develop an inclusive design system for an industrial machinery organisation?

1.3 Objectives

The main objective of the thesis outlines a proposal for creating an inclusive design system tailored to industrial machinery organisations, which covers the following purposes:

Objective 1: To explore the definitions of inclusive and human-machine interface (HMI) design and their significance in developing a comprehensive design system.

Objective 2: To present principles for a seamless design process for product teams based on literature review, practical work with Modes and collaboration with the design system team.

Objective 3: To thoroughly evaluate the accessibility and usability of the current design standardisation, including the UI kit and style guide, from the users' viewpoint.

Objective 4: To identify the possible effective strategies for providing comprehensive support to all Metso product teams and raise the awareness of design for diversity in the organisation irrespective of position, product lines, and geographical location.

In addition to the previously mentioned areas of focus, the research at the case company also investigated the following secondary areas of interest:

Automation: Design systems are intricate products that present immense potential for automation in the upcoming years [29]. This thesis delves into the widely discussed subject of automating the transition of design systems towards more sustainable growth.

Branding: In the transition from the predecessors to the current entity, product branding principles are considered and discussed in the **CASE STUDY**. In addition, besides Modes, there are other Metso standardisations for design, like marketing materials, office applications, and industrial products. Differentiations and overlaps with the Brand Hub are mentioned throughout the thesis.

Cross-cultural design: The diversity in Metso's product teams is valued as they offer various services worldwide. The thesis strives to gather extensive inputs during the research phases to enhance stakeholder satisfaction.

1.4 Thesis Structure

The present thesis comprises five chapters, each structured clearly and concisely to provide a comprehensive overview of the research.

Introduction: The first chapter introduces the thesis topic, outlines the objectives and research question, describes the case company and research approach, and concludes with critical concepts.

Literature Review: In the second chapter, the basic definitions of design systems, HMI design, and inclusive design were explored. Each concept is explored in detail, including its benefits and drawbacks, allowing for a comprehensive understanding of their underlying principles.

Metso Inclusive Design (MID): In the third chapter, the case study of the Metso Design System is thoroughly explored, including an analysis of its users, context, use cases, and feedback. A comprehensive understanding of the system's capabilities and limitations was also gained through different data collections, and analyses were conducted to gain insights into the perspectives and requirements of stakeholders. The process utilised the agile business development approach and the human-centred product development approach. Additionally, this chapter analyses relevant benchmarks to provide insight into the current landscape of these concepts, particularly within industrial machinery organisations in Finland.

Discussion and **Conclusion:** The final chapters combine the thesis findings to understand better inclusive design systems in an industrial machinery organisation and how it can contribute to this segment on a larger scale.

Overall, the thesis represents a rigorous and systematic approach to addressing the research question and provides valuable insights for academics and practitioners.

2 Literature Review

This chapter provides a comprehensive analysis of three core themes that form the crux of the thesis: design system, HMI, and inclusive design. The author has meticulously defined and contextualised each topic by integrating existing research and their insights. The relevant principles, challenges, and values of each theme have been discussed in detail. Additionally, the author has presented concrete examples from Metso and industrial machinery context and provided a detailed account of discussions among themes. The purpose is to demonstrate how these core themes are instrumental in addressing the research question.

2.1 Design System

This section provides an in-depth analysis of the terms *design* and *system* to formulate a thorough definition of *Design System*. It presents six fundamental principles that a design system should comply with, comprising inclusivity, confidence, consistency, independence, reusability, and robustness. The section concludes with a discussion on the importance of design systems in the product development process, along with the potential challenges that may hinder its inclusivity.

2.1.1 Study of Design System

The concept of *design* has been thoroughly examined in various fields, including architecture, manufacturing, marketing, management, and psychology [30], [31]. This thesis uses design to describe crafting, developing, and constructing digital products. Prior research has categorised design into two distinct groups: functional and aesthetic.

When evaluating creativity within design, usefulness or functional value is typically used as the standard metric for assessing the creativity [32], which is closely tied to the goal satisfaction [33]. Therefore, enhancing functional design necessitates identifying problematic sub-components and focusing on incremental improvements instead of handling design as an independent unit, either screened, accepted or rejected [34, p. 120].

According to Christensen and Ball [34], aesthetic design is influenced by cognitive and affective dimensions, including subjective properties, relevance prevalence, and perceiver's capability. When evaluating aesthetic design, they discussed that it is best to concentrate on the emotional or hedonic tone rather than the originality or functionality of the design. In essence, aesthetic evaluation emphasises the object perception's affective and cognitive dimensions to determine aesthetic pleasure. Therefore, assessing non-perceptual designs, which are conveyed verbally, can be more challenging. [34, p. 121]

In addition to common design categories, this thesis highlights the significance of incorporating safety design into designing HMI for the heavy machinery industry of Metso [17]. Safety design is a continuous co-design process to reduce risks, avoid or mitigate hazardous situations, and improve local conditions, including material, social, and psychological conditions [35, p. 347]. It also involves promptly addressing emergencies.

According to Erlhoff and Marshall [35], safety design can take various forms, including safety measures and emergency responses. Safety measures are continually attended to and developed to prevent a wide range of potentially hazardous situations due to unforeseen misuses, malfunctions, or environmental factors. Emergency responses require swift action, and strategic decision-making is crucial to executing a well-planned response. Time is of the essence in such situations. Prioritising actions depends on the perceived level of risk to those involved. A comprehensive approach is necessary in a large-scale incident, combining functional and safety design with emergency plans at all levels. [35, p. 347]

> **Co-design:** Co-design is a design approach that involves all stakeholders in the process to ensure that the result meets their needs and is usable. It is not a design style but a participatory approach that embraces inclusivity, collaboration, cooperation, and community design. This method also incorporates socio-technical aspects to create a comprehensive and sufficient design. [36]–[38]

To truly grasp the organisation of information and interactive elements on a screen-based interface, one must understand the intricacies of screen design. This multidisciplinary field draws from graphic design, HCI, and ergonomics to determine how interfaces are manipulated and how users engage with content, including the manner, location, and purpose of such engagement. Designers must consider a variety of interactions that may involve multiple temporal and spatial modes, as well as different functionalities depending on the nature of the inputs.

They are, for example, various tools, from metaphorical symbols and information and navigation system architecture to sound design and manipulation, feedback forms, static images, and text. The goal is to create interfaces that optimise user engagement with content, accounting for various modes and functionalities considerations. As such, designers must deeply understand these tools to create screen interfaces that effectively cater to their users' needs. [35, pp. 349–350], [39]–[42]

This thesis also explores the *system* concept, referring to complex structures of interconnected parts or ideas. The complex systems cannot be fully understood by analysing their components [35, p. 390]. Various things, from artefacts, consciousnesses, and communications to organisms, can be partially controlled, planned, or created when designing systems. Thus, it describes the competency of dealing with ignorance [43].

Developing a design system incorporating standardised designs is crucial to expediting project development. Standardisation has been the subject of extensive research and involves ensuring consistency and uniformity across various iterations of products, services, strategies, or manufacturing processes. While standardisation can enhance efficiency, its effect on flexibility may be restricted, and outcomes may vary depending on contextual factors such as business size and aesthetic preferences. In light of these contextual factors, some studies have produced mixed results. [44], [45, p. 11]

> **Design system:** Incorporating a design system can significantly enhance the design process by providing a library of reusable design and development components for user interfaces. This approach ensures the branding is consistent and helps adhere to UX design principles. Moreover, the system provides valuable insights into the

rationale behind each design choice, making it easier for designers and developers to work together. By minimising technical debt and promoting collaboration, a design system is a powerful tool for ensuring uniformity across all interfaces [46, pp. 7–17].

In other words, the power of scale is undeniable. Especially in design, it is always believed to be bespoke, tailor-made solutions for individual problems. To maintain Metso's exceptional standards for product design, construction, and delivery, it is imperative to establish a standardised approach for UX and UI. By doing so, teams can reuse components and maintain an internal repository, which can be utilised to create a wide range of products [47, pp. 2–3]. This approach ensures consistent conventions are followed, and a shared repository of reusable components is available, allowing multiple teams to work concurrently without duplicating efforts or causing compatibility issues. As a result, components are readily accessible, and the design is modular, leading to enhanced efficiency and quicker application delivery.

2.1.2 Principles of Design System

Establishing a set of guiding principles is essential to designing a system, irrespective of the tools and technologies employed. These principles should be derived from carefully chosen qualities that align with the business's core values. They determine the UX and serve as practical and subjective standards that guide decision-making and uphold consistency in direction. Ultimately, they fortify the organisation's core values. [48]

Consequently, this thesis outlines general design principles that may serve as a reference. They are (1) **INCLUSIVITY**, (2) **CONFIDENCE**, (3) **CONSISTENCY**, (4) **INDEPENDENCE**, (5) **REUSABILITY**, and (6) **ROBUSTNESS**. The first two categories emphasise the involvement of human factors, while the others are the expected traits of a tool as a design system, mainly from the implementation perspective.

However, it is essential to note that individual preferences and values may vary, and some principles may not be applicable in specific contexts. Therefore, organisations should carefully evaluate and adapt these principles to their unique needs and priorities.

2.1.2.1 Inclusivity

This sub-section only delves into the concept of *inclusivity*, which entails catering to the needs of stakeholders and ensuring accessibility. However, a detailed discussion of its full definition is reserved for the **INCLUSIVE DESIGN** section.

Human factors play a crucial role in most methodologies, as illustrated in **FIGURE 16**, and it is imperative to comprehend their requirements to initiate the design thinking process. Co-designing from the outset of the design process is essential to ensure design decisions are informed by actual user needs, with a focus on what is most valuable and vital. Qualitative and quantitative research methods should be employed to

grasp people's objectives, requirements, and behaviours after understanding users' perspectives and the problem context. Real stakeholders in the field commonly test solutions and assumptions with prototypes. All results and testing should be shared and regularly conducted with all those involved in the design and development process to ensure their needs are met.

In addition to user needs, every decision-making must take accessibility into account as it affects everybody. A critical starting point for factoring accessibility is employing existing legal requirements and standards [49]. However, the design system team should humanise these standards to convey more concrete and crafted accessibility guidelines.

Accessibility is about the broadest possible audiences who use the design system regardless of how they engage with the documentation content. Thus, getting familiar with assistive technology is an excellent way to learn how people use it to get things done [50]. Everyone who works in the organisation and digital platforms has a role in contributing to the design of system resources and making them accessible and inclusive. Therefore, designing generously and embracing the accessibility requirements of design systems can help designers and developers create better products for all users.

2.1.2.2 Confidence

The principle of *confidence* is a vital aspect of any design system as it pertains to establishing and maintaining trust. Trust is contingent upon understanding and consistently meeting and surpassing user expectations. The process of earning trust can be expedited through continued interaction, but it is also highly vulnerable to potential damage.

To mitigate the impact of failure, a design system must remain reliable, consistent, and transparent. Achieving this level of dependability requires adherence to sound design and engineering practices rooted in audience data, available resources, and project timelines. Accordingly, design system practitioners should prioritise building trust with users through practical measures like implementing confidential identification access, conducting frequent content reviews, utilising proper domain usage, identifying link rot, and, when appropriate, publishing and sharing the development process and progress.

2.1.2.3 Consistency

Consistency is an integral component in creating and managing design elements in a predictable and reliable pattern. The ultimate objective is to ensure that designers and developers across the organisation can easily comprehend and contribute to the process [51, pp. 79–80]. To attain this, it is customary to establish and document the guidelines of the design system. As the system evolves and expands, consistency becomes paramount to minimise disruptions and provide a seamless experience across various platforms and devices.

Nevertheless, uniformity should not be misconstrued as consistency. Different products may have distinct audiences, goals, and missions, necessitating unique solutions. The design system team can promote continuity by developing shared

solutions and values that prioritise UCDs, considering the user's overall experience and journey, not just specific tasks [52].

Style guides, device and platform support, device testing, community involvement, regular governance, and multi-step process support are all common practices that can aid in maintaining consistency. These practices align with the principles of Design Ops, which are essential for product design teams to operate efficiently and collaboratively, thereby heading to automation ability [53, pp. 5–25].

DesignOps: Design operation optimises design procedures, diversity and inclusion of personnel involved, and methodologies to increase its value and impact [54], [55, pp. 14–20].

2.1.2.4 Independence

The fourth principle of a design system, *independence*, is highly valued by developers. It is advantageous for a design system to be treated as a separate dependency and reside in a source control repository distinct from the main codebase. While establishing such a repository may require some initial effort, it offers numerous long-term benefits. These benefits include the ability to create versioned releases of the code, facilitate code sharing across teams, products, and codebases, encourage component development in isolation rather than a single use case, provide infrastructure for a robust front-end testing architecture, and establish a foundation for a living style guide website. It is imperative to uphold a singular source of truth for all components, which necessitates the establishment of a dedicated design system repository that encompasses all codes for each component, including CSS, JS, HTML, and documentation. By consolidating all these facets, dependency and update management are simplified. [51, pp. 85–86]

2.1.2.5 Reusability

In design systems, *reusability* is another critical consideration that should be prioritised. This means that the components in the system should be designed in a way that allows them to be utilised in multiple contexts instead of being too rigid or limited to a single use case. Neglecting reusability can result in users creating their own patterns, leading to inconsistencies and inefficiencies in the long run. To ensure reusability, the components should be modular, composable, generic, and flexible [51, pp. 86–87].

Firstly, according to the author, modularity refers to the ability of the components to be broken down into smaller, more manageable parts. Secondly, Sylor [51] explained that composability means the components' capability to be combined without dependencies, which allows them to be easily adapted and extended to serve various use cases on a generic level. Thirdly, generality denotes the ability of the components to be used in a wide range of applications. Lastly, flexibility indicates the ability of the components to be modified without affecting other areas of the system. In keeping with the "Don't Repeat Yourself" principle, each component should have a clear purpose and function and that there should be no ambiguity or confusion about its role within the system [56, p. 320].

By adhering to this principle, design systems can be made more efficient, effective, and maintainable while reducing the risk of errors and inconsistencies.

2.1.2.6 Robustness

Design systems should also adopt the principle of *robustness*, which involves thorough testing of both the implementation and design to ensure their reliability. Testing provides confidence in the code and design base, facilitating adoption. With continuously updated software, designers can upgrade or override instances without breaking them unexpectedly [6]. However, maintaining a design system's robustness requires much effort in testing individual applications or products. Instead, testing design system components can narrow the test scope and gain higher confidence.

To ensure stability in a design system, Shopify's chief designer, Bennett-Chamberlain, introduced four examples of testing: unit testing, functional testing, visual regression testing, and automated accessibility testing [51, pp. 98–99]. Unit testing is an indispensable process that verifies small code sections to ensure they function as intended. It is typically accomplished by executing these portions with a predetermined set of inputs and confirming that they produce the anticipated results. Functional testing is another crucial process that involves running code examples on a headless browser to ensure that expected outcomes are achieved when simulating various user actions. Visual regression testing is a critical process that identifies unintended changes in component styles by taking before-and-after screenshots and utilising an algorithm to detect visual discrepancies. Lastly, automated accessibility testing is a crucial process that employs tooling to ensure components are accessible and satisfy necessary standards.

Overall, having these six principles at the beginning of the design system construction can ensure its maintainability, stability, scalability, and success beyond frameworks or tooling. As technology constantly advances, adapting and incorporating newer and better practices keep the system growing and on the right track. However, these principles should be considered as they may only be appropriate for some teams. The design system is not a one-and-done product but a continual iteration process, so it is a best practice to experiment and develop new and better approaches, qualities, and values [57].

2.1.3 Values and Challenges of Design System

Creating a design system is a commendable initiative that can offer several benefits. However, there are several misconceptions and challenges associated with the process.

2.1.3.1 Values of Design System

There are several ways that a design system can be beneficial to the product growing process: (1) design scale and consistency, (2) debt management, (3) faster prototype and iteration, and (4) usability and accessibility improvement.

Regarding *scalability*, as a product and its team grow, designers and developers often concentrate on their specific domains, resulting in an inconsistent visual identity that fails to harmonise the brand. Without established design conventions, this can impede compelling design critique.

> **Design critique:** The design critique process entails the expert analysis and evaluation of design work to discern its effective and ineffective elements, aiming to improve its overall quality and impact. (Sylor-Miller, 2023, pp. 98–99)

> **Design convention:** Design conventions are fundamental principles, behaviours, aesthetics, values, or applications that are crucial reference points and guidelines. Design goes a long way in critiquing and transforming these conventions to ensure they can be communicated, perceived, and practised by diverse individuals and groups. [35, pp. 81–82]

Bennett-Chamberlain emphasises the importance of a shared design system as a trustworthy information source for product teams [58, p. 13]. To ensure accessibility for all members, he suggests designing the system in a way that documents all elements, including components, guidelines, and UX best practices internally. By doing so, the design system can promote cohesion and synchronisation among team members. It also serves as a reliable source of truth for official patterns and styles, simplifying scaling efforts and keeping everyone aligned.

Maintaining *consistency* is crucial when scaling designs. Repeatedly utilising standardised components can enhance predictability and manageability for designers and developers in comprehending products. Furthermore, this method can save designers time and budget, enabling them to concentrate on improving the UX rather than the aesthetics. [58, p. 15]

When striving for scalability and efficiency, it comes to technical and design *debt* challenges. It is important to note that this debt does not refer to financial debt. Instead, it relates to building for short-term gains [58, p. 14]. In terms of design, this debt is evident in an abundance of non-reusable and inconsistent styles and conventions, which become increasingly difficult to maintain over time. This accumulation of debt becomes a hindrance to growth. However, by employing a design system, product teams can keep design and code overhead to a minimum, remain within budget, and continue to expand and improve the product.

Incorporating agile and growth hacking strategies necessitates acknowledging the importance of design systems in empowering product teams to *prototype* and *iterate* more efficiently. By utilising a design system as a basis, designers and developers can construct flows and interactions easily, allowing many prototypes and variations to be created for experimentation. Consequently, data and insights can be gathered more quickly, expediting further iterations. Moreover, developers can save time by minimising

the amount of code needed, from a hundred lines to a few characters. This streamlined approach expedites the experimentation process, making it happen faster.

Lastly, effective design systems value **USABILITY** and **ACCESSIBILITY**, and their implementation can be expedited. Inconsistencies in interface conventions can impede usability, but a design system can overcome this by creating a comprehensive component library, saving quality assurance time and surpassing the limitations of frameworks or tooling [51, pp. 91–95, 117]. Design systems are constructed from individual atomic elements, much like LEGO blocks. It is imperative to implement accessibility at this level to optimise the product for supporting disabilities, varying connection speeds, and hardware variations [58, pp. 15–16].

Atomic design: Atomic design is a design system approach formed by Brad Frost [59]. It is composed of five levels inspired by the periodic table of elements in chemistry. These levels are arranged from the lowest to the highest and comprise atoms, molecules, organisms, templates, and pages.

2.1.3.2 Challenges of Design System

One of the common myths is that a universal design system may not adequately cater to the needs of multiple areas within an organisation [58, p. 17]. For example, Metso has digital and industrial products, but each requires high-quality and industry-specific design standards. Nonetheless, inclusiveness is a vital principle that can facilitate the creation of new solutions that can be incorporated into the system. This approach can compensate for customised solutions in specific areas and reduce design and technical debts.

To sustain consistency and growth, a design system must be subject to careful consideration. However, the process of updating the design style can pose significant risks insofar as it diverts resources away from new feature development and may negatively impact usability [58, pp. 18–19]. Despite these challenges, the components of a design system remain robust and reliable. For instance, in Figma design, the main component and its subsidiaries are interdependent, meaning that changes made to the main component are automatically inherited throughout the system. This principle ensures consistency, reduces the hourly budget, and increases work efficiency.

Apart from the common misconceptions surrounding design systems, their working methods and utilities also present some challenges. For instance, some of the popular image-based design tools like Figma and Sketch have limited interactive prototyping capabilities, which can be a hindrance from a design perspective. As a workaround, designers may resort to using plugins or creating custom solutions to supplement these tools, resulting in increased costs and complicated workflows. Consequently, the design system is not a *single source of truth* in its gut but one step away from becoming a fully integrated system that utilises only one library.

In practice, design system documentation is crucial for any design system team. According to a study by UXPin, it is also the biggest challenge in terms of design system maturity for most organisations. Documentation is essential as it helps in training, buy-in, and workflow with usage guidelines and concept rules. This, in turn, increases adoption and ensures product teams deliver a consistent UI experience.

However, unlike coding works, maintaining and updating a design system and its documentation is a resource-intensive process that can slow down the maturity process. One of the reasons for this is choosing the wrong documentation tool or an ineffective execution. For instance, Metso manages multiple design system versions, including two component libraries for developers and a UI kit for designers. This presents another challenge since image-based design tools might require different variations for prototyping or sketching. As a result, managing and updating these resources and platforms requires considerable effort and gradually becomes a governance challenge.

2.2 Human-Machine Interface

This section provides an in-depth analysis of the concept of HMI, exploring its historical roots and current applications. The thesis owner aims to highlight the essential properties of HMI and to emphasise the importance of accessibility and usability by focusing on three fundamental principles: safety, human factor engineering, and high performance. These principles serve as a bridge between the design system and inclusive design, which are the core aspects of this thesis. Finally, there will be a brief discussion of the challenges relating to digital design systems and human factors.

2.2.1 Study of Human-Machine Interface

In 1999, the introduction of the term *humachine* in the MIT Technology Review Special Edition by Benditt [61] marked a significant milestone in the field of technology. This term describes the increasingly synergetic relationship between humans and machines where technology is integrated with human beings to enhance performance and efficiency [62]. It is important to note that the study of HMI bandwidth has been ongoing for several years and has revealed the rapid development of HMI since 1970, as shown in **FIGURE 1**.

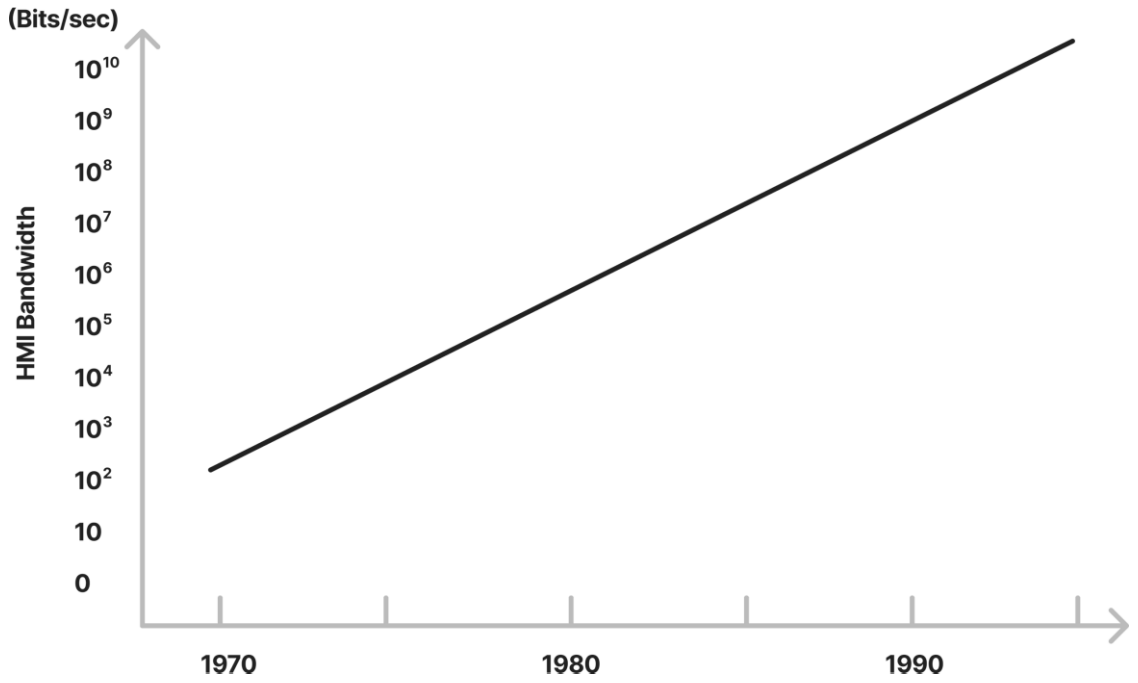


Figure 1. Growth of bandwidth offered by HMIs, reproduced from Fiset [63].

Two decades later, Sanders and Wood [64] presented a detailed definition of the term humachine as a hybrid entity that blends human characteristics such as creativity, intuition, and judgement with the mechanical advantages of machines, such as big data processing and economies of scale. The advent of artificial intelligence (AI) has further strengthened this convergence. By overcoming the limitations and drawbacks of humans and machines, AI capitalises on their strengths, resulting in significant advantages [64].

As technological advancements continue to shape the world, merging humans and machines has gained significant traction. This process aims to synergise both entities' unique strengths and qualities while respecting their identities. The HMI market has witnessed remarkable growth in recent times, reflecting a greater emphasis on human-centricity and the exploration of the human component of technology (**FIGURE 2**). The term humachine encapsulates human's desire to leverage machines' power to augment their capabilities.

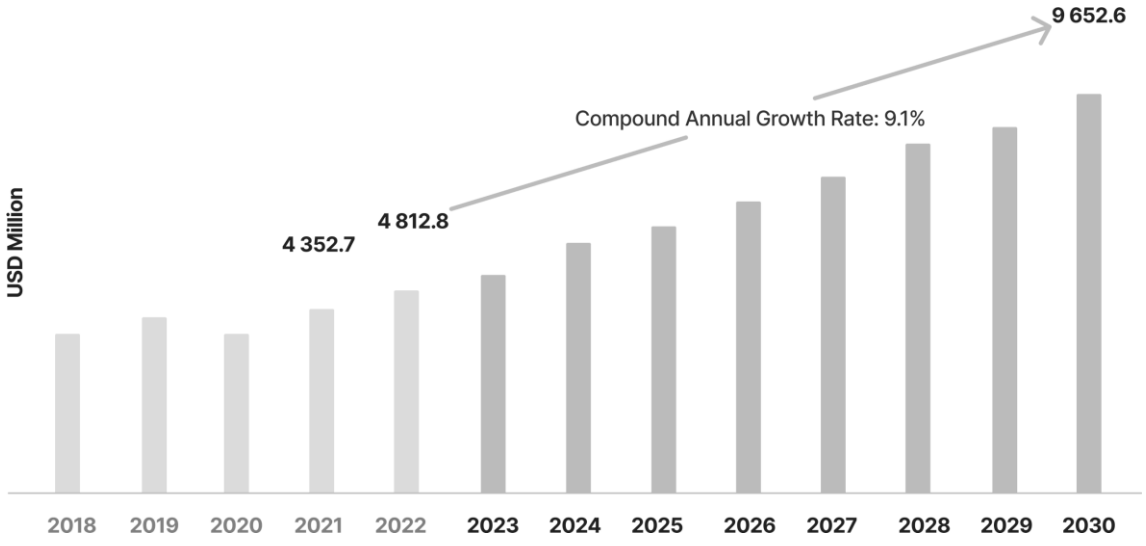


Figure 2. HMI market size during the forecast period (2022-2030), reproduced from Market Research Future [65].

HMI design: Human-machine interface design refers to the process of designing hardware and software that facilitate users in managing and monitoring processes through a control system [5, p. 14,20].

A range of systems utilises HMIs, including supervisory control and data acquisition systems (SCADA), distributed control systems (DCS), and standalone units [63, p. 1]. Fiset [63, p. 1] specifically defines a DCS as a computerised and resilient control system that is designed for continuous and complex batch processes. It comprises multiple independent controllers spread throughout the system, without any centralised operator supervisory control [5, p. 13].

On the other hand, SCADA is a computerised system specifically designed to monitor and control geographically dispersed processes [63, p. 1]. The system comprises various components for acquiring, processing, transmitting, and displaying necessary process information [5, p. 16].

However, SCADA systems present unique communication challenges due to the various media types that must be utilised, such as phone lines, microwaves, or satellites. These challenges can result in delays or data integrity issues [63, p. 1]. In addition, SCADA systems are typically shared rather than dedicated. Lastly, a stand-alone unit is typically an embedded system that performs predefined tasks, usually with specific requirements. Therefore, to ensure the smooth functioning of SCADA systems, it is essential to address the communication challenges and to design the system with a clear understanding of its specific requirements. [63, p. 2]

The scope of this thesis revolves around the study and further discussions of HMI designs intended for HMI designers and developers. Specifically, primary users are those directly responsible for operating equipment controlled by the HMI, such as field service technicians and operators. Hence, the intended audience belongs to the secondary user category, contributing to operational activities, including maintenance, engineering, or management. Notwithstanding, this thesis can also serve as a point of

reference for product owners and managers to ensure that their designs are in sync with operators and design systems, leading to elevated safety and productivity at a larger scale. To achieve that, it is imperative to identify and comprehend the unique requirements of each user type during the HMI design and lifecycle, as depicted in **FIGURE 3**, as roles and responsibilities can vary across industries and facilities.

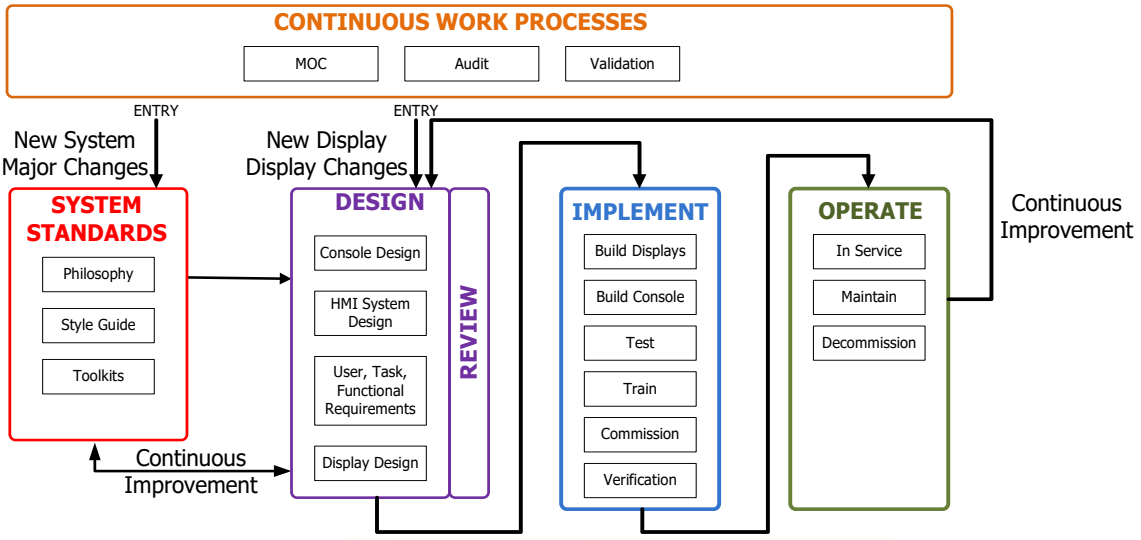


Figure 3. A diagram of the scope of an HMI lifecycle, taken from ISA-TR101.01-2022

2.2.2 Principles of Human-Machine Interface Design

Upon reviewing the previous section, it becomes evident that HMI is closely linked to Human-Computer Interaction (HCI), albeit with a broader scope of machine interactions. Humans have encountered a variety of Human-Technology Interactions (HTI) aimed at facilitating and supporting their interactions. As a subset of the HTI umbrella term, HMI focuses on how technologies enable safe, direct, effective, and trustworthy interactions between humans and autonomous systems in their environment [66].

Furthermore, research has indicated that the human ability to comprehend information has not kept pace with the rapid advancements in HMI technology [63, p. 3]. Thus, the usability of an interface must ensure that users can achieve their objectives without being hindered by personal preferences. In other words, while aesthetics play an important role in HMI design, the primary focus must be usability. So, HMI design principles should aid both users and developers in understanding the underlying principles and technical rationales for effective development, operation, and maintenance.

Ultimately, researchers have studied how ergonomics and human-centred design can improve working conditions in various environments. This thesis emphasises the principle of *ergonomics* in HMI design, which encompasses (1) **SAFETY**, (2) **HUMAN FACTORS ENGINEERING**, and (3) **HIGH PERFORMANCE**, besides other related topics, such as those found in design systems [5, p. 29], [67].

2.2.2.1 Safety

Ergonomics places a strong emphasis on ensuring the safety of individuals [67]. Thus, *physical ergonomics* standards must be implemented in most work environments when designing HMI, thanks to the Occupational Safety and Health Administration (OSHA) [68, p. 313]. In Finland, regional compliance with occupational safety and health laws is enforced by the authorities to guarantee healthy and safe working conditions in accordance with working life legislation [69].

Safety is particularly crucial in hazardous environments such as manufacturing or construction, so Metso's Courier® HMI has published several safety manuals on topics like radiation and the proper use of emergency buttons to shut down machines in alert cases. The design of safety signs in construction has also been studied, with red signs proving to be more easily identifiable with shorter response times than other colours [70, pp. 9–21]. As new technologies emerge, ergonomics has expanded to encompass cognitive ergonomics [68, p. 313].

2.2.2.2 Human factor engineering

Cognitive ergonomics is essential to designing and evaluating occupational tasks like physical ergonomics. It examines human work from a mental perspective and considers the interaction between an operator and a task, which plays a significant role in task performance [67], [68, p. 313]. Mental work measures can provide valuable insight into where task demands may negatively impact human performance, as noted by Bommer and Fendley [71].

Supporting that statement, Galy and Melan [72, pp. 313–325] posit that cognitive load theory (CLT) and multiple resource theory (MRT) can prove to be valuable references for professionals involved in the design and development of HMIs. CLT identifies the limitations of working memory and the three distinct loads that impact it: intrinsic, extraneous, and germane. On the other hand, MRT considers the five resources, namely visual, auditory, cognitive, speech, and motor, that impact human workload and performance in high-pressure environments [73]. Using these theories, HMI professionals can establish design principles that accurately measure the mental workload required to complete a task and optimise human performance [68, p. 314].

Therefore, it is not advisable for an HMI design to assume that operators can recall every detail of a complex system. Instead, an HMI design should make it easier for the operators to comprehend the process and control system, irrespective of their experience level, by presenting relevant information in an easily understandable format [5, p. 29].

2.2.2.3 High performance

As stated previously, the goal of HMI is to ensure that information is effectively transmitted and comprehended by users through visual, auditory, and tactile means [74]. According to Macleod [75], cognitive ergonomics has two major aspects: how people perceive processed information through those means; and how they make decisions

based on this information. Thus, HMI designers and developers must focus on visual perception, as these play a crucial role in enabling humans to observe and recognise critical information.

When it comes to HMI design, presenting information through affordances is important. It involves using various visual elements, such as characters, images, colours, textures, and layouts, to convey programmed, virtual, and lingual information [74]. The key to producing optimal results is to follow consumer-centred and visualisation design principles. These principles are rooted in cognitive psychology and aim to create a seamless and intuitive user experience [74, pp. 263–265].

> **Affordance:** Affordance is the relationship between an object's properties and the capabilities of those who interact with it, such as humans, animals, or machines, which determine the possible ways the object can be used [76, pp. 10–12].

In the design of HMI functions, it is essential to prioritise the end-user experience by creating intuitive interfaces that align with their expectations. Consistency across displays, including abnormal conditions that users are familiar with, is crucial in achieving this goal. A systematic approach to structuring HMI is also recommended, as it helps reduce complexity, simplify human actions and minimise the number of steps required to accomplish a given task [5, p. 29], [74, p. 263].

In critical situations, such as managing alarms, a lack of situational awareness has been identified as a crucial factor in accidents resulting from human error [5, p. 29]. To address this issue, it is recommended to use an HMI that provides real-time updates on the process's current state and optimal performance. By doing so, operators can clearly understand the process status, make informed decisions, and reduce the risk of human sensory system deficiencies leading to potential hazards.

HMI is designed with the intention of providing visually appealing elements and establishing a cohesive and recognisable interface that allows consumers to differentiate between various functions. Practically, a fundamental aspect of HMI design is to avoid visual clutter by utilising simple geometric shapes, minimal silhouettes, and saturated colours. Moreover, designers must ensure that critical elements stand out visually by utilising sharp contrasts with other aspects while still meeting the consumer's needs. To create an optimal HMI design, designers must follow the space-coordination principle, which involves dividing the interface's functional area into reasonable and appropriate dimensions. This results in a less crowded and more comfortable experience for consumers.

In visual design, it is essential to consider the principles of luminosity and colour contrast. According to Gong [74, p. 264], people tend to prioritise bright visual elements over darker ones, which serve as background. Additionally, Fiset [63, p. 9] recommends against using coloured text and suggests that background colour be used for effective colour coding. In practice, appropriate colour combinations should be used to ensure the success of a visualisation HMI. **FIGURE 4** provides examples of both suitable and unsuitable colour matches.

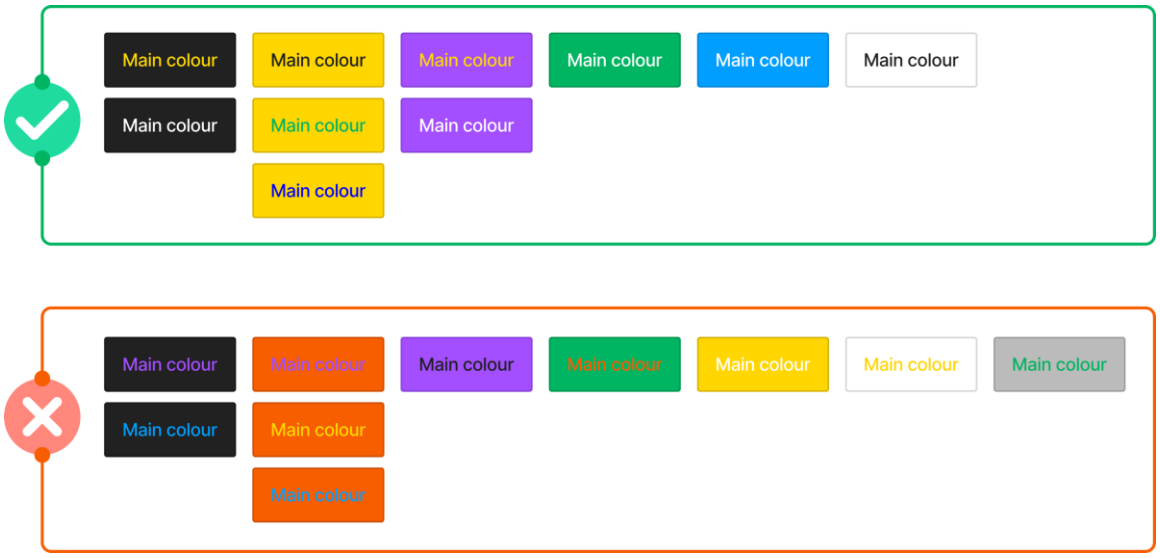


Figure 4. Easy and challenging to distinguish collocation of colour, reproduced from [74, p. 264].

For a successful HMI, a balanced ratio between visual elements and background must be achieved, and primary visual elements must be placed at the centre of the background. Moreover, properly using colours can help users find information and complete tasks more efficiently. However, HMI designers must consider different colours' symbolic and cultural meanings and their potential psychological effects. Combining different colours with symbols, diagrams, or text can enhance cognitive efficiency, interface usability, and user trust and satisfaction. These principles ensure the displayed information is clear and straightforward, enhancing decision-making and task performance while reducing errors [74, p. 263].

In conclusion, the principles of HMI involve understanding users' needs and preferences and machines' capabilities and limitations. Technological advancements in tactile and auditory components now allow designers to integrate these features into visual design, resulting in more natural and seamless interactions between humans and machines. The primary goal of HMI design is to enhance efficiency, effectiveness, and user experience, which requires designers to consider various factors such as the users' cognitive and physical abilities, operational context, and available technology. Adherence to HMI principles and best practices enables designers and developers to create interfaces that promote user satisfaction, productivity, and safety. **FIGURE 5** offers an overview of these principles.

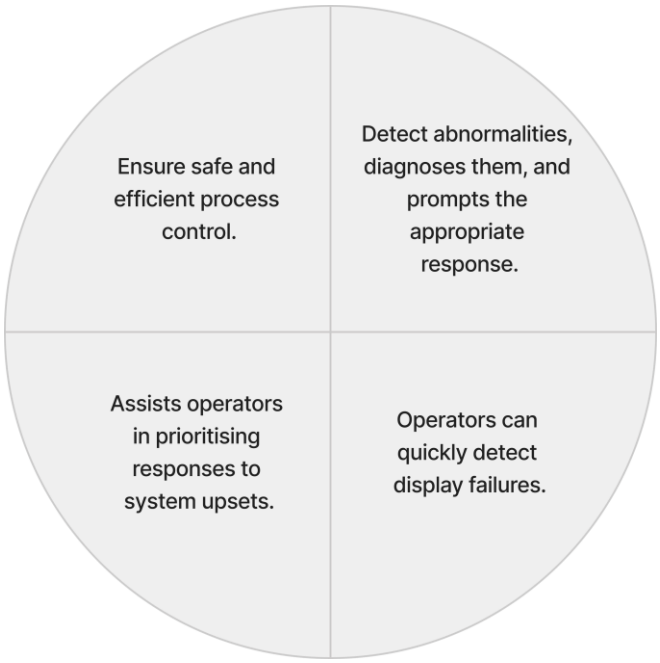


Figure 5. Four HMI principles should be adopted, as recommended by the International Society of Automation [5, p. 28].

2.2.3 Challenges of Human-Machine Interface Design

The preceding section discussed the design principles of HMI and how specific challenges influence them, but mostly from human factors such as cognition, mental workload, and performance. However, these challenges often arise from inconsistent HMI designs that do not follow a standard or widely accepted graphic toolkit. When multiple implementers create their designs, variations arise, leading to issues. Likewise, enhancing existing HMI systems can be a complex process that involves operational and maintenance interviews, review processes, and safety incidents. The governance level is also critical, as it can present difficulties for plant management while providing opportunities and solutions to system owners and end-users. To overcome these challenges, an adequate HMI standard should incorporate objects from a common toolkit and utilise a consistent colour scheme. Furthermore, it is indispensable to consider trends and contextual information to ensure that the HMI design meets the system's requirements. This approach goes beyond merely displaying process and instrumentation diagrams (P&IDs).

After thoroughly examining the **DESIGN SYSTEM** section, it becomes evident that design systems used in an industrial setting must consider additional factors for accessibility requirements, features, and supported technologies. This is particularly important when incorporating HMI design into a design system, as the similarity in design practices emphasises that the usage environment and equipment may vary significantly among users. For example, some users may work in poorly lit environments, while others may have low-resolution or small screens, and some may be required to wear gloves. When creating a design system, it is crucial to consider these aspects to ensure all users can quickly adopt and access it.

Finally, when working towards achieving high performance in an industry setting, utilising component libraries can often involve handling large volumes of incoming data streams [77]. It is crucial to process this data efficiently and accurately, particularly when it comes to charting components within a design system (**FIGURE 6**). For this reason, it is essential to carefully consider and select an existing charting library that considers these factors.

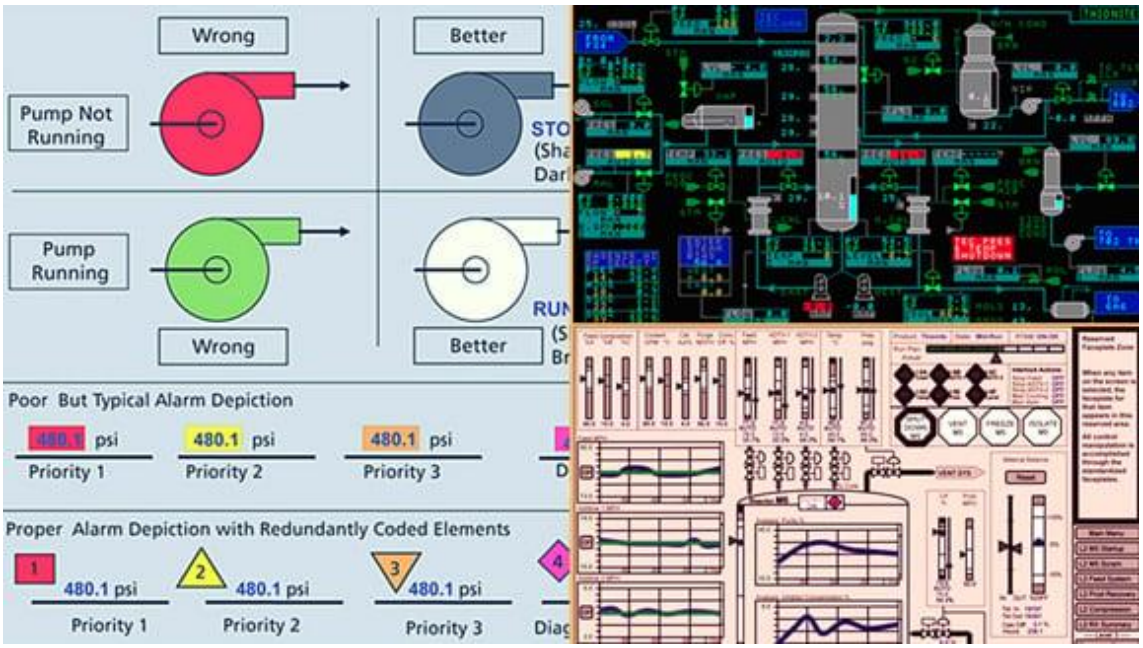


Figure 6. Displaying information in different fashions [78].

2.3 Inclusive Design

In the concluding part of this chapter, the thesis author delves into the concept of inclusive design, which addresses the research question and the secondary focus on cross-cultural design. Three fundamental principles are presented to recommend every product team follow: recognition of diversity, a focus on broader positive impact, and an inclusive approach. This section also examines the challenges associated with inclusive design, particularly concerning design systems and human factors. Additionally, this section provides real-world examples from Metso to better illustrate these concepts.

2.3.1 Study of Inclusive Design

Since the 1970s, inclusive design has been a topic of study in the workplace [79]. The goal is to collaborate with product manufacturers to recognise the market potential in designing products that consider the needs of disabled individuals. To achieve this, exclusionary design features must be identified [80, p. 851]. Legislative changes, such as the EU Employment Equality Directive [21], have significantly required employers to accommodate employees with diverse abilities. Along with the concept of HMI design, ergonomists and design specialists have also developed guidelines and instruments to

assist professionals in designing inclusive workplaces [81]. In 2005, the British Standards Institute officially defined inclusive design as creating products and services accessible and usable by the broadest possible range of people without needing any adaptations or specialised design [82].

> **Inclusive design**: Inclusive design aims to create products, services, and environments for everyone without specific modifications. Designers achieve this by considering the needs of diverse users throughout the design and development process, resulting in intuitive and accessible experiences for all.

The distinctions between inclusive design and other design philosophies, such as design for all or universal design, accessibility, and usability, are significant and must be recognised. Although variances in terminology and standards may exist, the ethical principles underlying these concepts are analogous worldwide [35].

Regarding product design, the other two philosophies - *design for all* and *universal design* - acknowledge the limitations of creating a single product that can cater to everyone's needs. Instead, the goal is to make mainstream products accessible to as many people as possible within the constraints of technology [83]. On the other hand, inclusive design takes a more targeted approach, identifying a specific market for a product and making informed decisions to optimise its performance indicators [82]. While all three methods strive to expand the accessibility of mainstream products, inclusive design acknowledges the commercial realities of catering to a specific target audience.

> **Universal Design:** Universal design (or Design for All) aims to create products and environments accessible and usable by all people, regardless of their age, abilities, or limitations [35, pp. 419–422].

One significant difference is that inclusive design is a method, whereas *accessibility* and *usability* are attributes [84]. By adopting inclusive design, designers and developers can enhance product accessibility rather than simply striving to meet accessibility standards. Ideally, they should collaborate to create experiences that comply with standards and are genuinely accessible to all users.

> **Accessibility:** Accessibility aims to remove any potential barriers that may hinder people with disabilities from having an equal UX. It involves creating an inclusive environment where everyone can access information and services without limitations [85].

> **Usability:** Usability is about designing products for effectiveness, efficiency, and overall user satisfaction of the product. The incorporation of these elements in the design process can ensure that the product is inclusive and accessible to all users [86].

By considering accessibility, businesses can create more user-friendly products that address diversity within the population through appropriate design. The intersection of accessibility and usability is a critical aspect of product design, which is closely related to inclusive design. As demonstrated in **FIGURE 7**, it is essential to have a product that can effectively and efficiently meet the needs of designated users, including those with disabilities, to achieve specific objectives within a particular usage context [86], [87]. Moreover, inclusive design tackles various inclusion concerns beyond disabilities and

compensates for the limited scope of accessibility in addressing broader concerns. Ultimately, embracing the principles of accessibility and usability can lead to greater inclusion, success, and customer satisfaction.

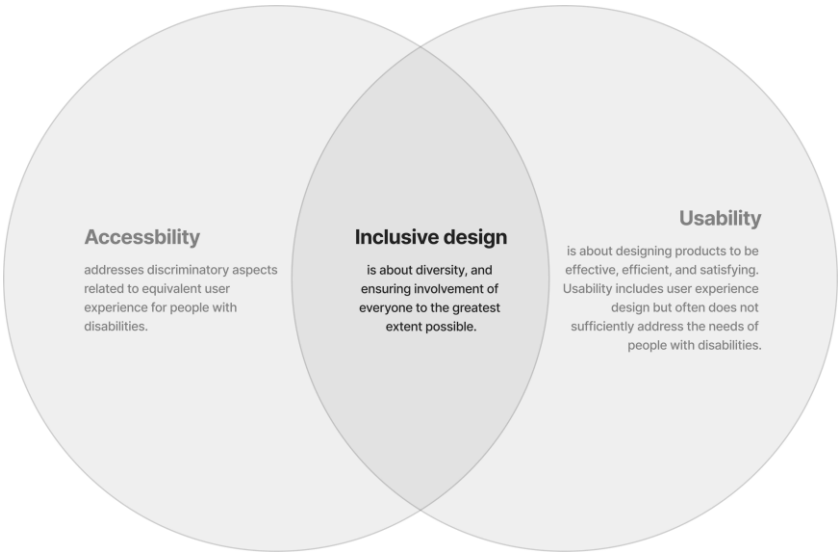


Figure 7. A Venn diagram showing the relationship between inclusive design and other concepts.

2.3.2 Principles of Inclusive Design

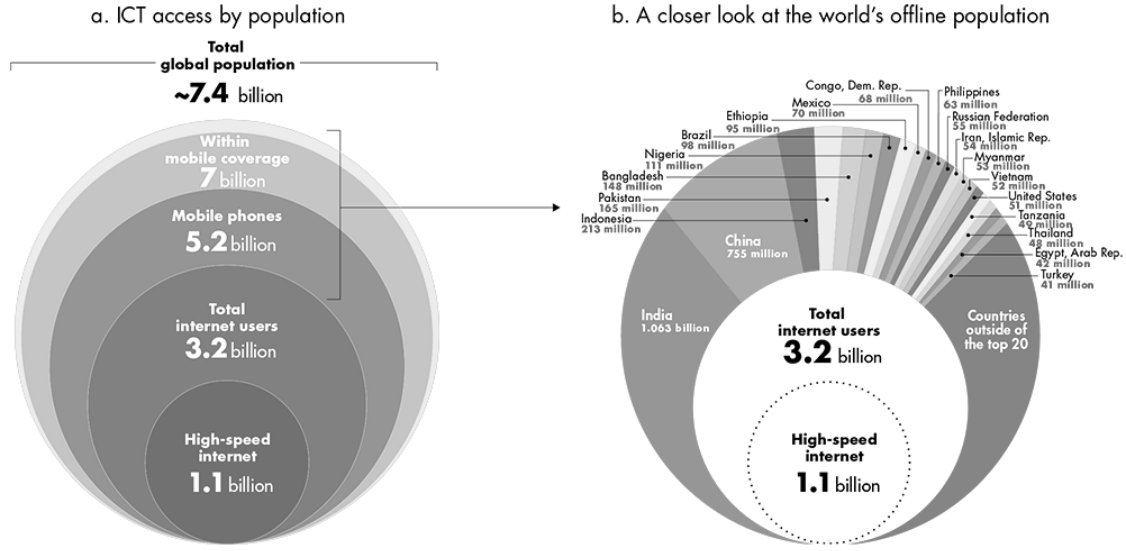
Each design choice has the potential to impact social participation and can either facilitate or hinder accessibility. As such, product designers and developers are responsible for developing inclusive products, services, environments, and experiences. This shared obligation calls for a dedication to three core principles: (1) **DIVERSITY ACKNOWLEDGEMENT,** (2) **BROADER BENEFICIAL IMPACT**, and (3) **INCLUSIVE APPROACH**.

2.3.2.1 Diversity acknowledgement

It is of the utmost importance to acknowledge exclusion that arises when biases related to culture and disability are used to solve problems. A common mistake in modern design is the assumption that all users come from Westernised, Educated, Industrialised, Rich, and Developed (WEIRD) cultures [88]. Unfortunately, this assumption often goes unquestioned throughout the design process, leading to unwarranted discomfort, embarrassment, and offence to users while causing irreparable harm to brands. To create globally used products, development teams must research the impact of each imagery, typography, and taxonomy on various cultures and languages to avoid cultural misunderstandings.

Recognising human diversity as a valuable resource for better design is the first step in this direction. In fact, the internet landscape has significantly transformed since 2015, with nearly three billion new online users joining the global community (**FIGURE 8**). These

users have unique web experiences based on language, device, and bandwidth. Therefore, products must be physically, cognitively, and emotionally appropriate for each user.



Sources: World Bank 2015; Meeker 2015; ITU 2015; GSMA, https://gsmaintelligence.com/; UN Population Division 2014. Data at http://bit.do/WDR2016-FigO_5.

Note: High-speed internet (broadband) includes the total number of fixed-line broadband subscriptions (such as DSL, cable modems, fiber optics), and the total number of 4G/LTE mobile subscriptions, minus a correcting factor to allow for those who have both types of access. 4G = fourth generation; DSL = digital subscriber line; ICT = information and communication technology; LTE = Long Term Evolution.

Figure 8. Statistics on Internet access as recently as 2015 (*World Development Report 2016: Digital Dividends*)

In response to this challenge, Google launched the Next Billion Users (NBU) initiative. The initiative provides insights from 26 topics to improve the internet experience for everyone [89]. By leveraging these insights, businesses and organisations can design accessible products for all users, regardless of their backgrounds or abilities.

In addition to modern global digital audiences, design methodologies should also focus on cultural facets and how they inform design decisions in the long term: the interface as cultural products and the identity factors (**FIGURE 9**). Due to the irrelevance, the theory of cultural dimension is not discussed in this thesis.

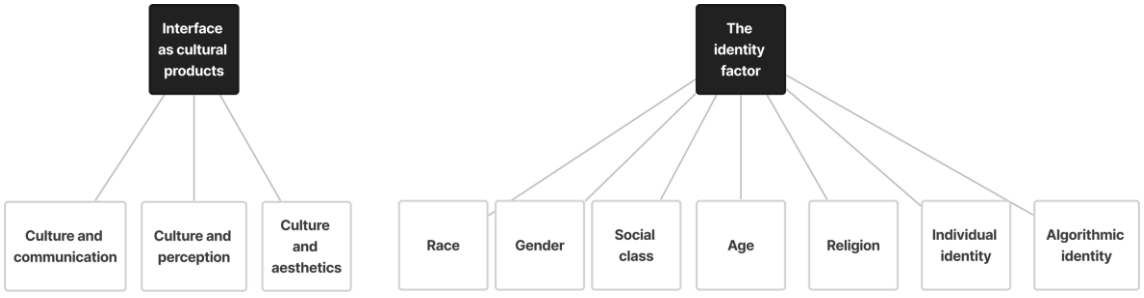


Figure 9. Facets of culture [88].

Cultural products, which refer to digital interfaces that facilitate human social activities, offer valuable insights into preferred methods of communication, social norms, perceptions, and aesthetics [90]. Well-designed interfaces reinforce people's communication preferences and influence their perception of design and content. Different societies may have varying expectations from digital interactions, interpret information differently, and hold diverse mental models. Hence, it would need to be more accurate to assume that mental models are fixed within the same country or culture, underscoring the importance of the research [88]. By conducting thorough research, designers can deliver aesthetically appealing and functional products and experiences that cater to cross-cultural audiences.

Still, designing for a global audience requires more than producing culturally relevant aesthetics. Designers must also consider users' identities, including race, gender, social class, religion, and personal preferences. For instance, race is based on physical characteristics; therefore, design choices, such as photos and illustrations, can reinforce or challenge racial dynamics. Hence, designers must acknowledge this complexity and celebrate individuality as users' identities are nuanced, situational, and ever-changing [88].

Following that, *gender identity* is the perception of oneself in relation to the gender role imposed by society, rather than one's biological sex [91]. *Gender roles*, in turn, are the expected behaviours, attitudes, and expressions that correspond to an individual's biological sex or gender identity. These roles are externally enforced, similar to those of race [88]. Consequently, it is crucial for designers to empower accurate representation of users' gender identities. This can be achieved by providing users with multiple approaches for controlling their names and representation in digital spaces, as well as transparent identity records and data management [92].

Likewise, social class is a multifaceted construct that varies significantly across cultures and is commonly associated with an individual's level of society, often determined by birth or aspirations and linked to wealth and power [88]. Thus, targeting influential individuals and focusing on social status is crucial during the marketing phase.

Age identity is closely intertwined with social class, as it reflects how different age groups interact and communicate, shaping a shared identity that defines their generation. In contemporary times, younger generations tend to adopt emerging technology more quickly than their seniors, approaching it with innovation and fresh perspectives [93]. As such, interface designers must provide pathways for users to define themselves while ensuring that the interfaces are user-friendly and cater to the needs of all age groups.

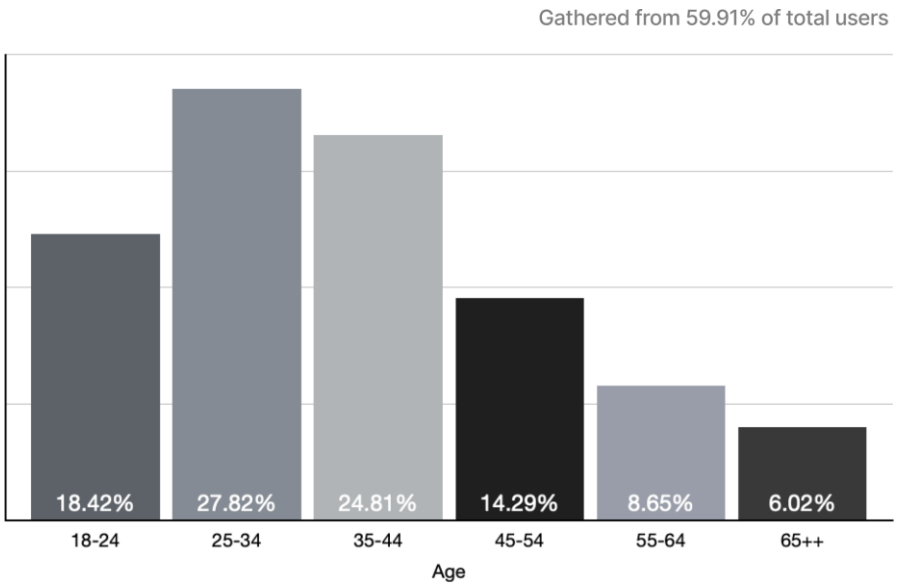


Figure 10. An overview of Modes style guide audiences, retrieved data from Google Analytics.

Lastly, *algorithmic identity* is a phenomenon that occurs when an individual's identity transitions to the digital realm and gradually becomes filtered, categorised, and monitored [94]. As designers, it is essential to exercise caution and avoid enabling this subtle form of legislation, whether deliberately or accidentally, to ensure that users always retain access to and control over their digital identities [88].

When it comes to designing HMI, the ultimate goal is to create specialised products that cater to the diverse needs of users. HCI deals with the interaction between users and machines, while economics offers a way to incorporate UX thinking into the industrial process. The design process involves visualising and implementing targeted experiences, while cross-cultural studies provide designers and researchers with a basic understanding of human thought and behaviour. It is best to approach design problems by defining the specific issues at hand, especially for those with disabilities, and exploring which concepts can help resolve these problems.

Displayed in **FIGURE 11** are the various levels of abilities present within the population. The base represents individuals without any challenges, and the severity of obstacles increases as one moves upward. Inclusive design endeavours to broaden the target audience by integrating individuals with varying abilities while acknowledging that unique solutions may be required to cater to the needs of those with more significant obstacles. To achieve this, a range of products and derivatives can be developed to serve a diverse population, each with a specific target audience. This approach can enhance the UX for a wide range of customers in different situations by reducing the level of ability required to use each product and addressing points of the disablement exclusion [82], [84, p. 20].

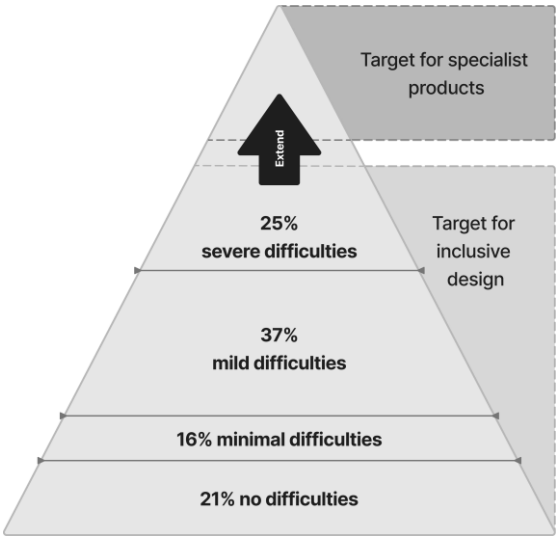


Figure 11. The pyramid model showing a range of population diversity was reproduced based on a Microsoft 2003 survey.

In the past, disability was considered a personal characteristic [84]. However, in 1980, the World Health Organisation (WHO) redefined disability to cover any limitation or deficiency in capacity due to an impairment that hinders an individual from engaging in activities regarded as standard for a human being [95]. This aligns with the medical model's view of disability as a quality of the individual that arises from a health condition and necessitates medical attention [96].

In modern times, the notion of disablement encompasses more than just physical well-being. As outlined by the International Classification of Impairments, Disabilities, and Handicaps [97], disablement comprises three distinct dimensions that detail the reaction to or encounter with the effects of illness, injury, or disorders at varying levels. These dimensions include impairment, disability, and handicap, which relate to the body, individual, and society (FIGURE 12).

Impairment: Any abnormality or loss of physiological or psychological function refers to an impairment in the health [97, p. 3].

Handicap: In healthcare, handicap is a disadvantage caused by a physical or mental impairment or disability. This disadvantage limits or prevents a person from performing normal activities based on age, gender, and social and cultural background [97, p. 3].

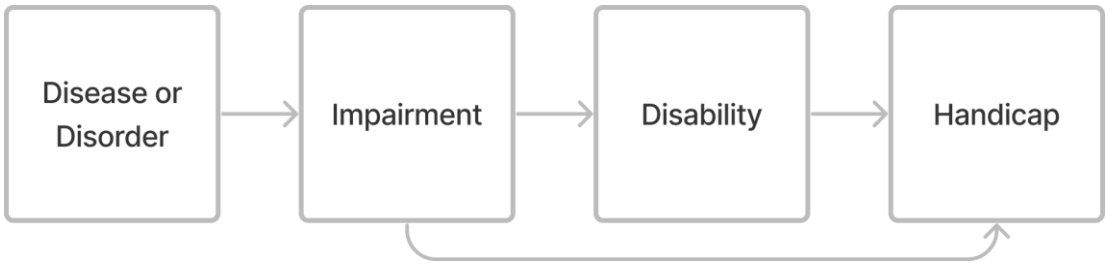


Figure 12. Links among the three ICIDH concepts of disablement.

It is now established that temporary or situational factors can hinder an individual's abilities, including situational impairments, activity restrictions, and participation limitations. For example, a short-term injury, language barriers, or environmental factors such as weather conditions or noise pollution can negatively impact an individual's physical, cognitive, and social well-being, resulting in their exclusion from equitable participation in society [84, pp. 16–18], [98, p. 18].

The International Classification of Functioning, Disability and Health [96] recognises social exclusion as the central model of disability, framing it as a problem created by society rather than an individual's attribute. Disability prevalence can increase due to various factors, such as socioeconomic deterioration caused by financial crises, such as the one in 2008/2009, and the COVID-19 pandemic, which can lead to activity limitations and disabilities [98, pp. 22–23], [99]. Within two years, these crises can turn temporary health issues into permanent disadvantages for vulnerable adults and older workers [98, pp. 23–26].

In addition, the technology industry continues to move towards mobility, there has been an increase in moments of disability. Though the numbers go up every year, the internet and mobile coverage remained unavailable, inaccessible, and unaffordable to about half the world's population in 2015 (**FIGURE 8**). Interactions with technology rely heavily on a human's five sensory perceptions and cognitive skills. With the rise of mobile technologies, situational limitations have become more relevant to people than ever before. This prompts the question of whether humans must adapt to technology or vice versa. Therefore, it is critical to address disability through political action that can make physical and social environments more accommodating.

Overall, humans exhibit an exceptional capacity to adapt to varying situations, providing valuable insights to product development teams that take the time to comprehend these adaptations [84, pp. 27–28]. These insights often emerge when experiences deviate from their intended outcome. For instance, a user's emotional response may differ from what designers had envisioned, even if the user has all the necessary abilities to use the product. Moreover, design diversity encompasses empathy, a critical component in building inclusive and accessible products. Mere simulation of different abilities is inadequate; product teams must invest time in learning about users' experiences from their viewpoint to understand how people adjust to the world around them genuinely. This approach enables designers to identify the barriers that people face and the common motivations they share.

"Empathy fuels connection. Sympathy drives disconnection," says Brené Brown, Professor.

2.3.2.2 Broader beneficial impact

The second principle of inclusive design emphasises creating solutions catering to universal human needs. Designing for inclusion means addressing the diverse spectrum of abilities and limitations that individuals may face. Inclusive design creates solutions that benefit everyone, regardless of their abilities, by connecting individuals with similar circumstances. While designing interactions, it is important to account for exclusion experienced by users.

Designing solutions for individuals with permanent disabilities may initially appear to be a limitation. However, such designs can benefit a wide range of people. For instance, features like closed captioning can benefit the hard-of-hearing community and individuals in crowded places. Similarly, high-contrast screen settings, designed primarily for individuals with vision impairments, can be useful for anyone using a device in bright sunlight. This approach is known as the persona spectrum, as named by Microsoft [84, p. 40].

The *persona spectrum* is a valuable resource that facilitates understanding the diverse needs and motivations of individuals across various circumstances, whether permanent, temporary, or situational. This tool is instrumental in cultivating empathy and designing effective solutions that cater to a broad spectrum of people. It is crucial to note that no one exists in isolation, and the persona spectrum acknowledges this. The *persona network* comprises a wide range of individuals, including acquaintances, family members, colleagues, and even passers-by. [84, pp. 43–44]

TABLE 1 has been thoughtfully crafted to encompass crucial insights, complemented by Metso's illustrative representations depicted in **FIGURE 13** respectively. Metso has always placed paramount importance on fostering a diverse, inclusive, and psychologically secure work environment, with a particular emphasis on neurodiversity, anti-racism, women in mining, and LGBTIQ+ inclusion. It is worth noting that the persona spectrum solely highlights cognitive diversity, as it is intricately associated with neurodiversity, as evident from **FIGURE 14**, and not the other three themes.

Table 1. Persona Spectrum, inspired by [84, pp. 38–42]

	PERMANENT	TEMPORARY	SITUATIONAL*
MOBILITY	One arm Quadriplegia	Arm injury, arthritis Spinal cord injury	Tactile constraint due to holding other items while checking inside a mil. **FIGURE 13A**

	PERMANENT	TEMPORARY	SITUATIONAL*
VISION	Blindness Low vision** Partial vision** Colourblind	Cataract Rubbing causes blurry eyes One eye covered Transient achromatopsia	Vision constraint due to dark and dusty environment. FIGURE 13B
AUDITION	Deafness Profound hearing loss Partial hearing loss	Ear infection Temporary hearing loss	Audition constraint due to industrial noise-cancelling headphones and face masks. FIGURE 13C
SPEECH	Non-verbal	Laryngitis Speech impediment Foreign languages	Speech constraint due to different accents. FIGURE 13D
COGNITIVE	Dyslexia Autism** ADHD** Bipolar**	Stroke Low literacy Anxiety Depression PTSD	Cognitive constraints due to diverse abilities, thinking styles, and learning approaches. FIGURE 13E
	***Lifelong symptoms or cannot be corrected with supportive gadgets or surgery [100], [101].*		**Machinery industrial and international organisational contexts*
	Total: 87M (25%) European adults [102]		

a

Image description: Field service employee checking trommel screen inside the mill at a mine in Canada.
Copyright: Metso Corporation

b

Image description: Staff in a site in Austria.
Metso - Koralmbahn
Copyright: Metso Corporation

c

Image description: Photoshoot images from India case study for aggregates.
Copyright: Metso Corporation

d

Image description: Metso people photographed in office and factory in Brazil.
Copyright: Metso Corporation

e

Image description: Metso people photographed in office and factory in Brazil.
Copyright: Metso Corporation

Figure 13. Metso Corporation's case studies contain copyright-protected examples of situational impairments.

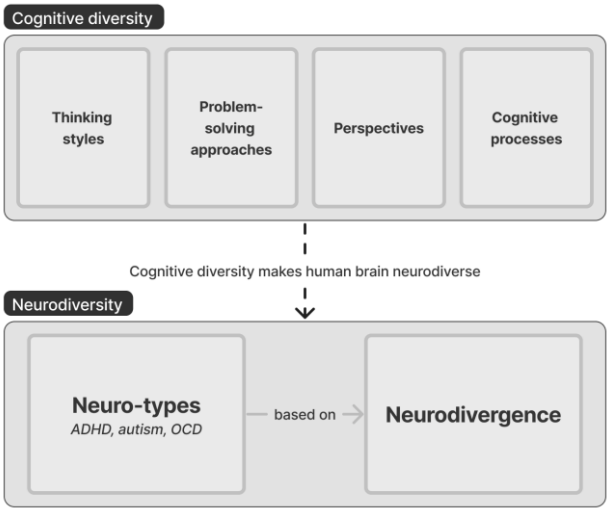


Figure 14. The difference between neurodiversity, neurodivergence, neuro-types, and cognitive diversity [103].

2.3.2.3 Inclusive approach

As previously discussed, inclusive design prioritises human diversity through perspectives and practices. Traditional UCD techniques, such as personas, scenarios, and usability testing, effectively understand human needs but often fail to consider diversity. In contrast, inclusive design embraces diverse perspectives and participation, accessible design, and development tools throughout the design process (**FIGURE 15**).

To implement inclusive design in existing design processes, developing a toolkit or set of guidelines is recommended based on the three principles outlined in this thesis [84, pp. 54–55]. This toolkit should complement existing iterative and heuristic design processes, evaluate them, and introduce new practices simultaneously.

Designers learn through experience and have access to various human-centred design methods from different sources. Therefore, the inclusive design toolkit should continuously evolve and become the primary direction for the design process to enhance inclusivity.

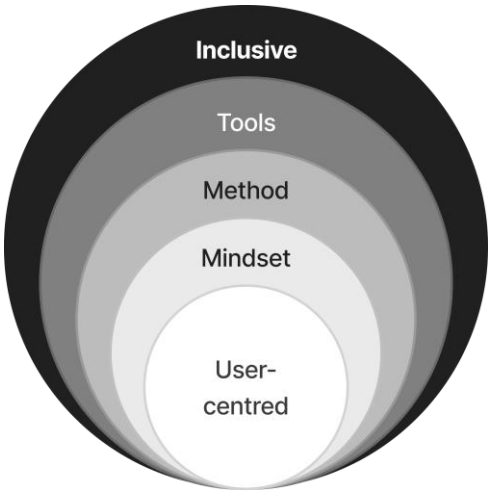


Figure 15. From inclusive mindset to action, reproduced from Microsoft [84, p. 50].

2.3.3 Challenges of Inclusive Design

Creating inclusive designs necessitates designers having a deep comprehension of user needs and potential barriers to access. However, this can be a challenge in cases where designers are unfamiliar with specific disabilities or cultural backgrounds. This raises a pertinent question: what if designers cannot surpass standardised guidelines to produce more inclusive products? This becomes even more critical with the EU's new accessibility directive coming into force by 2025 [104]. While some current acts and standards have addressed social and cultural exclusion, they need to adequately equip designers for the multitude of barriers and various abilities that should be considered in the design process and solutions. Therefore, designers must take responsibility and educate themselves and others to think beyond their implicit biases and understand abilities outside their own [88].

Another challenge is balancing inclusivity with aesthetics and usability. Some design choices prioritising inclusivity, such as larger fonts or more straightforward layouts, may not align with a company's branding or marketing goals. For example, at Metso, professional internationalisation and localisation are critical factors in design and branding; therefore, there is a strict demand for integrating culturally responsive experiences into the design system. As a result, designers must exercise caution when using visual elements like typography, icons, symbols, colours, images, and illustrations to cater to the needs of both users and business stakeholders.

With regards to typography, design systems and branding must steer clear of stereotypography, which is when a typeface imitates a culture or country. Additionally, in a multiscript system, if the font provided by the brand is unavailable in some regions, designers and developers should conduct thorough research to determine which web font can serve as a suitable fallback while maintaining an appropriate visual density and accounting for text expansion factors, mainly when dealing with Chinese, Japanese, Korean (CJK), and Latin alphabets [88].

Every organisation has distinct colours and icons that align with its brand. However, due to cultural filters, some brand colours and icons may impede users from understanding their intended meaning, regardless of the icon designers' intentions or even if they are globally accepted. Therefore, icons should always be paired with supportive text, be customisable, and have a consistent meaning across the design system to ensure they function as expected.

In industrial design, there are a variety of obstacles to consider, such as incorporating design systems and promoting inclusivity. Additionally, the lifespan of a product is a critical issue that demands attention. In the past, control systems were built to endure for at least 10 to 30 years [105]. However, it is vital to incorporate circular acceleration in control systems to allow for upgrades and growth alongside technological advancements, ensuring the product's longevity [106]. This concept is also relevant to digital product design [107], where optimal performance and upkeep are necessary for continued success.

3 Metso Inclusive Design (MID)

This thesis implements a customised design process by combining human-centred and agile concepts. This implies that lean UX and design thinking are valuable additions throughout the work. The customised development process comprises four phases: pre-development, development, evaluation, and post-development. These phases are interdependent and should be conducted iteratively to achieve optimal results.

As part of the post-development phase, the materials regarding the inclusive design system will be refined and included in the next release of the Modes, which is scheduled for 2024. Although confidential insights, research analysis, survey reports, and proposals have been excluded from this thesis, they have been stored in the case company as a digital guidebook and the design system workspace.

As a result, based on the exploration of problems and users, this chapter will answer all four design questions, which are defined to establish a more focused approach for the Metso Inclusive Design as an outcome:

Question 1: What constitutes a design system that can raise inclusiveness with the users and end-users?

Question 2: What represents safety design aspects between the end-users and the machine in industrial machinery product design?

Question 3: How can users be satisfied and encouraged to contribute to the Modes ecosystem by engaging in its content, updates, and high-performance framework?

Question 4: How can Modes enhance customer experiences regarding cultural or localisation needs while maintaining the Metso brand?

3.1 Methodology

By integrating theories of the UCD and agile development method from the Modes team, the improvement project was iteratively deployed through four main concepts: *design thinking*, *lean UX*, *agile*, and *growth hacking .* They are derived from the lean UX schema and an extended lean start-up perspective to enhance the customer experience (CX).

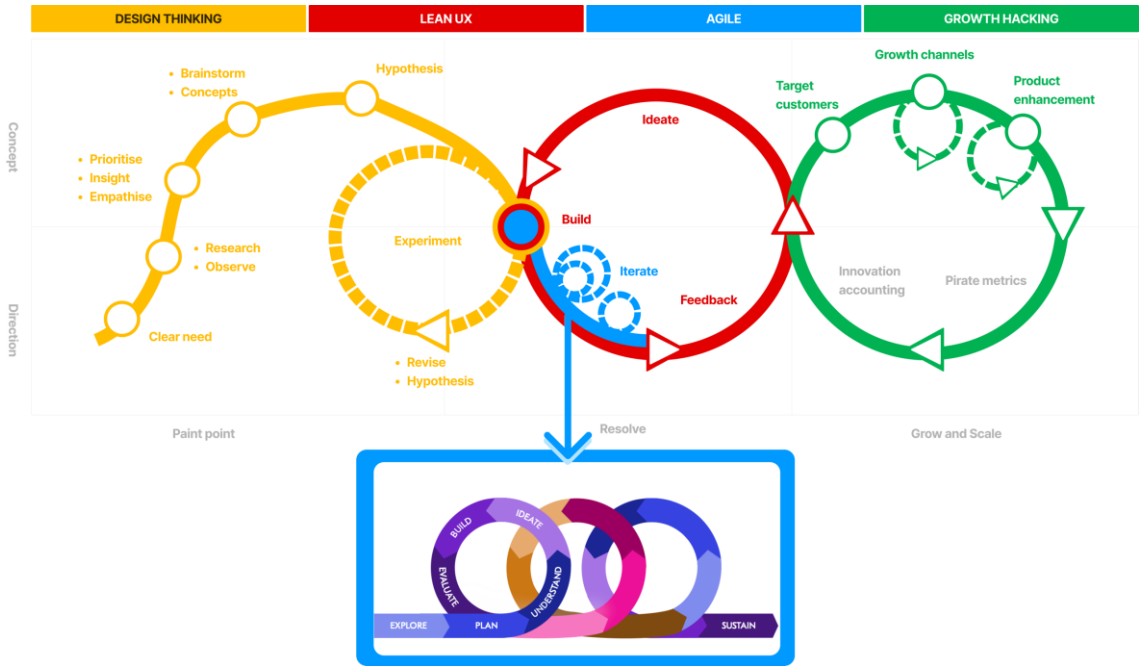


Figure 16. The revised human-centred product development process spans across four concepts.

Design thinking: Part of the UCD approach was employed to identify problems that matter and craft through dialogue and prototype reasonable unique value propositions for Modes (FIGURE 17). Based on the exploration of three important themes of the thesis, the user's fear or pain points were collected and analysed through observation, resulting in business solutions and alternatives. Relevant empirical cases were benchmarked based on research on UX actors in product design and results from multiple visited industrial companies. To better understand the demands and interaction experience of end-users, the studies utilised questionnaires, documentation from Modes and Courier® HMI teams, and relevant design frameworks, revealing the cultural aspect of their experiences. Additionally, workshops and recurring meetings were conducted with product and Modes teams to explore users' thoughts, feelings, and improvement suggestions.

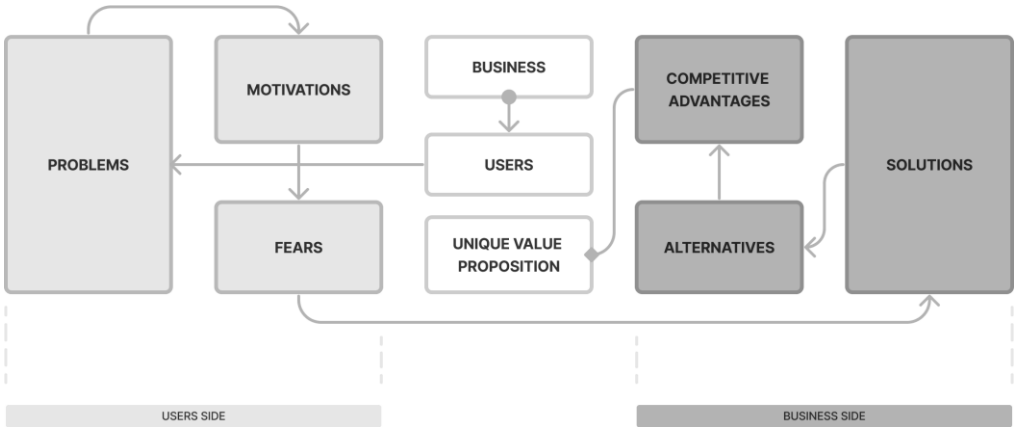


Figure 17. A simplified version of the UCD canvas retrieved from *The Rectangles*.

Lean UX: The thesis project could quickly and iteratively validate the developed inclusive design solutions and business ideas to incorporate continuous improvement by applying the lean methodology [111]. Concrete solutions were conceived through three field visits and sharing and six demonstration sessions addressing the defined questions by leveraging generative toolkits. These activities were associated with problem-driven views and experiences exchange while sustaining flexibility throughout every approach. Together, the participants contributed improvement ideas for the inclusive design system based on their experience and knowledge. The solutions were in the form of minimum viability that guaranteed meeting the users as soon as possible to learn from them while focusing on small batch sizes of stories.

Agile: The thesis incorporated the established operational procedures of Modes to conform with the organisation's objectives and aspirations. The planning and activities were broken down into this anatomy, from bottom to top: story, epic, and initiative [112]. Applying the *scrum* project management framework [8], the thesis was completed in six short iterations (i.e., demonstration sessions or sprints) with development support and refinement feedback and evaluation from cross-functional teams and members.

Growth hacking: The Modes team has been actively engaging in marketing and knowledge-sharing initiatives that extend beyond the scope of this thesis. Since December 2022, they have focused on developing videos and webinar series highlighting the design system's reusable and high-performance assets to reach a large user base and provide helpful information about the design system. The thesis work contributed to that effort, including tracking selected KPIs, developing inclusive design marketing strategies, enhancing user support channels, and improving the inclusivity of Modes.

3.2 Pre-development

The analysis was carried out in two stages: firstly, through discovery (analytics, benchmark, survey, and style guide critique), and secondly, through exploration (survey, focus groups, and card sorting) (FIGURE 18). The study participants shared their valuable

insights based on the available Modes resources, including the style guide, Figma UI kit, React component documentation and demo page, and Web component documentation and demo page.

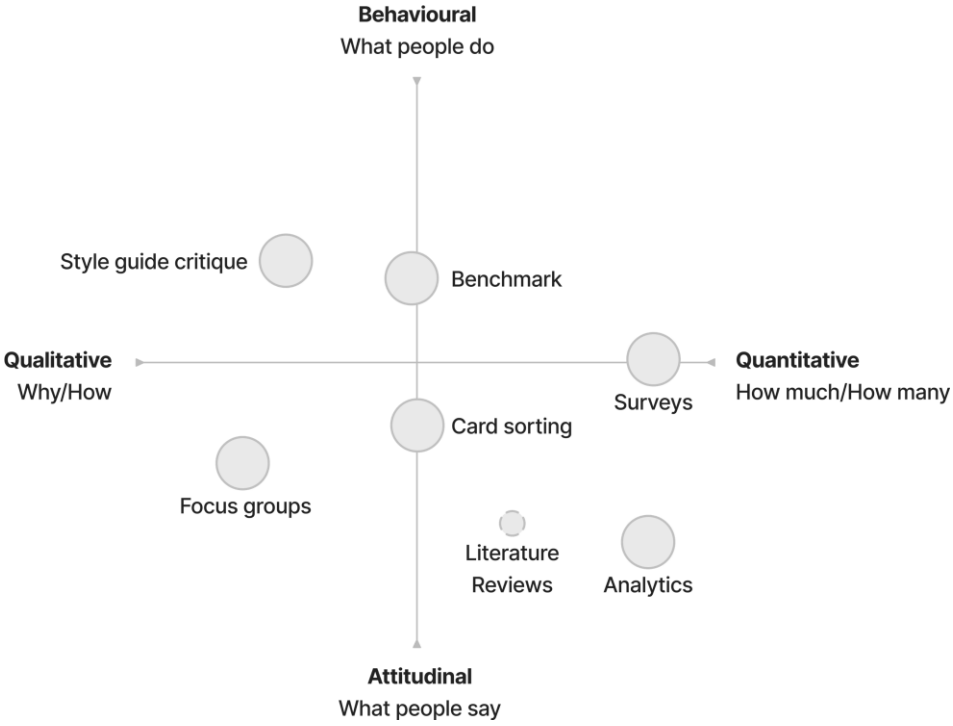


Figure 18. An overview of user research methods used in the pre-development phase.

3.2.1 Business Analytics

Procedure: In this section, Metso's business aspects and strategy, including its vision and mission, will be analysed through public websites and internal platforms exclusively available to its employees. The goal is to create an effective mission statement for Metso Inclusive Design, considering the company's business objectives, branding, and the potential challenges that may arise. Moreover, informal intelligence was gathered during the thesis project. As this information is widely known within the organisation, it will not be attributed to any single source.

Finding: With **300** years of expertise in the mining and metals industry, Metso supports the industry's transformation towards technology-driven productivity enhancement and emissions reduction. Besides, the organisation values its skilled workforce and is committed to driving positive change with its customers. In addition to the section, Metso has a large diversity in culture with more than **90** nationalities of employees. Therefore, it emphasises employee well-being through a committed workforce, robust performance culture and financial performance.

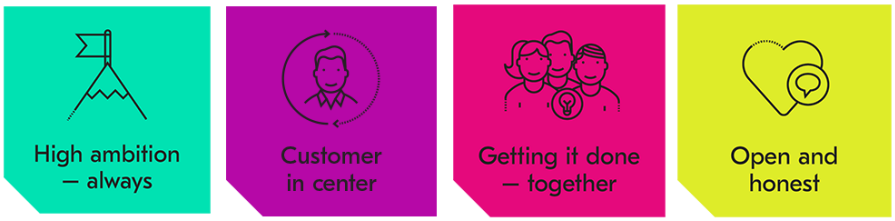


Figure 19. At Metso, certain values guide the company's principles and expectations [16].

Metso has proactively approached diversity and inclusion to shape its culture and values (**FIGURE 20**). This initiative has yielded numerous advantages, especially for this thesis's future works, although it also presents specific challenges due to the diverse range of cultures within the organisation. Individuals perform to the best of their abilities when permitted to be themselves Therefore, Metso's primary focus areas include diversity and inclusion (D&I) within the organisation, the development of a D&I strategy, prioritisation of D&I initiatives, equitable compensation practices, and the psychological well-being of its employees [113].

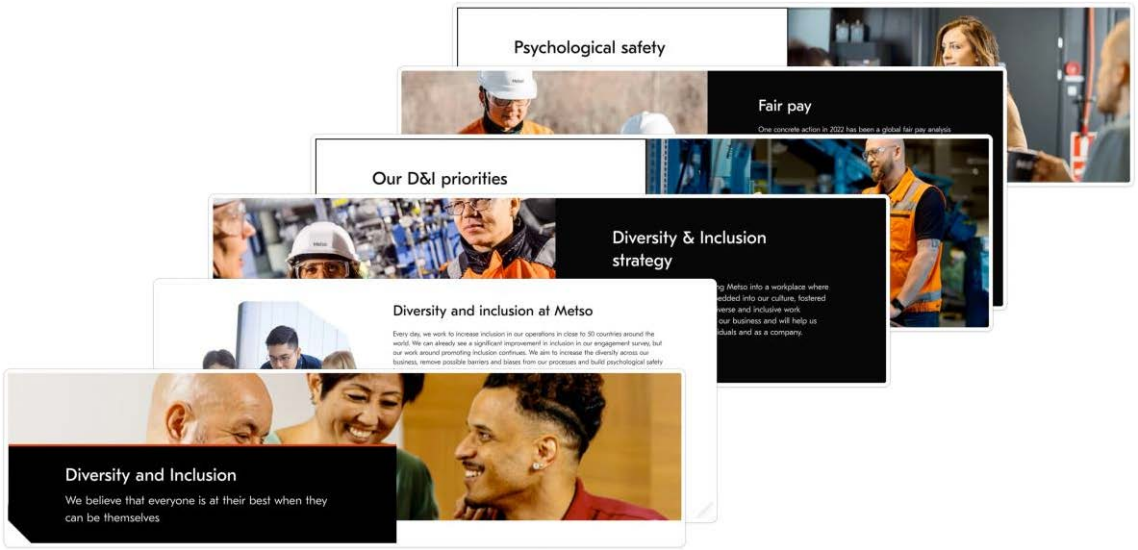


Figure 20. A glimpse at Metso's diversity and inclusion page on their official website.

3.2.2 Metso Brand Identity

Metso possesses a dedicated branding team primarily responsible for upholding a consistent and professional brand image across all communication channels (**FIGURE 21**). The team's responsibilities include developing print materials, organising events, and even designing the interior of Metso's facilities. Also, they have established standards for various platforms, such as promotional posters, pamphlets, and signage, all of which can be accessed through the Metso Brand Hub.

Moreover, the brand team has also created guidelines for web pages in the Metso ecosystem via the Metso Web Guidelines. The branding website prioritises safety and efficiency as the company's core values and aims to be a *partner for positive change*. Since the launch of the design system, the branding and design system teams have been working collaboratively and exchanging valuable information.

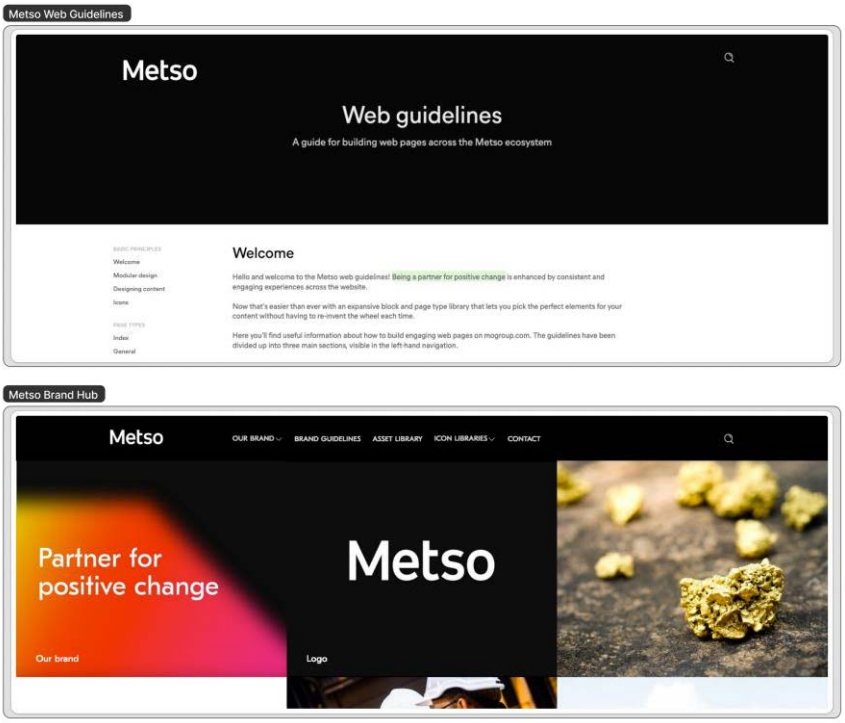


Figure 21. A glimpse of Metso brand identity guidelines.

3.2.3 Metso Design System (Modes)

Implementing a design system offers numerous advantages for product teams, including transitioning to updated branded components while maintaining consistency seamlessly. This allows teams to devote their efforts to enhancing their product. At the same time, the design system delivers a cost-effective solution by providing a comprehensive set of design guidelines, tools, methodologies, and assets to ensure overall efficiency and consistency in developing digital products and services that eliminate the need for teams to create their own (**FIGURE 22**).

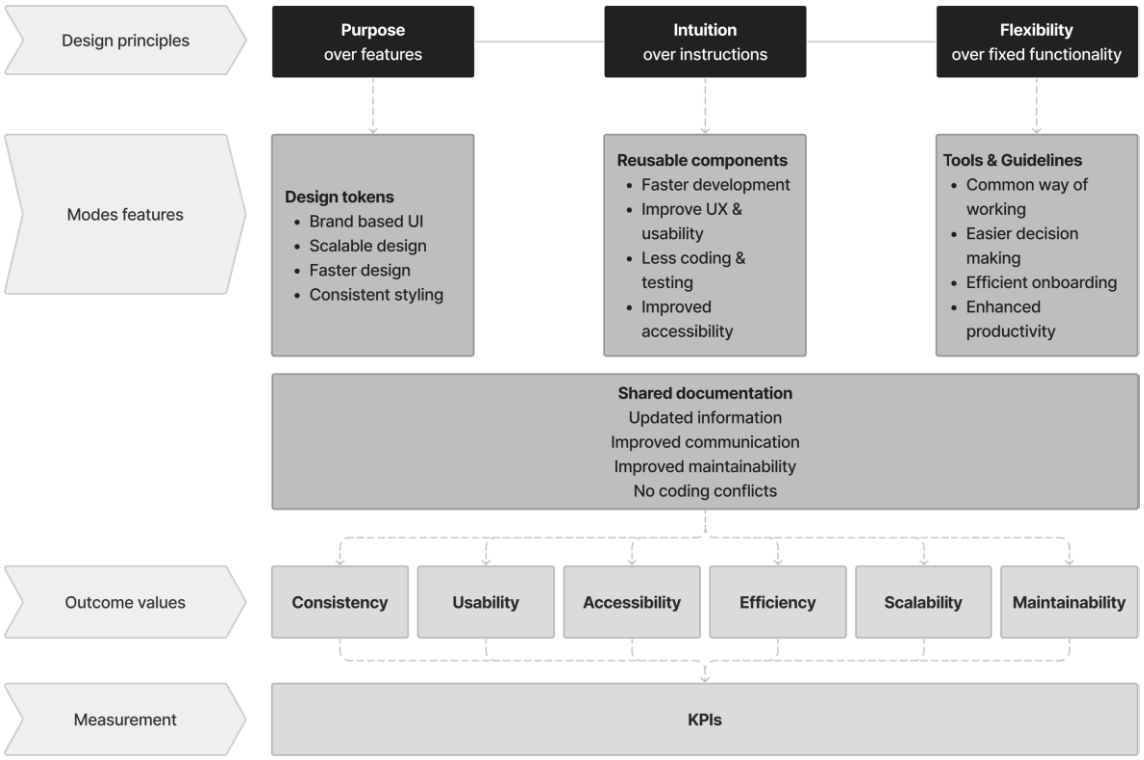


Figure 22. Principles and benefits of Modes (reproduced).

Eventually, Modes has successfully been employed in over **26** reference products, and its documentation has been accessed by numerous users, validating its effectiveness and applicability.

3.2.3.1 Toolkits

Like other design systems, Modes comprises three main components: design, implementation, and documentation (FIGURE 23). The Figma design component serves as the bedrock of the system and provides the basis for implementation. Following it, the React (**DSUI**) and Web (**Modes UI**) component libraries are leveraged to facilitate specific frameworks during implementation. Then comes the last piece, the documentation component, hosted by Zeroheight, which furnishes valuable instructions for usage scenarios and underscores best practices for design and development. Thorough documentation bolsters the efforts of designers, developers, and other product teams working on the system. Additionally, all-encompassing and up-to-date documentation is crucial in preventing issues arising from incorrect usage, consequently saving users time. Overall, it is imperative to seamlessly integrate these three elements to ensure efficient design system development and user adoption at Metso.

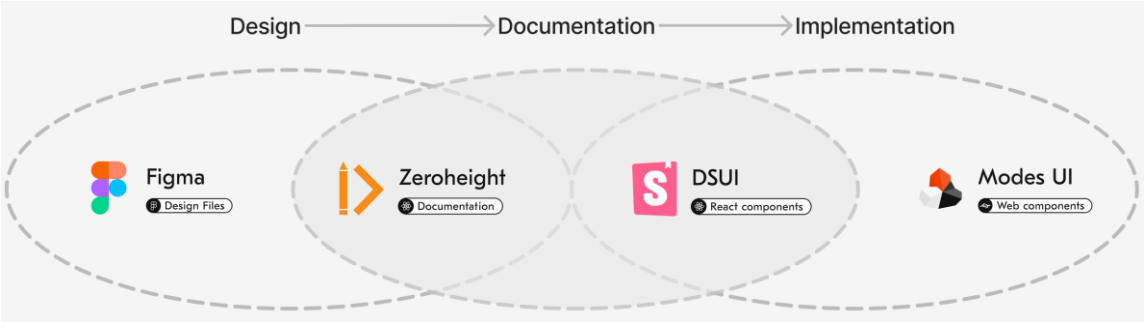


Figure 23. Modes' toolkits in a simplified linear workflow.

Design tools play a critical role in the success of corporations, but obtaining a license can be daunting. From substantial fees to legal agreements and lengthy waiting periods, it can be quite challenging to navigate. Additionally, relying on third-party tools like Figma or Zeroheight can pose complications for design systems, detracting from the goal of a fully integrated system that uses a single library. However, Frost [114] has suggested that vendor and self-hosted solutions can be viable options for creating a design system, and it may make sense to consider a licensed third-party tool in the future. Ultimately, it is crucial to carefully weigh the pros and cons of independent and third-party design system solutions to ensure Modes has the best possible outcome in the long run.

3.2.3.2 Modes' success measurement

So far, Modes is recognised for its organised compilations of principles and reusable design components. It has become an indispensable resource for designers and developers. However, the efficacy of a design system extends beyond its mere presence. Its actual value is derived from its quantitative capacity to generate quantifiable, concrete advantages for an organisation. Therefore, the KPIs are designed to measure two key areas: Design System Adoption and Coverage.

3.2.3.2.1 Adoption

A design system must be adopted by design and product teams to serve their purposes. Correspondingly, the Design System team has systematically collected KPIs to ensure optimal user coverage and improvement. Having joined the group in May 2022 and initiated the thesis contract in March 2023, the metrics presented in the below overview cover the period from June 2022 to March 2023.

Modes Style Guide: The design system team boasts a rapidly expanding global user base, with **340** members across Europe, Asia, and America. Positively, the rate of returning users stands at **69.9%**, indicating high satisfaction and retention.

Component Libraries: The React components, or DSUI, have been downloaded **22,224** times, with **134** downloads for the last version. Meanwhile, the Web components or Modes UI, have been downloaded **6,583** times, with over a thousand downloads for the latest version. It should be noted that Modes UI migrated to GitHub from Azure DevOps in March 2023.

UI Kit: The contribution rate in Figma is computed based on specific actions selected, such as creating a file, a branch, or a team. A total of **64** events have been executed by product team members for the design system, which is a minimal number compared to the view event (**22,579**).

3.2.3.2.2 Coverage

The more comprehensive a design system is, the less likely designers and developers will need to create custom solutions for user interface problems. Hence, the Modes development team has been diligently working towards achieving the adaptability of the Modes product to diverse design inputs. To achieve this goal, they have optimised the product's mobile functionality with the current component set and upgraded the charting components.

Additionally, four themes have been added to the product to ensure compatibility with different environments and lighting conditions (**FIGURE 24**). For example, incorporating a dark mode into a design system can enhance its functionality in dimly lit settings, thereby minimising the luminosity emitted by device screens. Despite this, the feature maintains a minimum colour-contrast ratio, promotes optimal visual ergonomics by reducing eye fatigue, and adapts brightness levels to suit prevailing lighting conditions.

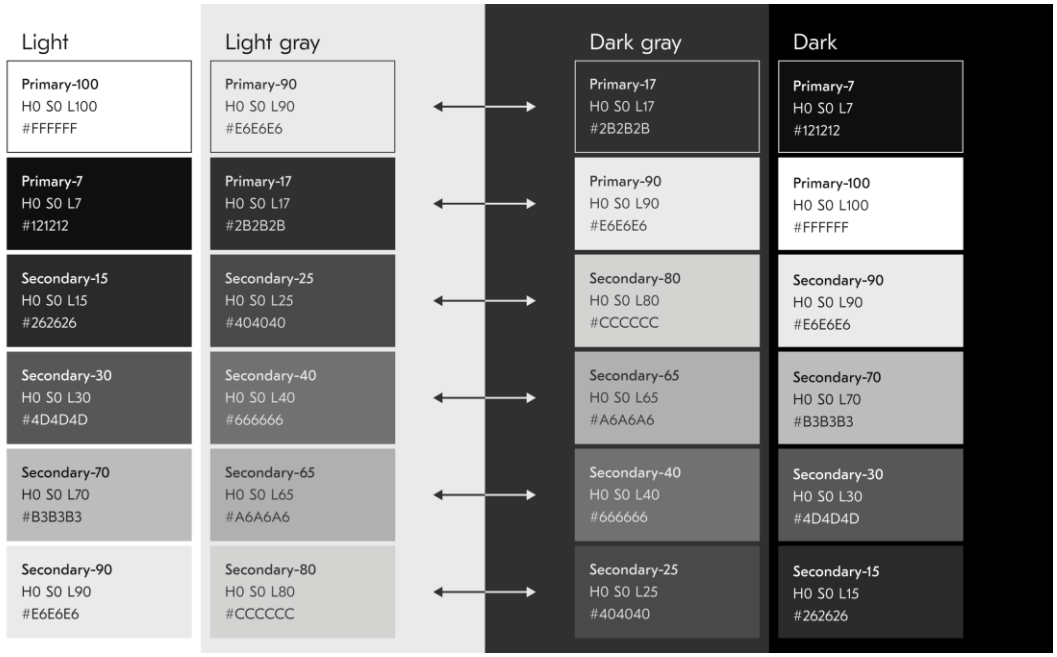


Figure 24. Four themes ensure inclusiveness across various operation environments (taken from the Modes style guide).

As of August 2022, Modes has become technology-agnostic by incorporating Web components into its ecosystem, further enhancing the design system's inclusivity coverage. These Web components have been seamlessly integrated with the current React applications and have contributed to the product's overall efficiency and reliability.

It can be concluded that the central objective of this section is to explore and gain a comprehensive understanding of the resources and works of Modes, thereby planning for inclusivity improvement.

"We are creating a single source of truth of how we want to present Metso for our customers operating our (software) products. Our Design System is a constantly evolving set of reusable design elements for user interfaces in line with our brand identity and UX design principles.", says Piia Alavesa, Product Owner leading the Design System creation with a team of UX Designers and Developers.

3.2.4 Benchmark

It has been observed that several Finnish organisations have recently adopted inclusive design methodologies and systems to cater to a large and diverse audience. According to Salminen , **30** Finnish organisations have either developed or are working on a design system. However, due to these organisations' industry-specific nature, all the listed industrial companies have kept their design systems private. Meanwhile, **12** public design systems are available to the public, education, health, and telecommunication sectors.

Procedure & Data Analysis: To maintain confidentiality, empirical evidence sourced from available literature has been utilised. Accordingly, the following benchmark will apply Google's HEART (Happiness, Engagement, Adoption, Retention, Task Effectiveness) framework, which provides a concise overview of different types of meaningful metrics, to categorise the evidence solely. The evidence is gathered from companies that the Modes team had the company visits: Valmet, Vaisala, and Wärtsilä (TABLE 2).

Table 2. Inclusive design approach at works.

CRITERIA	ORGANISATION	EVIDENCE
HAPPINESS & ENGAGEMENT	VTT Technical Research Centre of Finland	**Eija Kaasinen** (Principal Scientist): The process industry has fewer operators, which means more responsibility for the remaining operators. Inclusive design is crucial for successful UX design, and involving workers early in planning is essential. Integrating new systems into the workplace requires developing work processes parallel to implementing the latest tools for seamless integration. [116] → *Inclusive design*

CRITERIA	ORGANISATION	EVIDENCE
TASK EFFECTIVENESS	Valmet	**Nina Flink** (UX Manager): The automation system should not distract the operator. In high-pressure situations, the user must confidently handle the task. Poor UX affects situational awareness, leading to errors. Good UX is crucial for safe operation. [116] → *HMI design*
	Vaisala	**Sauli Laitinen** (Design Manager): Vaisala established a continuous delivery pipeline with Jenkins, Bitbucket and Jira for efficient software production. Eficode's DevOps consultant automated Vaisala's Design System by integrating testing, documentation updates, and publishing the latest component versions. The result was an optimised and streamlined process that significantly improved efficiency. [117] → *Automated design system*
ADOPTION	Wärtsilä	**Marco Ryan** (CDO): Wärtsilä has launched WeLeap, a gamified micro-learning tool that offers self-paced content to keep employees up to date with the latest technical advancements and the impact of digitalisation. WeLeap is designed to be fun, interactive, and social for maximum engagement and is available on desktop and mobile platforms. [118] → *Inclusivity awareness-raising approach*
RETENTION	Wärtsilä	**Jyri Kulmala** (General Manager of Online Development): Wärtsilä Online's customer portal, built on Amazon Web Services, provides customers easy access to services from any device. Nordcloud's 2-week design sprint helped enhance the portal's visual appeal and user experience, boosting productivity and efficiency. The platform has experienced remarkable growth in user activity due to an increased reliance on online services. [119] → *Adaptive design and business values*

Finding: Upon closer examination, it becomes clear that every piece of evidence conveys a distinct concept. Notably, these concepts seamlessly align with Metso's five pivotal priorities for promoting diversity and inclusion. These priorities encompass a variety of tactics, such as conducting employee engagement surveys, removing obstacles and prejudices, fostering awareness through workshops and communication, and creating an environment of psychological safety.

To ensure these initiatives' long-term success and sustainability, the thesis outcome must be integrated into the existing Modes ecosystem and working methods. For

example, this can be accomplished using the style guide switcher premium feature, included in the enterprise plan for the style guide hosting [120]. This feature empowers users to easily navigate between style guides and access the necessary information without incurring extra costs for the design system team.

Overall, the Metso Inclusive Design approach is based on a foundation of credible information sources. This approach is a sound business decision and reflects the company's unwavering commitment to diversity and inclusion values.

3.2.5 User Groups Analytics

Procedure: Comprehensive data analysis was conducted using Google Analytics, covering the period from July 2022 to February 2023, which spanned approximately eight months.

Data Analysis: Two supplementary surveys were conducted over three months to understand Modes' usability better. These surveys collected feedback from **27** participants representing various job roles within the product teams. Nearly half of the participants identified themselves as developers. Of the 27 participants, 25 (**92.6%**) cited a single job role, while 2 (**7.4%**) identified two or more. The survey results revealed that software developers, product owners, product owners, and software platform users were the respondents' most common job role combinations.

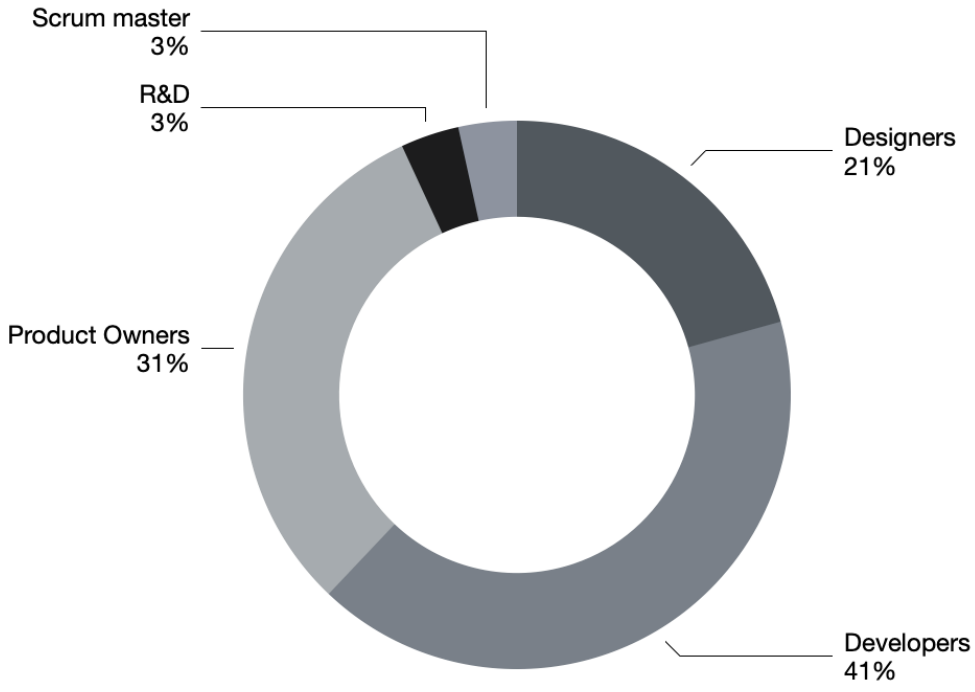


Figure 25. Top roles are using Modes.

Acknowledging the importance of Metso's primary users, specifically product designers and developers, whom consultancies frequently contract, it is essential to establish a productive collaboration between these external users and internal business and product owners. Such collaboration ensures that customer requirements and business objectives are aligned, leading to successful product outcomes that ultimately benefit end-users, such as customers and operators, in their daily operations. As Modes expands, it may also target a tertiary audience. Currently, Modes' resources are primarily accessible through a single sign-on authentication system, allowing users to access multiple independent software systems using the same login credentials [121]. Therefore, these audiences may only participate in selected workshops or special events.

The diagram shown in **FIGURE 26** illustrates the transparent relationship between stakeholders and Modes. Each dot in the graph represents a role directly or indirectly associated with Modes, based on the seven main activities belonging to the three user groups and the design system team.

In the graph, the primary and secondary users occupy more than half of the area on the upper left side. They are responsible for performing various consolidation, support, creation and use activities. On the other hand, the tertiary audiences take up the remaining half and can gain inspiration, benchmarks, and education from Modes.

One needs to learn how to read the heptagon to understand the relationship between these roles and Modes. The closer the dot representative is to the centre of the heptagon, the more influence they have on the design system. Conversely, the further the dot from the centre, the more the design system impacts the stakeholder. For example, Modes is a valuable resource and reference for teachers to educate students. In contrast, the design system requires more consolidated guidelines and instructions from brand and communication managers to maintain the look and feel of the UI elements. As illustrated by dashed outlined dots, product designers and developers can also contribute to the design system.

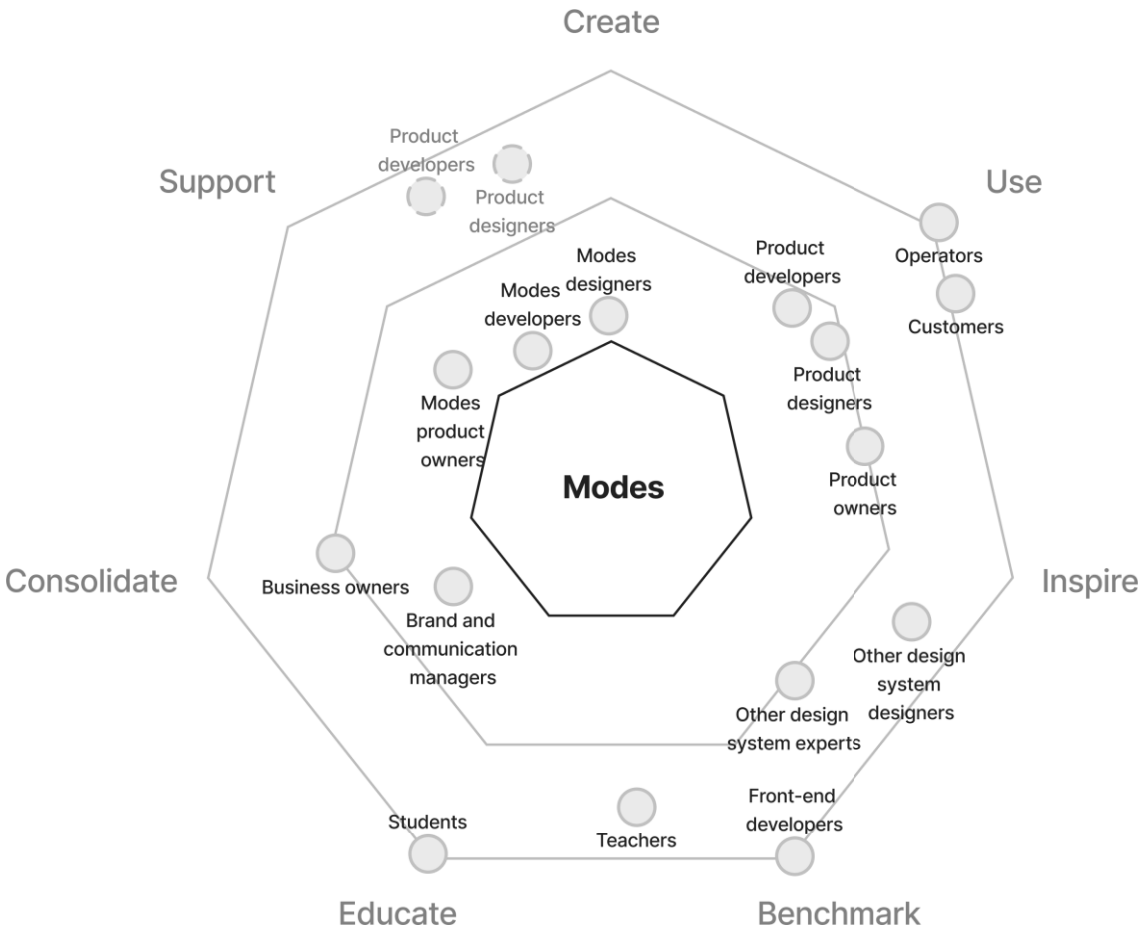


Figure 26. A scatter plot showing the relationship between Modes and its stakeholders.

To ensure the successful implementation of Metso Inclusive Design, it is crucial to consider the demographics of primary and secondary users. This includes assessing their languages and functional requirements for the systems they operate.

For Metso, with its vast global network of offices and partners across five continents with **484** locations, enterprise-wide applications must function seamlessly across international borders, adapt to diverse hardware configurations from various vendors, and cater to the specific needs of local users (**FIGURE 27**). One way to achieve this is by using common open software supporting different national languages. Each locale has its language, characters, fonts, and customs used to input and format data. As this specification outlines, internationalisation technology provides numerous benefits to the global market, enabling any application to run using any locale installed in the system [122].

The analytics revealed that Finland, India, the United States, Australia, and Brazil were the top five countries with the highest number of users. The considerable number of users from Finland and India could be attributed to the vast user base in these countries. Metso's headquarters and design system team are also in Finland, fostering solid ties with domestic product teams and designers in various regions. The diversity of

nationalities among all the users indicates that Modes has reached many Metso offices worldwide.

Figure 27. Metso's locations and partners' details [123].

All companies share a common goal of designing innovative products that meet the needs of their current and potential customers. As a company that aims to reach the top tier like Metso, Metso Inclusive Design and engagement plan should go beyond providing a reader-friendly experience. It also involves considering what humans find appealing, what technology can achieve by understanding standards, and what is economically feasible in this phase [124].

3.2.6 Demo and Design Sessions

Procedure: Between March and September of 2023, a series of six demonstration sessions and twenty-six weekly design sessions were held with primary users. Each session was thirty minutes long and covered many topics, including suggestions from the thesis owner and other participants. Qualitative feedback on the Modes ecosystem and work process was collected from participants and analysed. After that, the card-sorting method was employed to identify critical areas of discussion.

Data Analysis: The initial phase of the analysis involved a meticulous review of the qualitative feedback to develop a comprehensive understanding of the study's objectives. Then, a thorough examination of the transcripts, taking detailed notes on the findings, was conducted. After that, the feedback text was distilled into meaningful units, amalgamating and abstracting similar or associated content into sub-themes. These sub-themes were subsequently linked to a broader theme, presented in TABLE 3, along with the process and outcomes.

Table 3. Content analysis of data from card sorting.

CONDENSED MEANING UNIT	SUB-THEME	THEME
Linkage to implementation from UI kit and style guide	Guidelines	Usability
Inconsistent design showcasing and file structure		
Increase awareness and knowledge on Design System in general		
Lack of flexibility and openness for the next update: “I think some of these guidelines might prove a bit rigid with the upcoming [product update/release].”	Updates	
Lack of notice about updates in style guide		
An increase of new designers and developers	Onboarding	
Logo, icons, and illustration are stored in different places although they are considered as one category	Assets	
Lack of error indicator usage	Templates	
Lack of ready-to-use forms		
Confusion about contribution method and naming branch in Figma: “I’d like to propose a change for the Chart component in Figma to suit my needs better so that I don't have to make a bunch of local variants every time. It's not a big change, but a bit cumbersome to do. So, I guess I should open a branch for that? Should I prefix it with [add] or [fix]? Do I need a JIRA ticket?”	Figma branching	Contribution
User-friendly name for colours instead of tokens: “How should we name the colours easier for the end-users to perceive rather than sequential-red-20?”	Colour	Inclusivity
Lack of accessible colour guide: “I myself suffer from deuteranopia (red-green colour-blindness) and I have noticed that some categorial and event change colours tend to blend for me when red, orange, green and certain shades of yellow are present.”		
Lack of context of use for Modes in digital product	Context	
Base component practice	Component	

CONDENSED MEANING UNIT	SUB-THEME	THEME
Fragile container component with any content within: “The card component is acting up in Figma. When trying to re-size it, the component breaks down.”		High performance
Lack of customisable components’ properties		
Lack of code examples for React component		
Missing icons to deliver correct message/functions	Icon	
Icon set is cluttered and hard for developer to figure out with mismatch naming		
Has problem when being converted to icon font à required labour work from developers to fix each pixel		
Design tokens cover the component-specific level but miss the alias level in between à mismatch role indicated in the token and actual usage in the component	Tokens	
Operator solutions are missing in the design system	Control system UI	

Overall, the product teams at Metso were skilled at following the company’s style guide and found it satisfactory in content and structure (**FIGURE 28**). They appreciated that “there is a design system of this maturity” with “a lot of cool things and common tools which are developed by Modes team […].” However, some group members noticed certain discrepancies between Figma, Zeroheight, React, and Web Components and felt that the ecosystem could benefit from additional “accessibility guidelines” and “the interface of the controllers provided with our equipment that our customer uses every day […].” While respondents found the component design valuable, one recommended incorporating a more comprehensive range of colours beyond black and white. Additionally, there was a suggestion to create “more compact elements and views” instead of designing for individuals with visual impairments, as other systems can incorporate “smaller components where necessary […].”

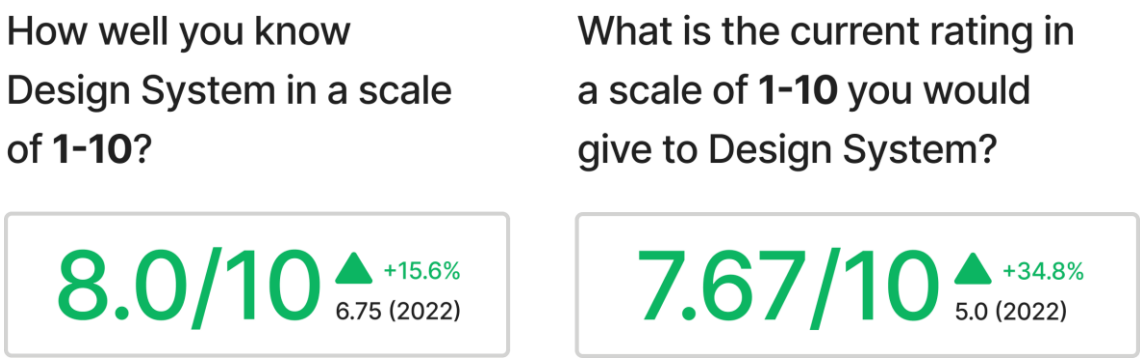


Figure 28. Retrieved ratings from the surveys.

Several areas require enhancement in the current design system. For instance, offering additional context for the examples provided, including details about their testing and everyday usage, would be beneficial. Moreover, the team should strive to provide more comprehensive resources for developers to facilitate their work. Respondents have expressed a desire for "more interactive examples of different components" to understand better how to create the necessary interactions. Another frequently mentioned concern has been the ability to estimate implementation time and have more customisable components during development. Furthermore, one respondent expressed a desire for "more reusability and wider adaptation and use of the Design System both within and outside of Digital Platforms," including access to code for various platforms with expected performance.

Finding: Upon careful analysis of feedback gathered from participants, it has been discovered that offering introductory guidelines and an improvement roadmap for inclusive design in an industrial setting can serve as an effective solution for professionals such as designers, developers, product owners, and control system operators, as they navigate their daily challenges. To this end, the Metso Inclusive Design, comprised of Modes members and assigned editors, ensures the accuracy and value of the information provided to new and experienced users. The outcome digital guidebook and user engagement plan should be user-friendly, providing easy access to information and guidelines and timely updates and support.

Target users' expectations toward the Modes style guide align with their human factors. While developing and using products, they face accessibility, usability, and diversity issues (e.g., visibility in different environments, no context of use, low performance, and designing for localised content). Hence, they tend to regard the Modes style guide as a primary reference to approach first.

A comprehensive understanding of Modes is critical for primary users to enhance the experience for secondary users. A well-crafted and expertly designed style guide can reduce the time and effort required for audiences to find and navigate the content (FIGURE 29). The benchmark expects the outcome to have certain elements, such as inclusive design, HMI design, automated design system, inclusivity awareness-raising proposals, and adaptive design and adhered business values. The analytics also recommend that the guidebook and engagement plan be depicted as a partner to support Metso's Digital Development team.

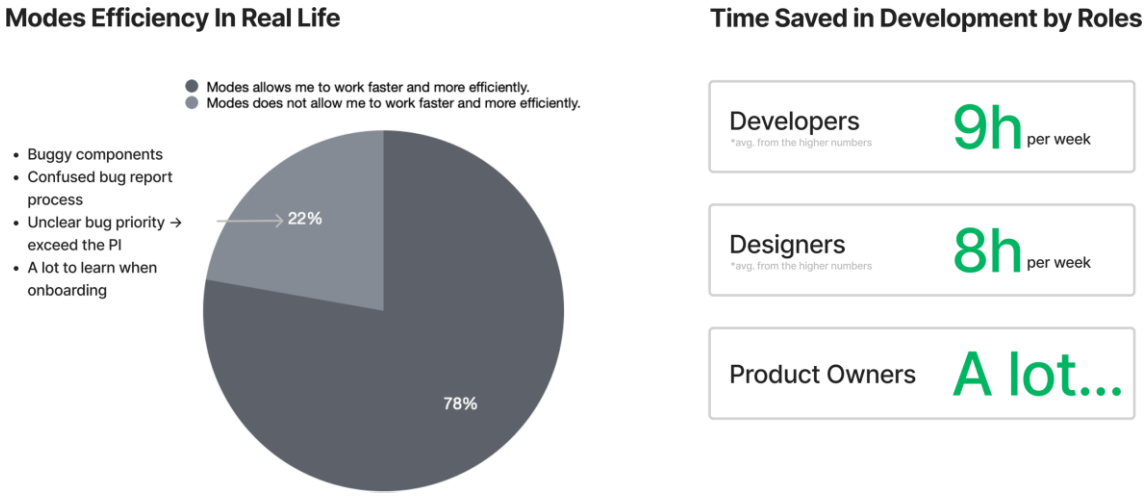


Figure 29. Modes' efficiency.

3.2.7 Infrastructure

Upon completion of all qualitative and quantitative research activities, the author of the thesis may utilise the style guide and communication critique to evaluate the data collected and ensure its alignment with the research objectives. By combining the critique technique with the insights gathered, the launch of the thesis outcomes can be improved. This section delves into two key areas: the Metso style guide and communication methods. When combined with the aforementioned research methods, the issues identified in this section provide a comprehensive understanding of the target audience and their needs, resulting in objective and evidence-based conclusions. The ultimate aim of this technique is to maintain a positive tone in all feedback for the benefit of all readers.

3.2.7.1 Modes Style Guide Critique

The style guide is readily available as a website (FIGURE 30), comprising five primary sections: Overview, Guidelines, Design Tokens, and Components. Each section is further subcategorised to provide a comprehensive and structured style guide overview.

Figure 30. A screenshot of the legacy Modes style guide landing page, taken before May 2023.

Overview: The *Overview* section presents the definitions and visions for the Modes, along with the available user research resources and the collaborative workflows. This information provides a clear understanding of the key concepts and procedures involved in the project. The user research resources are designed to gather relevant data and insights to inform the decision-making process. The collaboration workflow outlines the steps involved in working together as a team to ensure the successful completion of the project. It is imperative to follow this workflow to ensure that all aspects of the collaboration are completed efficiently and effectively. Adhering to these guidelines can provide a successful outcome for all stakeholders involved.

However, all of these pieces of work were presented in plain text form with a lengthy definition and monotonous. Although there was an effort to provide examples, for example, for the high-performance standards, the use context needed to be clarified. In addition, the implementation libraries need clarification due to the similarities in their names, i.e., DSUI and Modes UI, even worse when put next to the UI kit of which name is Modes Design System. Thus, there is a need to distinguish them across the style guide.

The Modes design system has a dedicated page for creating system KPIs for public audiences. However, the content on the page shows how to read component usage trends in Figma, while the team also measures their success using Zeroheight and Azure DevOps. For example, developers and project owners might only sometimes be familiar with Figma. Similarly, designers need help navigating Azure DevOps if they want to learn more about design system success measurements. As a result, they should get a solid overview of Modes metrics.

Upon the arrival of the thesis author, the migration from Sketch and Abstract to Figma was nearly complete and was fully accomplished thereafter. As the Modes ecosystem continues to grow, it is essential to highlight the seamless workflows that bridge the gap

between design and implementation, with the input of valuable users enhancing the process even further. Regrettably, the style guide falls short in this regard.

Guidelines: The *Guidelines* section is essential in defining the Metso company identity while ensuring a uniform look and experience across all digital products. It sets out the standards for visual and interactive elements, which must be strictly adhered to guarantee user-friendliness and aesthetic appeal. Adherence to these guidelines is critical in maintaining a consistent and polished brand image and implementing them successfully will only enhance Metso's reputation and create a favourable impression among stakeholders.

Earlier, the section on design principles, contribution, and theming guidelines was only a cursory introduction. However, given the varying levels of expertise among specialists and the importance of accommodating all user groups, it is necessary to include a comprehensive guide with detailed instructions and customisation information. By doing so, no user is excluded, and everyone can derive maximum benefit from the documentation.

Design tokens: Following that, the *Design tokens* section serves as the basis for all UI elements employed in designs, tools, and code. It is essential to establish this foundation to ensure consistency and a cohesive design language among platforms and products.

It is worth noting that not all Modes users and style guide readers fully comprehend the significance and functionality of design tokens (FIGURE 31). The original version of this section contained lines of coded tokens, which may be more familiar to developers but could exclude other readers from truly understanding the meaning of each token and how they are used within Modes. Therefore, there should be a plan to enhance this section and make it more accessible to all readers.

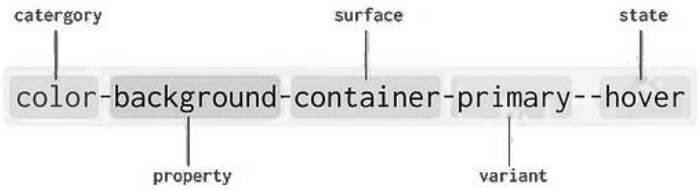


Figure 31. A simple line of tokens can narrate a complex story, taken from the *Design tokens cheatsheet*.

Components: The *Components* section provides product designers and developers with styling properties that can be used across all entries. The included illustrated examples, some interactive, serve as a valuable reference point for the development process. Additionally, the section consists of embedded illustrations of Metso applications across several platforms, such as desktop, web, and mobile. These resources are intended to ensure consistency and aid developers in creating a polished and professional final product.

The Modes style guide was developed by a limited number of editors consisting of Modes product owners, designers, and occasionally a few developers, catering to

diverse audiences. Although the guide primarily targets designers, it is noteworthy that developers outnumber them in product teams. By analysing basic statistics from an internal communication channel for all stakeholders working with Modes (totalling **132**), it was discovered that 43 members (**32.6%**) of the channel hold titles such as *programmer*, *software*, *engineer*, *developer*, or *IT*. In contrast, only nine members (**6.8%**) hold titles such as *UI/UX*, *UX*, and *designer*. It is pertinent to note that many engineers across the organisation hold non-software development positions. Therefore, the precise number of Metso developers cannot be disclosed across the various pools of engineers.

The guide presents a designer toolkit to its users, comprising reusable components tailored to designers. However, there appears to be a shortage of tools for developers, as the level of accessible, reusable content is significantly lower than that available to their design-oriented counterparts. Consequently, developers often have no choice but to create their content from scratch in alternative locations such as Storybook, resulting in a higher workload and navigation.

Apart from designers and developers, the style guide is also used by project managers, product managers, and product owners, who are internal personnel and external consultants. It is important to note that individuals outside of Metso may not be as familiar with the brand identity as those who work internally. Furthermore, the workforce at Metso is diverse, comprising people from different cultures and geographic locations. Therefore, the design system team is pivotal in standardising processes and ensuring coherence in the brand's visual identity across the organisation.

3.2.7.2 Communication Critique

Modes is committed to promoting effective communication with all product teams across the organisation. Their top priority is disseminating information about the company's design system and raising awareness of its significance. Furthermore, they strive to be easily accessible and prompt in addressing inquiries, providing relevant resources, and reviewing proposed designs. Therefore, the design system team is available through various communication channels to receive feedback and address any concerns that may arise.

Shared mailbox: If the users would like to share their feedback or questions on Modes toolkits, an email mailbox has been established. To obtain the email address, click the "Contact Design System team via email" link in the website footer. This mailbox allows them to submit detailed inquiries and provide examples for evaluation against the style guide, ensuring a fair and comprehensive assessment process.

Statistically, from the beginning of 2023, the designated mailbox has received 60 emails, whereas only three (**5%**) are the true communication regarding the design system work from users. Providing that there is an average of four follow-ups per thread. Research shows that traditional text-based communication might be overestimated as it gives people confidence about the effectiveness of their method [125]. However, face-to-face communication was **34 times** more effective than email [126]. The unprecedented time of the pandemic has accelerated a trend in remote work and virtual meetings [127]. Even though it is virtual, it still proves more social and communication interactions than exchanging emails.

Yammer: Metso is committed to improving employee communication, and one way they do this is by utilising *Yammer* as an internal social media platform. Yammer provides employees with a variety of groups to discuss both work-related and non-work-related topics. However, there is currently no group dedicated specifically to discussing Metso's style guide and UX design. This can restrict the Modes community from connecting more socially. Establishing a dedicated group would present the community with an exceptional opportunity to stay informed about the latest releases, upcoming webinars, and workshops led by the design system team.

Upon conducting a thorough search in the fields of IT and digital development, it is evident that proactive efforts are being made to promote inclusion, diversity, and design systems. The Modes product owner has recently published new articles that are being widely reposted and shared in Yammer to raise awareness about Modes among potential audiences. In addition, there is a welcoming community of **37** members caring about individuals working with disabilities, where they share stories and events related to a broad range of topics, including autism spectrum disorder (ASD) and celebrating special days like the International Day of People with Disabilities. This group serves as a supportive platform for individuals to share their experiences and uplift each other. While some groups are easily accessible and open, there are also well-thought-out private groups like the Metso Pride group for LGBTIQ+ members.

In November of 2023, the company hosted its first-ever Diversity and Inclusion Month. The event is intended to be a major attraction and allows employees to reflect on topics such as diversity, anti-racism, LGBTIQ+ rights, and women in leadership. These initiatives give the Modes team more reasons to engage in internal social media marketing and contribute to this effort on a broader scale.

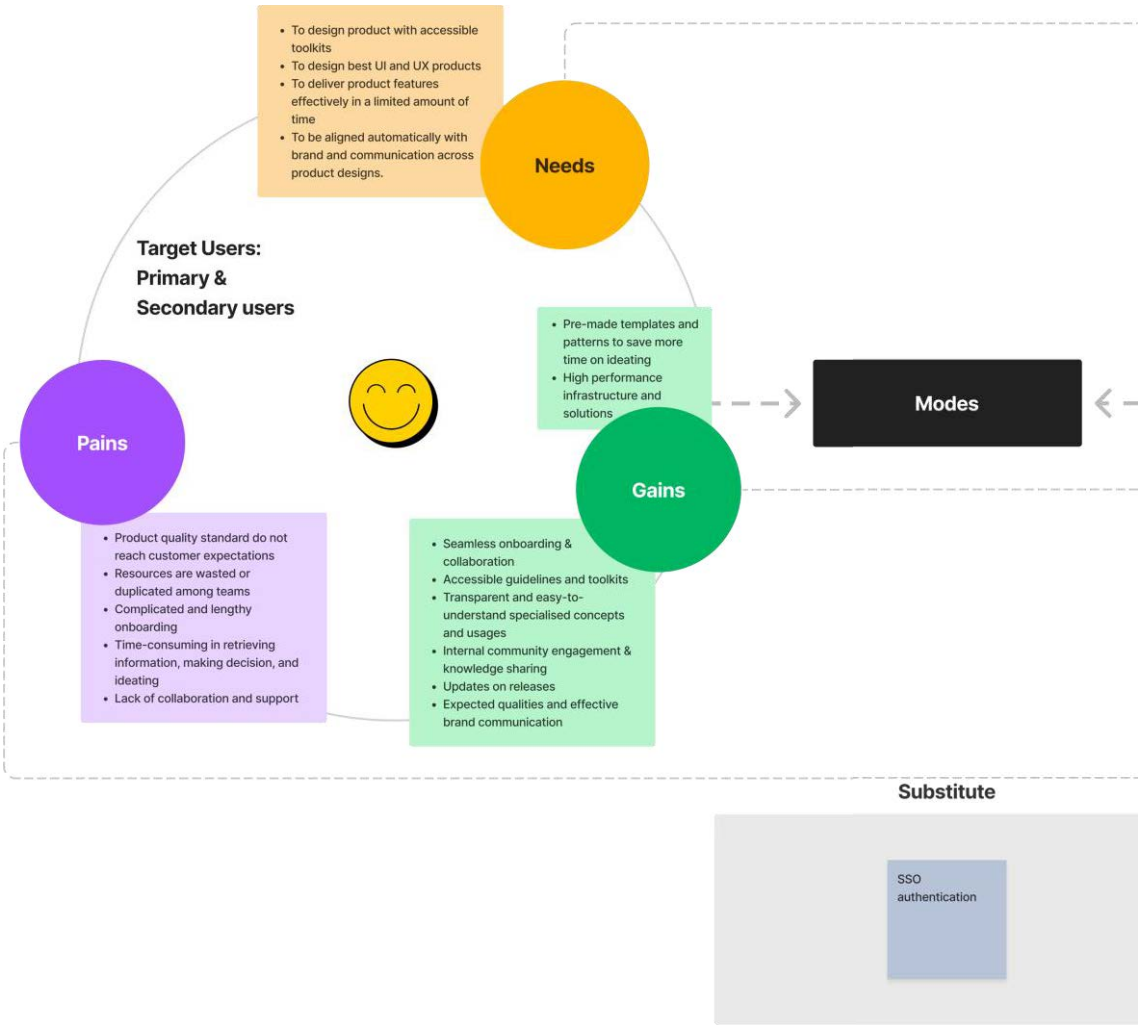
Teams channel: Modes relies on Teams as its primary communication platform, facilitating seamless interaction between peers and between the design system and product teams. The platform is fully synchronised with Outlook, which allows for easy scheduling of conference calls for further discussions. Teams is the official communication tool utilised by Metso, where the team hosts all meetings.

Under the design system team, four primary channels are available, catering from the most general level for all **131** members to receive updates to more specific channels for designers, developers, and researchers. These channels are accessible to all Modes users and contributors, making it easy to ask questions, align, sync, and collaborate on design and code-related topics. Group members can request recommendations and materials for the interfaces they create. The platform is open to all Metso employees, promoting open peer communication.

3.3 Development

By consolidating information through theoretical review, style guide critique, and benchmarking, a value proposition is developed for the thesis outcome (FIGURE 32). The value proposition canvas addresses the pain points of Modes' primary and secondary users and clearly defines what the result offers and how it will be delivered.

According to the findings obtained through the five research methods, it is recommended to create the Metso Inclusive Design and promote the Metso industrial design and engagement improvement plan as follows.



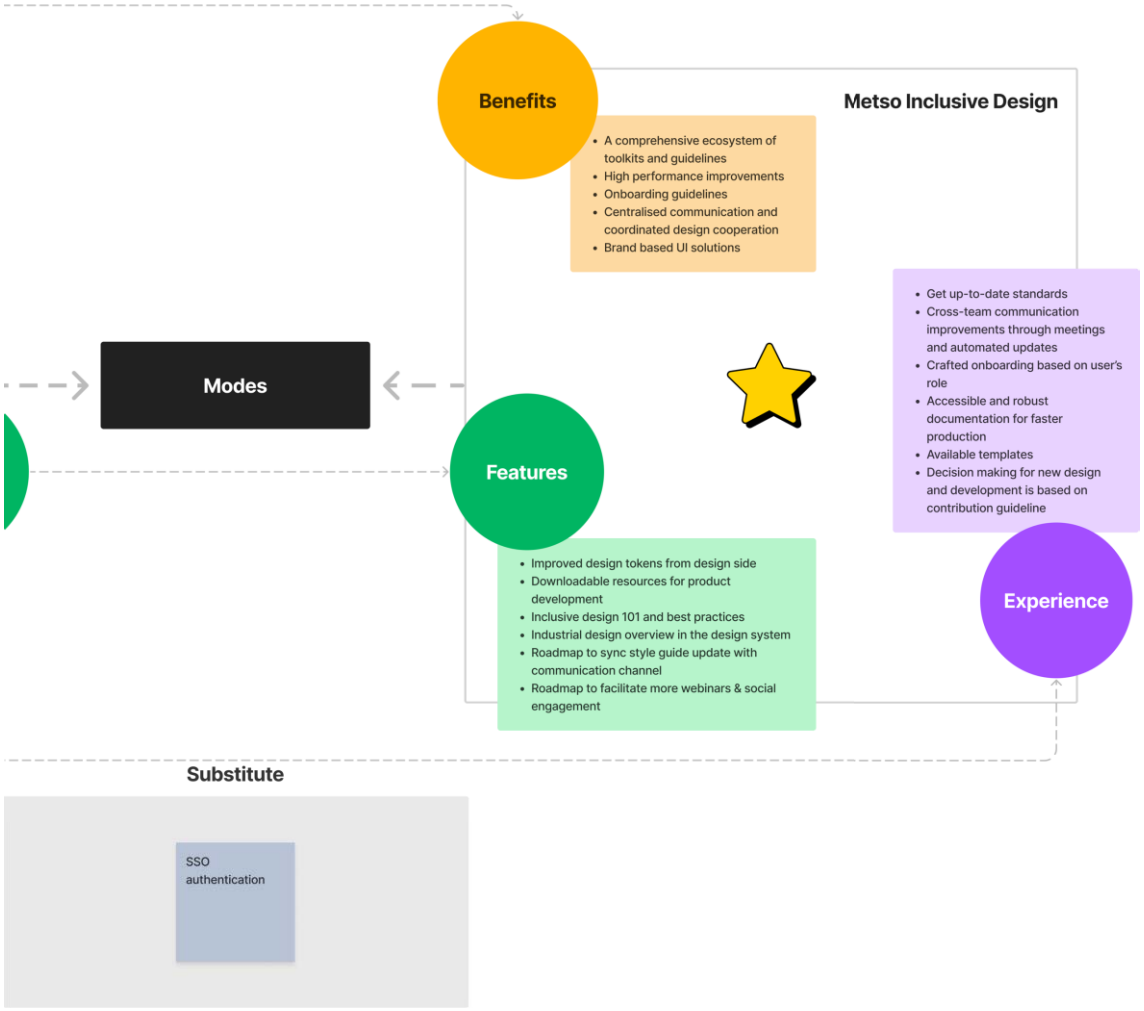


Figure 32. Value proposition canvas of Metso Inclusive Design.

3.3.1 Improve Modes

This section contains two contributions to improve the Modes: the token and style guide.

3.3.1.1 Tokens Improvement from the Design Side

Design tokens have been implemented to standardise critical elements to ensure cohesive visual design throughout all Metso products. Although this approach is still in the development phase and requires further refinement, the focus thus far has been on establishing consistent colours, elevations, spacing, and other design features.

The project was completed in a single sprint over three weeks and was carried out with the support of a UX designer and a developer. Thanks to the foundation of the legacy work, the improvement process was seamless. The work was done by following the instructions regarding variables provided by Figma [128].

As the content is confidential, the updated list of design tokens is not currently available for public display but is securely stored within the design system team workspace.

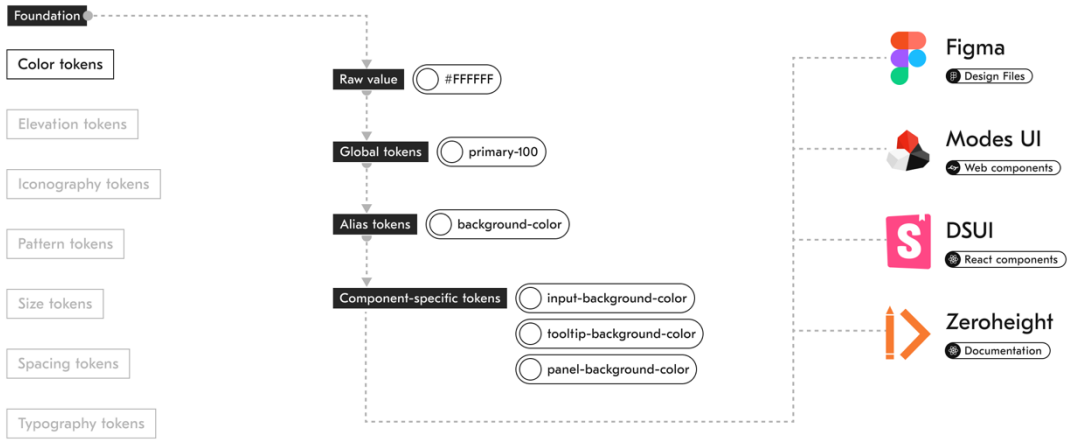


Figure 33. The proposed process of tokenising raw values to usable and specific tokens in different environments.

Global tokens (new): Global tokens are denoted by context-agnostic names and are fundamental values. These values are recorded at the base level of Modes and are accessible directly, as well as inherited by all other token types.

Alias tokens (modified): An alias token refers to another token or context, which is particularly useful when a single value needs to be utilised across multiple locations. This approach ensures clarity and precision in communication and is especially relevant in professional settings.

Component-specific tokens (new): Component-specific tokens are essential to associate every value with a component. These tokens are usually inherited from alias tokens and are often named to provide specificity in applying tokens during component development. By utilising component-specific tokens, teams can ensure high accuracy and precision in their work.

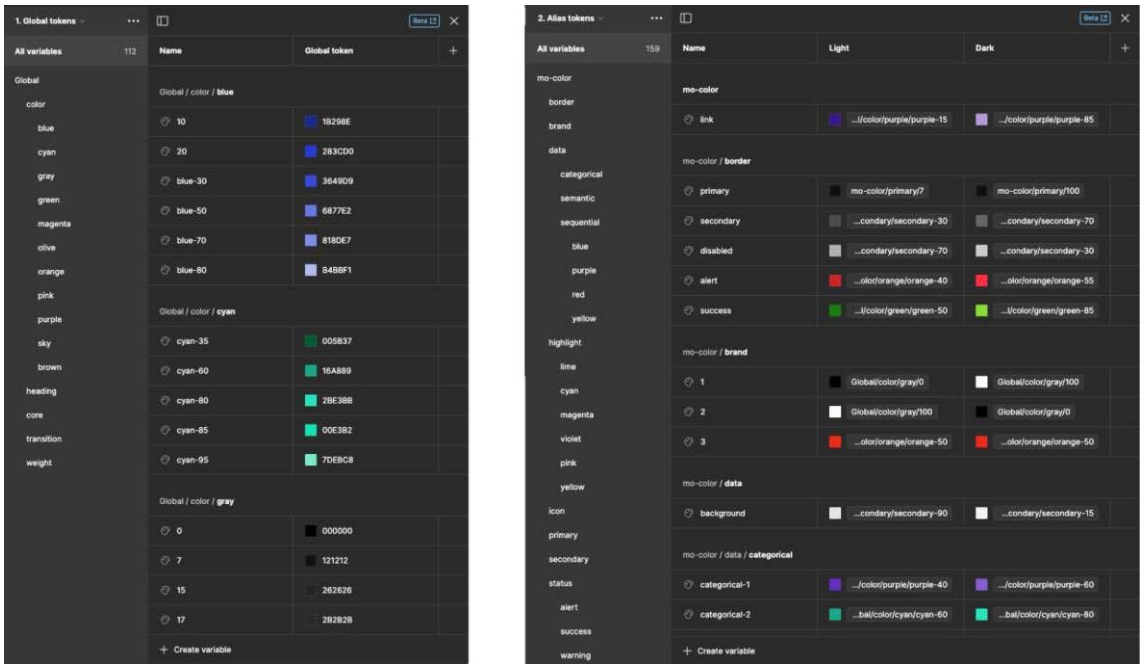


Figure 34. Embedded global and alias tokens to Figma variables.

3.3.1.2 Style Guide Improvement

Throughout the **DEMO AND DESIGN SESSIONS** and **INFRASTRUCTURE** sections, various enhancements were discovered and incorporated into the style guide. This process spanned a half-year, as the author occasionally needed to tend to matter outside the thesis' scope.

As specified in the ERROR! REFERENCE SOURCE NOT FOUND. segment, design thinking, lean UX, and agile methodologies were employed to guarantee that the work progressed smoothly. Every three weeks, feedback was collected through demonstration sessions, followed by internal refinement sessions to evaluate progress and pinpoint areas for improvement.

Table 4. The scrum framework helped the thesis owner structure and managed the work.

ITERATION	STORIES	EPIC	INITIATIVE
PROGRAM INCREMENT (PI) 9	The product owner wants to *automate design system KPIs* to guide the development of design system.	Implement and utilise the design system's Key Performance Indicators (KPIs) to monitor and	Design system continuous improvement
	The product owner wants to *add more KPIs* to reach more passive teams and ensure the team is working with relevant feature for the user teams.		

ITERATION	STORIES	EPIC	INITIATIVE
	The product owner wants to *promote the adoption and coverage* of the design system with users and general audiences by sharing knowledge through specific methods focused on KPIs.	increase its adoption and coverage through automation.	
PI8 – PI12	The users want to *add shadow effects* to essential components to highlight specific content in the view.	Enhance the overall quality and usability of the design system.	
	The designers and developers aim to *optimise the design tokens* for the user teams.		
	The designers and developers want to *fix bugs* and *refine guidance* to ease the contribution and collaboration.		
	The designer wants to *create specific templates* to reduce detachment rate and enhance user's navigation.		
	The designer wants to *create additional colour variants* and *user-facing names* to improve accessibility for users.		
	The designers want to *incorporate auto layout and constraints* in charting components to increase adaptivity and reduce detachment.		
	The designers want to *align design properties with implementation work* to improve consistency and save time during handoff.		
	The designers want to *provide clear guidance on usability, accessibility, and localisation* to raise user awareness and highlight the design system's support capabilities.		

Regarding the style guide content, the changes were done as follows.

Overview: The Modes Inclusive Design initiative has undergone significant improvements to enhance user engagement and information infrastructure. In achieving these objectives, more intuitive media files, design examples, and a more comprehensive discussion of high-performance standards have been included.

Additionally, semantic badges as visual cues were introduced to aid in navigation and created a separate tool page to differentiate the implementation libraries and provide easy access to them (**FIGURE 36**).

Together with the product owner, the thesis author has also made significant strides in improving the KPI page, adding more tabs to show component usage trends in Figma and measurements of success in Zeroheight and Azure DevOps, with plans to include GitHub in the future (**FIGURE 35**).

To ensure smoother onboarding, the Figma workflow has been restructured according to top roles using the design system. This restructuring includes defining specific tasks for each position and providing step-by-step instructions for setting, organising, and using branches for contribution. These changes have greatly assisted the Modes team and management roles, such as product owners, team owners, and admin in governance.

Guidelines: The documentation has been carefully crafted to provide a comprehensive guide, empowering users to leverage its benefits to the fullest extent. With a strong emphasis on accessibility, adaptive design, and internationalisation, the guidelines ensure that all users have an equal foundation to the information provided. Furthermore, asset guidelines and instructions on using error messages and alerts effectively have been included, saving more time for a broader range of users to navigate within a single page of documentation easily. These updates are aimed at helping everyone make the most of the Modes style guide, as illustrated in **FIGURE 35**. As a design system team member, the thesis author assures that the team has taken great care to ensure the documentation is user-friendly and accessible.

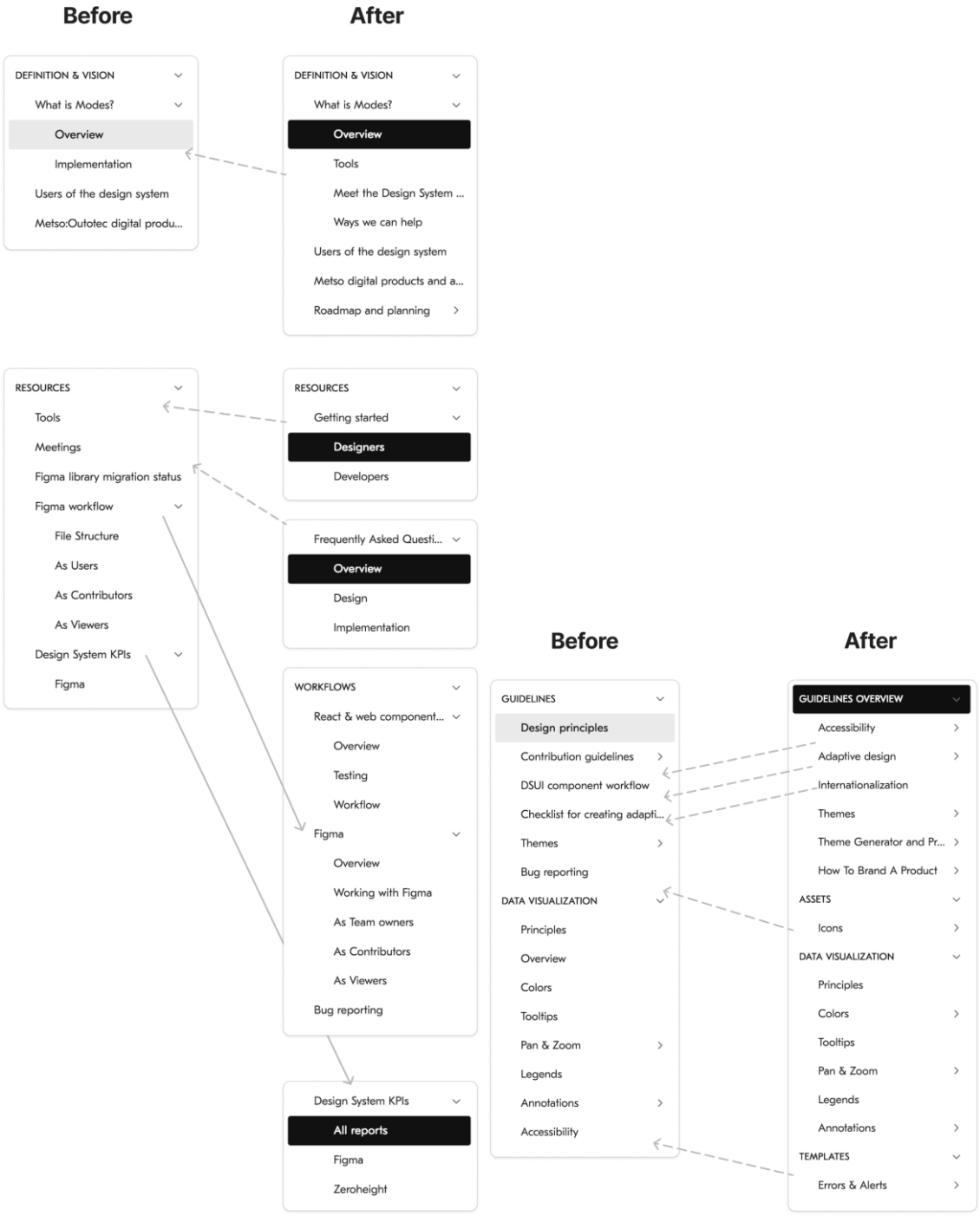


Figure 35. (Left) Overview page and (right) Guidelines: Before and after.

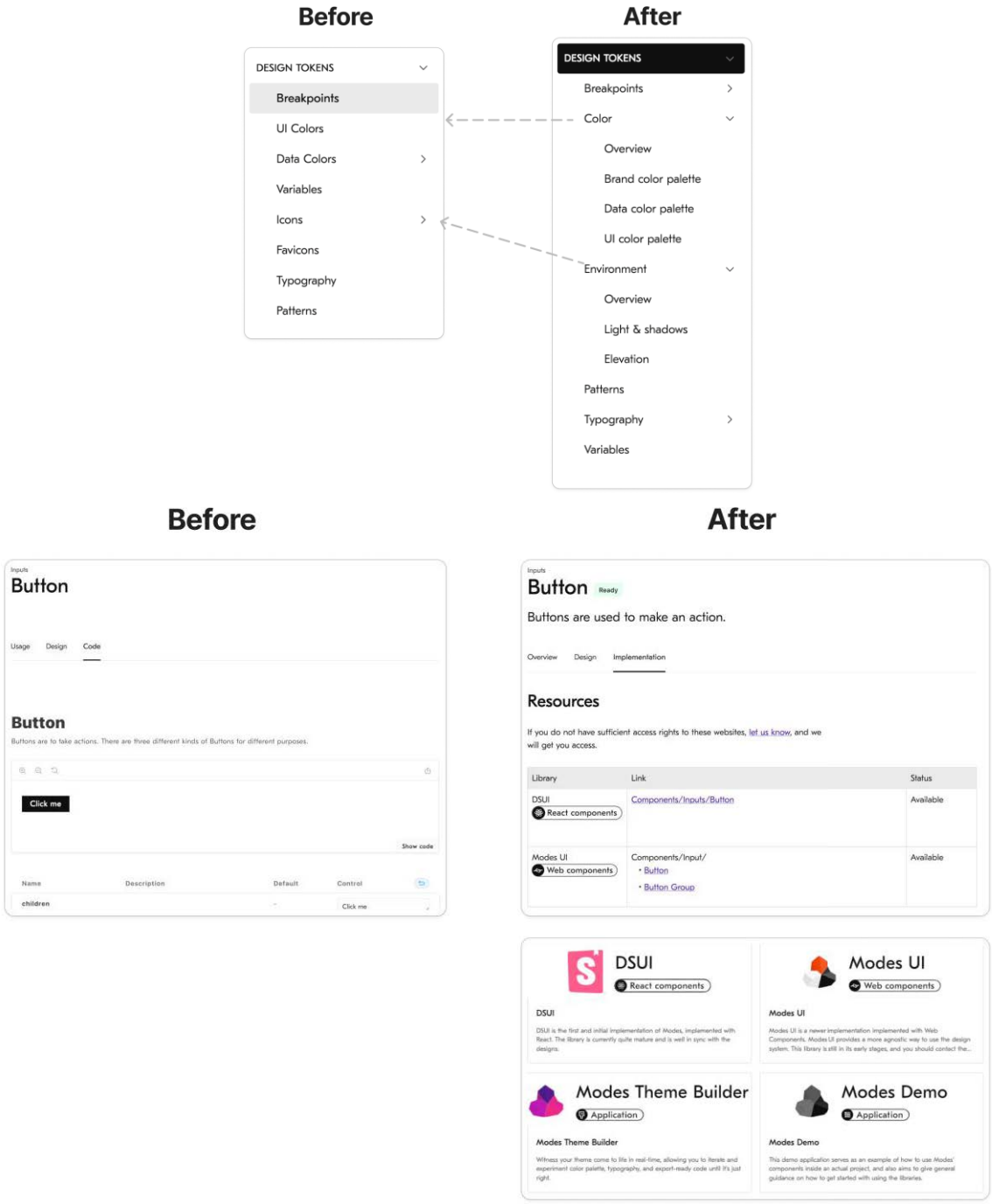


Figure 36. (Top) Design tokens and (bottom) Component implementation tab: Before and after.

Design tokens: As evidenced in the previous section, significant revisions have been made to the Design Token page to establish a comprehensive hierarchy of design tokens. It is essential to fully comprehend this hierarchy to grasp these design tokens' significance and functionality. The complete token formulations list is now available in the Modes team workspace, making the documentation in the style guide more streamlined. As previously indicated, both coding and Figma design can retrieve the design tokens effortlessly. Furthermore, by categorising the tokens into three levels, the

updated page offers more in-depth insights into colour functions and the newly introduced environment tokens.

Components: FIGURE 36 illustrates how a more effective implementation tab can enhance a component page. The new feature facilitates developers in smoothly navigating component libraries and quickly obtaining demo page status. In addition, to improve user-friendliness, the embedded code views were relocated and prioritised as secondary information. This decision was made because the previous placement of the views might have impeded developers from configuring the control or obtaining the necessary information promptly.

3.3.2 Create Metso Inclusive Design

Establishing a comprehensive site architecture for Metso Inclusive Design is critical before embarking on any content project. This is to ensure seamless navigation for users. To this end, meticulous information architecture and indexation (IA) planning was undertaken, with the design system team leading the Metso Inclusive Design project while adhering to the information structure outlined in the thesis, as illustrated in FIGURE 37.

Modes enable users to switch between the primary style guide and MID by leveraging Zeroheight's style guide switcher feature [120]. With an enterprise plan subscription, users can easily switch between guidelines by accessing the drop-down menu on the top bar navigation (FIGURE 38). However, it is essential to note that these pages are password-protected, and access is restricted to users who have logged in through SSO.

Figure 37. Metso Inclusive Design information architecture.

In addition, each element of the Metso design system has its logo, as does the Metso Inclusive Design. The first version of the Metso Inclusive Design logo was designed in Figma, with the partnership bolt a decagon, embodying Metso's sturdy foundation and structure and utilised throughout various applications, including office identity, marketing materials, and industrial branding. However, an implicit icon was required to accompany the partnership bolt to emphasise the significance of inclusive design further. After extensive research on *inclusive icon*, several patterns associated with inclusion and diversity were discovered, such as holding hands, supportive hands, a group of people, an infinity sign, and an assortment of elements with distinct properties (such as colours or shapes). These graphics shared a streamlined appearance or were always interconnected. After careful consideration, the infinity sign was chosen to accompany the decagon. As a result, the logo incorporates two brand colours (black and orange), with the infinity sign at the centre of the partnership bolt.

Figure 38. Style switcher on the landing page of MID.

3.3.2.1 Colours Improvement

The digital guidebook boasts a robust Inclusive Design section that prioritises accessibility (**FIGURE 39**). The page is thoughtfully curated based on user feedback and the author's experience. Modes' UX designers working with Figma libraries must conduct comprehensive accessibility tests before implementing new components. This section covers a range of topics related to accessibility, including data visualisation, evaluation methods, and tools. It emphasises colour and contrasts to cater to Modes' primary users who may have difficulty distinguishing between colours.

The thesis author analysed the complete set of W3C standards about colour and carefully curated content most relevant to Metso's product case. Rather than providing a shallow overview, the thesis presents beginner-friendly language and a structured writing style that explains the reasoning behind colour scales, contrast, and accessible colour combinations. Additionally, the author established a correlation between colours and font type to enhance contrast and improve typography guidelines. The thesis outcome also

includes a conversion table to assist designers in easily converting measurements, such as T-shirt size, to other units like points, pixels, web, Android, or percentages without relying on random websites. Furthermore, the author included best practices for line height, paragraph spacing, letter spacing, line length, baseline, and tabular numbers to ensure adequate spacing between elements. Though the guidebook does not feature a vision simulator, the Modes React component and page demo have already incorporated this feature. Lastly, the guidebook's tool tab lists valuable accessibility tools for Figma users.

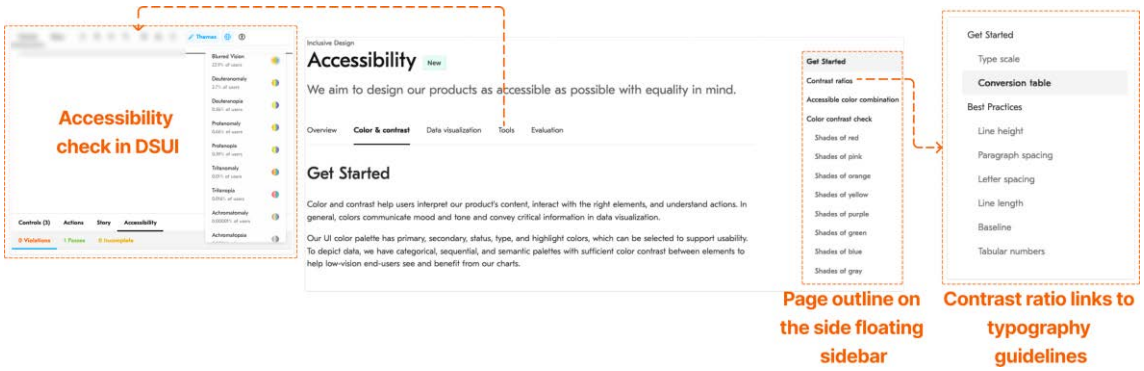


Figure 39. Overview of colour and contrast guidelines in MID.

3.3.2.2 Introduction to Internationalisation & Localisation

In fact, there is an introduction page about internationalisation in the main style guide, but it could be more than that. Thus, this thesis delved deeper into the concepts of internationalisation and localisation, explicitly examining their applicability to the case of Metso. These terms are commonly abbreviated as i18n and l10n, respectively, with the numerical figures indicating the number of letters between the first and last letters in their respective English spellings.

In a nutshell, localisation is the intricate process of tailoring a product, application, or document to meet the precise linguistic, cultural, and other demands of a particular market. It goes beyond merely translating user interface and documentation, encompassing various customisations, including date and numeric formats, currency, graphics, and more. Localisation may necessitate a complete overhaul of the logic, visual design, or presentation to cater to locales that diverge significantly from the original culture.

On the other hand, the concept of internationalisation can vary depending on the context in which it is used. Broadly speaking, it involves creating a product or application that facilitates its adaptability to diverse cultures, languages, and regions. This entails eliminating potential obstacles hindering its successful localisation or international deployment. Furthermore, internationalisation can enable integrating features that become available only after localisation. Finally, it can accommodate the inclusion of code that considers local, regional, cultural, and language preferences. Overall, internationalisation is an essential aspect of the design and development process, not an afterthought that necessitates expensive and cumbersome re-engineering.

As presented in the 'State of Internationalisation' report, an initial version of the language recognition table has been developed based on a previous study of Metso's locations and distributors. As per the guidelines, the table will be updated as necessary. However, during the editing phase, the Modes team encountered a significant issue where the new language selector consistently referred to the country. This caused concerns regarding the use of Spanish in Spanish-speaking countries like Chile, which may differ from that of Spain. In the guidelines, it is critical to stress that designers must not confuse languages, scripts, and countries. One possible solution is retaining the text in the local language, enhancing comprehension.

Figure 40. Difference between nations and languages [129].

Following that, the localisation process builds upon the foundations established by internationalisation to provide comprehensive guidelines and checklists for formatting, directionality, and design tailored to individuals who speak a second language. This segment also includes practical examples sourced from Modes or Metso digital products and is aligned with brand specifications to maintain a consistent tone.

Lastly, ensuring the compatibility of digital products with diverse regions and cultures is a crucial aspect of the design process. To achieve this, a comprehensive testing procedure was employed, which includes three essential steps: linguistic, cosmetic, and functional testing. It is important to note that while these testing procedures are critical at a general level for design, they may require further refinement during implementation.

3.3.2.3 Introduction to Control System Interface

Professionals working in industrial machinery are advised to understand control system design fundamentally. To help make this knowledge more readily available, the Metso Inclusive Design guidelines have been augmented with content from the **HUMAN-MACHINE INTERFACE**. These guidelines prioritise ergonomic design and conform to standards such as alarm systems (EEMUA 191), ergonomics of human-system

interaction (ISO 9241), and HMI philosophy (ISA 101). Practical experience is provided to readers through relevant images from Courier® HMI accompanying each topic in the guidebook. The guidelines have been structured to include an overview page, followed by sections on safety, human factors engineering, and high-performance categories. However, as specific product images and exclusive content are confidential, this section is primarily accessible to Metso users.

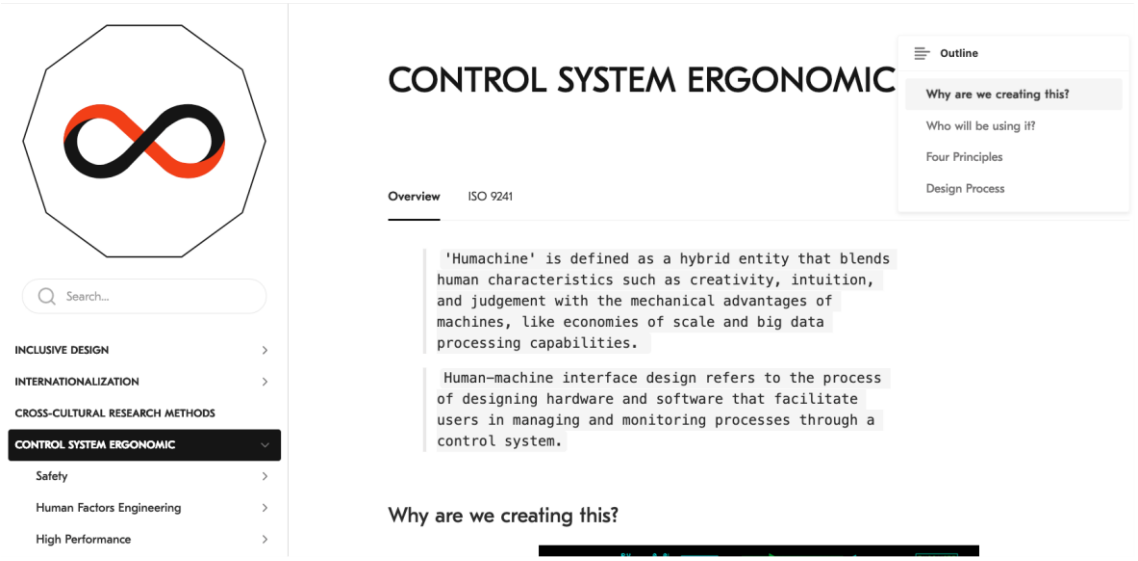


Figure 41. An overview of the Control System Ergonomic category.

3.3.3 Engagement Improvement

This section contains two contributions to improve the Modes' engagement: the webinars and community.

3.3.3.1 Webinars

Retrospect one of the objectives, incorporating Modes and Metso Inclusive Design methodologies can significantly enhance the productivity of product teams. By streamlining their information-seeking efforts, such as navigating multiple resources, teams can focus on critical strategic aspects of software product design and end-user requirements. This approach fosters a more insightful and harmonious work environment, ensuring that products are developed with the user's perspective at the forefront.

In both March and October, two informative 30-minute webinars were hosted. The focus was on general contributions to the Modes and its usability. In the first webinar, the author collaborated with another Modes designer to present how a designer could contribute to the design system. The new structure of the Figma workflow and contribution added in **STYLE GUIDE IMPROVEMENT** was proposed, starting from the role of a team owner to a contributor with continuous support and instruction from a designer

from Modes. Having two presenters made this webinar an excellent opportunity to showcase the contribution process, followed by a presentation from a developer. Ultimately, the audience was invited to participate in a survey, and the recording was widely promoted in the Modes community.

Continuing that progression, the second webinar explored the usability aspect of the design system deliveries. Unlike the previous event, the agenda solely focused on design work, with a presentation by the product owner and three designers from the design system. The webinar structure, which was based on the design system's product development process, was suggested by the author and mirrored the structure of their thesis (**FIGURE 16**). Given the relevance of the thesis outcome, the author was tasked with setting usability goals (i.e., explore and plan) and developing content for product building (i.e., build).

To effectively manage the time and resources, the initial stages of the process were streamlined, combining exploration and planning. This allowed presenters to showcase the capabilities of Modes, which offers a range of pre-designed components that are fully aligned with industry standards. Specifically, the high performance with standard ISA 101 was mentioned, together with the WCAG level AAA conformance and usability testing with Nielsen's heuristics. By selecting the most appropriate standards for each specific audience, Modes users are ensured that design components meet the requirements for both digital and industrial product design. This approach simplifies setting usability goals, eliminating confusion and ensuring each user can quickly achieve their desired outcome.

Three key factors were highlighted when showcasing a product: improving product quality, providing user-friendly components and demos, and prioritising communication and developer experience. The first element, enhancing product quality, requires careful attention to accessibility and colour choices. Specific colour combinations should be avoided as they can be disorienting, similar to strobe lights. When dealing with small-scale items, distinguishing between colours may only prove difficult when referring to their hex code or hue value. On a larger scale, colours are more distinguishable when placed side by side but can still be challenging to differentiate when viewed individually. Background colours also play a substantial role in user experience, particularly for those with visual impairments. Light backgrounds, such as white, make colours appear less distinct, while darker backgrounds make them more noticeable. Therefore, it is crucial to consult a colour guide when working with vibrant themes to prevent using indistinctive combinations on coloured backgrounds.

Secondly, a design system is more than just visual elements like colours, typography, and spacing. It can also include interactive elements that elicit positive emotional responses from users. By defining and adding interactions and transitions to the main components, it was aimed to improve the quality of the design system. The author also highlighted the effort to make these components available from the first publication. Furthermore, developers and product owners can observe how the interactions work with the Figma prototype. Modes can assist teams without designers by providing more examples and demonstrating how the design system components function cohesively via the new demo application provided by the Modes developer. This enhances consistency and positively impacts usability.

Lastly, when using libraries, it is important to consider the developer experience in terms of understandability, learnability, and reusability. Understandability refers to the ease of understanding the semantics of the features based on names and documentation. For example, in the Figma design, the thesis author already established a list of colour tokens as variables synced with tokens in component libraries to make it easy for developers to perceive them.

Learnability refers to how Modes enables developers to learn to use the design system easily and incrementally. With the new feature Dev Mode provided by Figma, developers can now experiment with components without interfering with the main designs, and designers can mark which sections are available for the dev.

Reusability is one of the design system's value propositions. Modes enables developers to implement designs with concise, maintainable, and reusable code. Our implementation pack contains accessible libraries that can help developers achieve this.

3.3.3.2 Community Engagement Idea Proposal

To achieve successful community-engaged design, it is imperative to incorporate feedback from the community, ethical principles, and design processes. A comprehensive roadmap is a crucial guide for the Metso design system and Metso Inclusive Design specifically, outlining short- and long-term goals aligning with the overall strategy. This roadmap provides clarity and purpose to the design system, emphasising its significance and longevity.

Yammer community: The Teams channel has proven successful in keeping more than a hundred primary users of the design system team up to date, indicating that Modes has an established community. Nevertheless, the aim is to broaden participation beyond existing users and attract tertiary groups and potential users within Metso. According to a **COMMUNICATION CRITIQUE**, Yammer holds excellent potential for forging a social community for the design system. This opens avenues for sharing resources and perspectives on inclusive design with related communities.

Engagement through metrics: Obtaining user quantitative and qualitative metrics is a critical aspect of user engagement. Sharing this data with users can further enhance their engagement and provide a more comprehensive understanding of the design system. While showcasing quantitative measures is beneficial, incorporating qualitative data can further augment the design system's narrative. It is noteworthy that there is no one-size-fits-all strategy for facilitating these activities.

When creating a design system, prioritising metrics as the backbone is imperative. Incorporating metrics into the system can help the Modes team secure management buy-in, provide transparency to teams, and demonstrate the system's effectiveness. A comprehensive table highlighting time-saving benefits per component and project is a potent tool to impress decision-makers and instil confidence in the investment. Moreover, by using Figma analytics to monitor component usage, the design system should capitalise on regular status meetings to scrutinise feature utilisation and exchange metric insights during weekly design workshops. This strategy can also facilitate the adoption of Modes.

Metso's additional product teams provide a compelling illustration of the advantages of digital product development support. By implementing design systems and prioritising metrics as a crucial element of their process, they have been able to reduce the working time of designers and developers by a noteworthy **21.3% per week** (**FIGURE 29**). This has improved organisations' efficiency, reduced costs, and streamlined operations. As a result of this progress, the inclusive design guide will soon be shared with product teams to promote best practices across the board.

Estimating the potential time savings derived from utilising a design system component compared to producing it manually is challenging, and there is no universally accepted formula to calculate it. However, approximating the time required to design or code a component and measuring the time needed to retrieve it from the design system library can provide a rough estimate of the time saved. Moreover, multiplying this difference by the frequency of the component's usage in the product can give one an idea of the overall time savings.

$$(Time\ to\ create\ a\ component - Time\ to\ retrieve\ a\ component\ from\ Modes) \times Number\ of\ times\ the\ component\ appears = Time\ saved\ using\ the\ component\ from\ Modes$$

Sharing lots of data is one thing; knowing how to tell a story from these metrics is another. Following each sprint, retrospective sessions evaluate the team's progress. However, after a year of diligent work on the design system, there must be ways to showcase its success and value to other teams effectively. To address this, the thesis author plans to promote the Metso Inclusive Design guidebook more extensively, and a novel approach should be taken to introduce it from the design system. As the end of the year is approaching, a design system digital journal will summarise the system's accomplishments and contributions made throughout the last twelve months.

Various organisations, such as Spotify, Collin Dictionary, and YouTube, have successfully implemented a gamification strategy, which has sparked much interest among their users. This approach promotes inquisitiveness, instils a sense of achievement, and motivates individuals to maintain their hard work. Although the thesis author has yet to establish specific guidelines for the structure of its presentation, a preliminary outline has been created for its gamification initiative. The quantitative and qualitative data outlined in this thesis endeavour to illustrate the effectiveness of this approach. However, the final version must include additional pertinent metrics and testimonials. Consequently, this work will be gradually refined until its official launch.

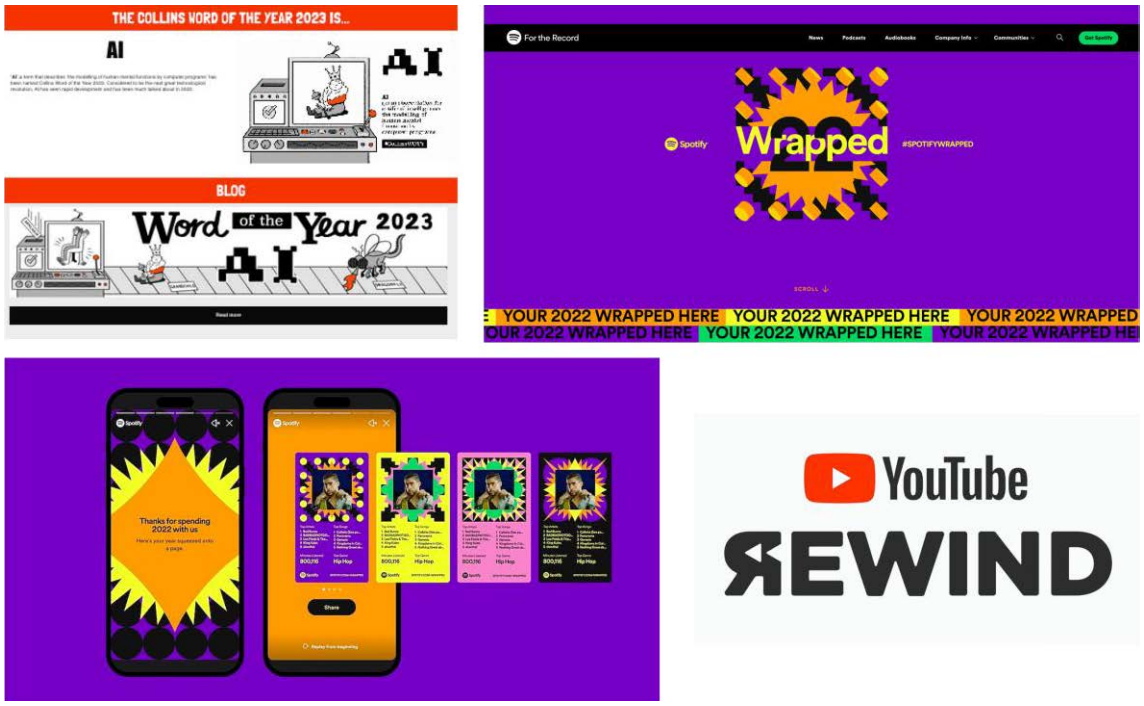


Figure 42. The moodboard from Collin Dictionary (Word of the Year), Spotify (Wrapped), and Youtube (Rewind).

Workshops: In addition to the scheduled webinars, the design system team may consider offering office-hour sessions or brief workshops to guide the design and implementation process. Recognising that not all designers have developer experience and vice versa, this initiative aims to foster community engagement and growth to the next level. Participants can explore and discover the best solutions for their design challenges by facilitating communication and collaboration in these sessions. One respondent mentioned, “I'm not sure if it would be possible also to include the stuff I've worked on to the design system (in some easy and convenient way). And honestly, some of the more complex components [the respondent has built] may not be done the smartest way, so those would probably need some extra work.” As Figma and other digital product providers have already published helpful content with the same objective, it is reasonable to consider this approach in the roadmap.

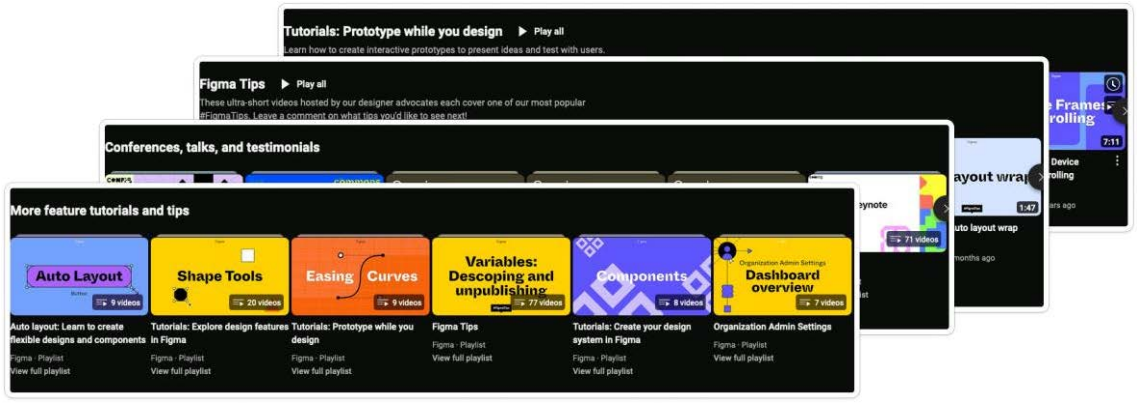


Figure 43. An overview of Figma's Youtube channels with available resources for everyone.

In conclusion, the Modes team will work closely with individuals, groups, and organisations to gain a deep understanding of their needs, aspirations, and challenges. Active collaboration and dialogue are essential to create a collective effort that values diverse perspectives and knowledge. The ultimate goal of this initiative is to foster empathy, cultural competency, and a critical understanding of social contexts within our workplace at Metso.

It is important to note that community engagement for design system roadmaps differs from typical product roadmaps, as they impact multiple teams and departments, including engineering and design. Therefore, balancing the design system's objectives with each team's requirements is crucial to carefully negotiating and considering how the strategy aligns with all endpoints.

3.4 Post-development

The Metso design system style guide has received positive feedback from its audience, particularly for specific pages including *What is Modes*, *Users of the Design System*, *Usability*, *Themes*, *Modes' Component Status*, and the *cover page*, which have all received a **100%** upvote. As a result, the design system team and thesis author will persist in their efforts and actively seek feedback for future iterations.

The initial release of the Metso Inclusive Design digital guidebook is now available through the primary style guide. The Modes product owner successfully requested a domain name system record for the new site, and the activation process was seamless, with the domain immediately operational. The official content of the guidebook has been presented in a significantly more comprehensive and user-friendly format than in the original thesis presentation.

To prepare for the official release, a survey was crafted via Microsoft Forms to gather reader feedback (**FIGURE 44**). The survey comprises eleven questions, eight of which are required (**APPENDIX 1**). In addition to customary rating and open-ended queries, a fundamental usability scale was incorporated. This subjective usability evaluation aimed to collect valuable, robust, and trustworthy insights [130].

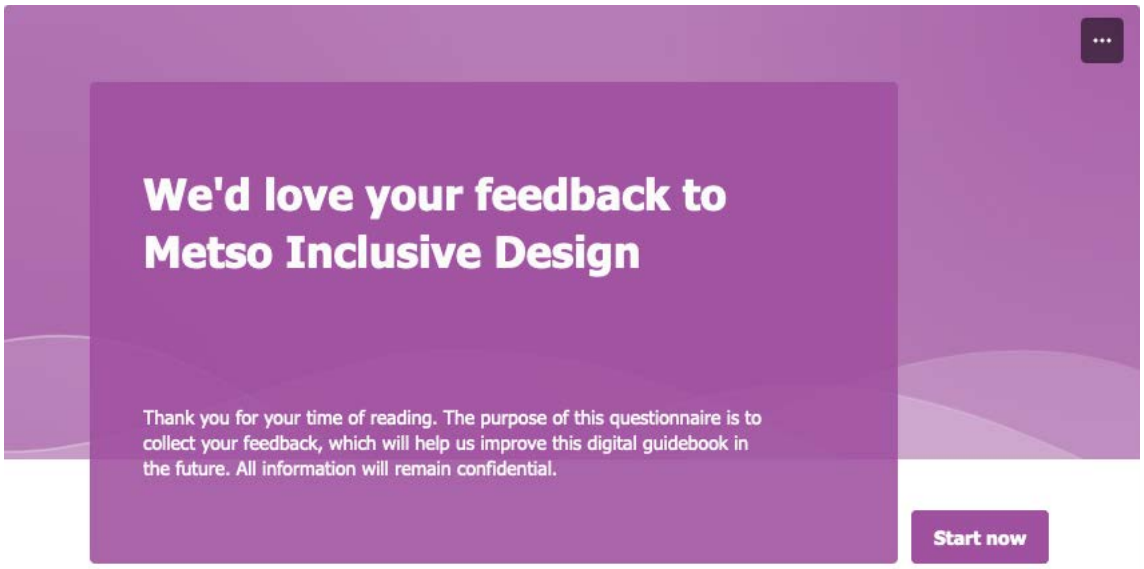


Figure 44. The landing page of the form.

The survey comprises ten statements, each rated on a 5-point scale. Participants are requested to express their agreement or disagreement with each statement. The statements were thoughtfully selected to ensure that half would commonly provoke strong agreement while the other half would typically cause strong disagreement. This was to prevent presenting alternating positive and negative statements. It is recommended that respondents read each information attentively and thoughtfully consider their response before proceeding to the next. The survey link has been conveniently placed at the bottom of each page to encourage prompt responses.

Combining the contributions from each item is necessary to determine the score for guidebook usability. Every item is allotted a score between 0 and 4 based on its usability. For items numbered with odd numerals (1-9), the score is calculated by deducting one from the scale position. Similarly, for items numbered with even numerals (2-10), the score is calculated by subtracting the scale position from 5. To determine the overall usability score of the guidebook, the sum of all the contributions should be multiplied by 2.5. This resulting score can range from 0 to 100. [130]

Last but not least, the visuals incorporated in this thesis were meticulously curated and endorsed by the brand operations manager, business stakeholders, and personnel featured in the photographs. Upon concluding the thesis, the author resumed their position as a UX designer, accountable for component design, maintenance, and governance in Figma. Concerning Metso Inclusive Design, the author serves as an editor and contributor, enhancing the guidelines for other editors by providing clarity in content.

4 Discussion

This chapter presents the discussion of the entire work. In the subsequent section, three precise responses to the research question, derived from the thesis research, are presented. However, specific constraints exist due to the broad scope of the thesis topic, and further improvements will be necessary to address them. Additionally, the thesis contribution is outlined before the final concluding chapter.

4.1.1 Improvement of Modes

Metso's design system represents a compelling innovation with the potential to serve as a robust infrastructure that aligns perfectly with stakeholders' mental models, a step further from being framed as a product. It significantly leverages essential industry terminology, such as DevOps, DesignOps and utility, to facilitate the acquisition of necessary investment and support. This shift in paradigm towards recognising the pivotal role of design systems is a testament to its significance in the success of a global enterprise, much like the essential infrastructure required for smooth daily operations.

As a design system, Modes is a powerful solution for streamlining the different workflows of various job roles. The system is designed to incorporate recommended best practices that discourage siloed team operations, ensuring consistency in software products and providing users with an unparalleled experience. Modes achieves this through its reusable components, detailed guidelines, and centralised source of truth. The system has successfully reduced the time required for product development by a substantial margin. Each component undergoes rigorous testing and approval by a specific team to ensure the best possible user experience. This heightened efficiency translates to significant cost savings and a shorter development cycle.

However, the Modes style guide can sometimes lead to a knowledge gap between designers and other product development team members, hindering effective collaboration and communication. To mitigate this issue, all product team members must comprehensively understand the system's guidelines and components. The design system team should establish a focused plan to educate and onboard users, ensuring that everyone can effectively work towards achieving the desired outcome. This approach fosters efficient communication and collaboration, ultimately improving outcomes and organisational success.

4.1.2 Development of Metso Inclusive Design

Metso has significantly invested in enhancing accessibility and emotional resonance for a broader audience through its digital and control system technology. Apparently, the design system team at Metso is dedicated to crafting experiences that adhere to the tenets of inclusive design. Their objective is to bridge the comprehension divide and offer comprehensive guidance to users on optimising design systems in their professional pursuits. As a result, this thesis aims to empower individuals with a more profound

comprehension of design systems and equip them with the skills needed to use them more effectively.

In contemporary times, inclusive design alludes to developing products and services that cater to a broad spectrum of users, irrespective of age, ability, or access method. To achieve this end, it is imperative to garner insights from a diverse group of people, including those with disabilities. By improving the accessibility of their offerings, businesses can organically expand their customer base. However, the surge in website accessibility lawsuits necessitates the analysis of data to comprehend the expanding market of consumers with disabilities. Inclusive design provides better risk management and enables the transformation of potential liabilities into brand assets. Inclusive design demonstrates a brand's commitment to all consumers, including existing and prospective customers, thereby enhancing its image.

Following that need, a guide has recently been developed to encourage more inclusive design practices. This resource is readily available to individuals and organisations involved in digital experience creation who aim to make their offerings accessible to a broader audience. The guide is a valuable supplement for everyone, even those familiar with inclusive design, but it requires more targeted direction on the necessary steps. Integrating inclusive design into the product team rather than treating it as a separate entity for optimal results is essential. A diverse group can educate themselves on creating products and services that resonate with a more comprehensive audience, resulting in more inclusive offerings.

Within the context of industrial machinery organisations, inclusive design is a practice that involves integrating accessibility and usability features into digital products and services from the outset. This methodology is predicated on a comprehensive understanding of the user's perspective and a demonstration of empathy towards their difficulties. The ultimate objective of this approach is to provide a competent and compassionate solution to ensure that the maximum number of customers and users can access and utilise these resources effectively.

In designing HMI, it is of utmost importance to consider the contextual and circumstantial constraints that the product may face. Given that the same product may have to be used by a heterogeneous user base in various settings, it becomes imperative to fashion the user interface to be adaptable to diverse physical and cognitive ergonomics requirements. This ensures that all users can operate the product easily, comfortably, and efficiently, regardless of any perceived limitations or dependence on assistive technology.

Achieving effective communication between humans and machines is a critical objective in the design of HMI. The visual representation of information is a crucial component of HMI design, and designers must incorporate principles of cognitive psychology and visual design methods while considering the needs and expectations of end-users. Creating user-friendly, reassuring, and satisfying interfaces requires a well-rounded approach that considers the human factors involved in the interaction. It is important to emphasise that this knowledge should be shared widely and inclusively with all personnel in the organisation to ensure that everyone benefits from it. Therefore, it is imperative to consider all aspects of HMI design to achieve optimal results.

Lastly, encouraging cultural diversity and inclusivity in digital platforms is an important goal when creating an all-encompassing guidebook. Human communication and culture heavily rely on digital interfaces and control systems, making it crucial to design cross-cultural digital experiences that are significant and tailored to the preferences of their target audiences. It's worth noting that a thorough implementation of culturally responsive design is necessary to understand the reasoning behind design choices. As such, the development team should aim to produce digital experiences that equip audiences to understand and navigate the significance within their communities.

4.1.3 Technical Limitations

Presently, the digital guidebook does not furnish downloadable resources for offline reading. However, to enhance user experience, a development roadmap has been devised to include a plan to prepare printed versions of various documents, such as cross-cultural research templates and internationalisation checklists, that can be used during workshops. The significance of providing accessible and convenient resources to our users is recognised, and the guide editing team is committed to fulfilling their requirements. Also, this action is to prepare for further collaboration with the Metso Diversity and Inclusion from the People Management department.

While the style switcher can be a valuable tool, it is essential to note that the search function is restricted to a single style guide, which may lead to reader confusion. Additionally, the Metso Inclusive Design could benefit from including supportive text, which is currently absent. Please rest assured that any modifications to the primary style guide will be reflected in the MID. When a more comprehensive understanding of HMI is required, it may be more advantageous to consult a guidebook specifically curated for HMI designers and developers.

The present standards necessitate payment for accessing the content, which may challenge individuals seeking further research. Consequently, the guidebook editing team must regularly update the content and ensure that it corresponds with the context of Metso's products. This requires a meticulous approach to the management of content, which must follow the latest developments in the industry and the company's overarching objectives.

5 Conclusions

In conclusion, this thesis has comprehensively explored the design process for an inclusive design system in heavy industrial machinery. The author has utilised a human-centred product development design process that considers UX, requirements and desires through extensive research, surveys, workshops, and user evaluations. The resulting style guide improvements and inclusive design guidebook await their official launch. The thesis has also highlighted the importance of considering human diversity and human engineering factors in the design process, which can be beneficial for defining problems, developing concepts, and refining solutions efficiently. By leveraging control system ergonomics, the thesis provided best practices to raise awareness of HMI design among designers and developers in other fields. Furthermore, involving users, designers, and developers in building a solid engagement and shared understanding ensures the success of product development. Lastly, the study has bridged the gap between cross-cultural and internationalisation approaches and control systems design while promoting other design methods, such as business and community design.

5.1 Answers to Research Questions

This section addresses the research question: **How to develop an inclusive design system for an industrial machinery organisation?**

Design questions should reflect practical cases by defining the problem accurately. Designing complex systems, ensuring inclusivity, and developing HMI are highly intricate and challenging tasks. Therefore, a human-centred approach to product development involves engaging users and other stakeholders in the design process, allowing them to contribute to forming design principles.

By leveraging co-design methods and tools, feedback was actively sought from primary and secondary users regarding issues related to inclusivity, accessibility, and usability. This input helped identify user needs, contributions, and engagement through several sessions, such as Modes toolkits, KPIs, demo sessions, and weekly workshops. These sessions played a crucial role in identifying potential issues and challenges.

Based on the issues identified, design questions were formulated to provide explicit design direction, promoting an agile product development process that integrated with three other key concepts. This approach ensured that the developed solutions were comprehensive, innovative, and tailored to meet the needs of Modes' users and stakeholders.

Employing well-developed concepts to build a strategic approach for the ultimate solution. The thesis employed design thinking to generate well-developed ideas and collaborated with specialists from diverse backgrounds and cultures throughout the UCD process. UCD tools were used in data analysis, webinars, and value propositions to create design concepts. The collective competencies of these design thinking and growth hacking actors were instrumental in shaping comprehensive and mature initial ideas that directly informed the foundation of the final solutions. These initial designs were a valuable contribution, as they incorporated the diversity of users and the knowledge of available technologies from the product development teams. Continuous

validation and improvement of these initial designs will enhance their value and ensure that they meet the requirements of the final solution.

Refining solutions through inclusive design perspectives. The present thesis explored the practical application of inclusive design in improving solutions across various design aspects, including business, community, cross-cultural, and HMI designs. This study utilised collaboration and contribution ways of working to facilitate the sharing of experiences and the exchange of ideas among participants. A focus group comprising Finnish industrial organisations was integrated into the study as benchmarks to provide recommendations for a guidebook and engagement plan. The resultant tangible and visual design artefacts offer a tool for reflection, feedback, and further refinement by the participants.

5.2 Thesis Limitation & Future Work

Before the official release of the Metso Inclusive Design guidebook, certain aspects required further refinement, which are out the thesis's scope. Expressly, the digital guide necessitates a more precise depiction of product areas and hierarchy to effectively showcase the contextual and product-specific needs and the optimal methodologies for inclusive design. Such refinements will ensure that the guidebook is a comprehensive resource for individuals and entities committed to inclusive design.

The thesis has not covered the use of storytelling as a means of conveying the significance of design systems to stakeholders is a potentially practical approach. By utilising relatable, engaging narratives, novel concepts can be introduced in a manner that is more easily understood, rendering the process more approachable. These narratives can highlight how product teams leverage design systems to implement best practices or showcase end-users' experiences, emphasising the importance of maintaining a cohesive look and feel. As such, it is advisable to incorporate a compelling brand narrative that elucidates design decisions in future engagement enhancement initiatives.

5.3 Thesis Contribution

Overall, this thesis provides a valuable contribution to the field of inclusive design and serves as a helpful guide for designing services for heavy industrial machinery. This thesis bridges academia and industry with practical applications for various groups:

Metso Design System: The thesis presented actionable and sustainable recommendations for organising the upcoming development of Modes and its related resources, focusing on inclusive design.

Metso: The study findings would foster stronger connections among the product teams at Metso, resulting in a more cohesive and inclusive design community. Moreover, it would underscore the importance of design and design-focused processes throughout the organisation by affording software and HMI product experts a forum to voice their perspectives and drive innovation. Standardising the design system and providing clear usage guidelines could streamline the product

development process, yielding substantial cost and time efficiencies for the company, thereby bolstering profits.

Academia: This thesis discussed design operations in a global industrial machinery organisation, expanding on concepts explored in academic research, such as design concepts, working frameworks, and multidisciplinary teams.

Design community: This thesis aims to significantly contribute to the ongoing discourse on developing and implementing a design system within an industrial machinery corporation. The thesis encourages other designers to explore the potential impact of utilising a digital guidebook and community communication on all relevant parties throughout the entirety of the product development cycle to enhance the field of inclusive design further. The thesis is believed to provide a deeper understanding of this field, with scholarly research on a relevant topic firmly grounded in and benefit professionals and the industry.

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Appendix 1

Full list of questions in the feedback survey.

QUESTION	ANSWER TYPE	ANSWER
OVERALL, HOW WOULD YOU RATE THE CONTENT?	Rating Required	5 stars, from bad to excellent.
DO YOU AGREE WITH THE FOLLOWING STATEMENTS?	Likert scale Required	5 options, from strongly disagree to strongly agree. • I would like to use this guideline frequently. • I found the guidebook unnecessarily complex. • I thought the guidebook was easy to perceive. • I would need the support of a specialist to be able to perceive this guidebook. • I found the various topics in this guidebook were well applicable to my work. • I thought there was too much inconsistency in this guidebook. • I would imagine that most people would learn to use this guidebook very quickly. • I found the guidebook very cumbersome to use. • I felt very confident using the guidebook. • I needed to learn a lot things before I could get going with this guidebook.
HOW SATISFIED ARE YOU WITH THE FOLLOWING ASPECTS OF THE GUIDEBOOK?	Likert scale Required	5 options, from very dissatisfied to very satisfied. • Information architecture • Materials provided • Topic relevance • Best practices • Overall content

		• Use of methods • Examples
HOW LIKELY ARE YOU TO RECOMMEND THE GUIDEBOOK TO A COLLEAGUE?	Rating Required	Scale of 10, from not at all likely to extremely likely.
WERE YOUR EXPECTATIONS OF THE GUIDEBOOOK MET?	Choice Required	• Beyond my expectations. • Met as expected. • Below my expectations.
WHAT DID YOU LIKE MOST ABOUT THE GUIDEBOOK?	Long answer Required	
HOW COULD THE GUIDEBOOK BE IMPROVED?	Long answer Required	

DO YOU WANT TO CONTRIBUTE TO THE CONTENT OF THE GUIDEBOOK?	Choice
	Required
		• Yes (Information might be needed for further contact)
		  ○ Go to next question.
		• No (Remain anonymous)
		  ○ Submit.

WHICH PRODUCT TEAM ARE YOU FROM?	Short answer	
WHAT IS YOUR JOB ROLE?	Short answer	
PLEASE PROVIDE YOUR EMAIL ADDRESS IF YOU WOULD LIKE US TO CONTACT YOU ABOUT YOUR FEEDBACK.	Short answer	