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Integrating Work Engagement Theory in a User-Centered Design Process

Designing a Visualization Tool for Radar Surveillance Data

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Civilingenjörsprogrammet i system i teknik och samhälle

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Abstract

The objective of this thesis is to investigate the incorporation of work engagement theory into the design process of an IT system. This is accomplished through the development of a web interface that facilitates data visualization and analysis for radar surveillance operations at Saab. The incorporation of work engagement in the design process is rare in previous research but holds the potential to enhance employee engagement, promoting greater enthusiasm for their daily tasks and alleviating stress and burnout. This, in turn, can foster a workforce that is both more productive and successful.

The thesis has been divided into two core parts; the development of a design framework used for theoretical analysis of work engagement, and the practical implementation of the framework in the development and evaluation process. The design framework, crafted through an extensive literature review, integrates work engagement theory complemented by other relevant theories, all supported by a user-centered design methodology, thus ensuring a comprehensive and consistent approach to capturing engagement. The practical implementation of the framework consisted of developing and evaluating the web interface in three iterations. In each iteration the users' needs were defined as functional requirements, a prototype was developed and a user evaluation was conducted. Following these interviews, modifications were made to the functional requirements, guiding the subsequent iteration.

The final evaluation revealed that users saw potential in the proof-of-concept tool, praising its innovative design process, ease of use, and visualization techniques. They believed these aspects could inspire future development of existing tools and enhance engagement.

After the iterations, it became evident that adhering to the proposed design framework, based on user-centered design principles and UX theory, especially emphasizing UX goals, allows for effective integration of work engagement within an IT system in a highly technological context. It holds the potential for creating engaging interfaces and thus capturing quiet quitters, amplifying well-being and increasing organizational success.

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I en tid av snabb teknologisk utveckling har oron för minskat arbetsengagemang blivit alltmer påtaglig; oengagerade medarbetare leder till minskad produktivitet och utgör betydande utmaningar för företags framgångar. En global undersökning från 2022 visade på låga nivåer av arbetsengagemang bland svenska anställda, där endast 13% angav att de kände sig engagerade på jobbet. Denna trend understryker vikten av att aktivt arbeta med frågor kring arbetsengagemang för att främja en mer produktiv och framgångsrik arbetsstyrka.

Med tanke på den betydande roll som teknologi och IT-system spelar i mångas dagliga arbetsuppgifter, finns det en risk för att de orsakar stress och irritation. Trots detta kan tekniken, om den implementeras och designas med fokus på att skapa positiva upplevelser, fungera som värdefulla verktyg för att motivera anställda. Detta kan leda till mer engagemang, bättre fokus, förbättrat välmående och ökad produktivitet.

Detta examensarbete ämnar utforska hur teorier om användarcentrerad design tillsammans med arbetsengagemang kan bidra till utvecklingen av engagerande och effektiva system. För att göra detta genomförs en fallstudie där ett webb-verktyg utvecklas för att visualisera passivt inmätt radardata. Sedan tidigare finns det ett annat verktyg för detta, som dock är begränsat gällande vilken typ av data som kan visualiseras och vad gäller jämförandet av olika datapunkter.

Studien består av två delar. Den första delen handlar om utvecklingen av ett design-ramverk för att inkludera teori om arbetsengagemang i designprocessen. Den andra delen behandlar en praktisk implementering av ramverket i form av utvecklingen av webb-verktyget.

Design-ramverket togs fram genom en litteraturstudie. En betydande mängd tid ägnades åt noggrant utforskande av olika källor med målet att etablera en robust förståelse av den nuvarande statusen av forskning inom området. Ramverket kombinerar användarcentrerad design med arbetsengagemang. Användarcentrerad design innebär att designarbete utförs i flera iterationer med återkommande kommunikation med användarna. I ramverket består varje iteration av tre faser: att definiera användarnas behov, att utveckla en prototyp och att utvärdera prototypen. Arbetsengagemang kommer framför allt in i ramverket i utvärderingsfasen där tidigare forskning på användarupplevelser använts för att formulera de intervjufrågor som ställts under utvärderingen.

Den praktiska implementeringen bestod av att följa ramverket i tre iterationer. Först skapades en förståelse av behovet från Saabs sida genom flera möten med två vana användare av det befintliga systemet. Efter detta utvecklades en första prototyp i onlineverktyget Figma som användes vid utvärderingen. Utvärderingen gjordes med hjälp av medarbetare på Saab och bestod av att de ombads genomföra ett antal uppgifter i prototypen samtidigt som de högt beskrev vad de tänkte. Efter detta ställdes intervjufrågor som är baserade på teorin för att inkludera arbetsengagemang. När den första iterationen var klar sammanfattades och analyserades resultaten från utvärderingen utifrån teorier om arbetsengagemang. Dessa resultat blev sedan grunden till den första fasen i den andra iterationen.

Detta tillvägagångssätt genomfördes tre gånger. Först med den ovan nämnda prototypen i Figma och sedan med kodade versioner av systemet. Under varje iteration framhävde användarna positiva aspekter av systemets övergripande funktioner samt hur olika funktioner förbättrade det befintliga systemet. Förbättringsförslag lyftes också i varje iteration som bland annat handlade om otydlighet, saknade grafer och saknad funktionalitet. De olika problemen åtgärdades i den mån det var möjligt i nästkommande iteration. Den kodade betaversionen utvecklades sedan vidare till en slutversion av systemet. Den slutgiltiga versionen utvärderades inte som en fullvärdig iteration utan genom ett samtal med de två vana användarna som formulerade behoven från början.

Den slutgiltiga versionen av systemet tillåter användare att titta på data på aggregerad nivå i olika grafer och de kan klicka på punkter för att få upp mer detaljerade vyer för respektive datapunkt. Två datapunkter kan jämföras där deras data visas i en överläggning, eller sida vid sida. Graferna går att zooma och filtrera efter behov.

Designramverket som har skapats är en riktlinje för hur teorier om arbetsengagemang kan inkluderas i en användarcentrerad designprocess och har i denna studie beprövats i direkt anslutning till dess skapelse. Genom att ramverket har testats på Saab, i en högteknologisk kontext som kräver hög kompetens hos de anställda, har det applicerats i ett sammanhang där arbetsengagemang spelar en särskilt viktig roll. Systemet verkar, efter utvärdering med dess användare, ha potential för att bidra till arbetsengagemang samt fungera som inspriration på Saab för vidare utveckling. Det visar potentialen i att kombinera arbetsengagemang i designprocessen för att öka både välmående och produktivitet på en teknisk arbetsplats.

Acknowledgements

This thesis marks the end of our time at Uppsala University and at the STS program – time flies when you're having fun – and we want to express our gratitude to individuals whose contributions have been particularly valuable to the completion of this thesis.

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Lastly, I, Vilma, would like to extend my thanks to Alice as well. For being a pillar of support both throughout this thesis and over the years, making the studies more fulfilling and enjoyable – Thank you!

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Alice Gardell
Vilma Hägg Edelönn

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1 Introduction

In an era of rapid technological advancement, concerns about declining work engagement have become pronounced. Across industries, there is a growing recognition that disengaged employees exhibit reduced productivity and pose significant challenges to organizational success. A 2022 global survey revealed alarmingly low levels of work engagement among Swedish employees, with only 13% reporting feeling engaged at work. The majority, 72%, expressed a lack of engagement, while 15% were actively disengaged. This trend underscores the critical importance of addressing work engagement issues to foster a more productive and successful workforce [1].

According to the "State of the Global Workplace: 2023 Report" by Gallup, a significant finding highlights that 59% of global employees fall into the category of "quiet quitters". These individuals neither feel engaged nor actively disengaged at work. They demonstrate minimal effort in their tasks and experience a psychological disconnect from their employer. Consequently, they face a higher risk of stress and burnout due to feeling lost. Despite their current disengagement, this group remains employed and potentially receptive to motivation and fulfillment if their engagement needs are addressed by their employer. Effectively managing this sizable demographic presents a substantial opportunity for increased productivity [2].

Given the significant role of technology and IT systems in the daily tasks of the average employee, they also carry the potential to induce stress and burnout. Nevertheless, if implemented and designed thoughtfully, focusing on creating positive experiences, they could serve as valuable tools for motivating the group of quiet quitters. This could lead to heightened employee engagement, improved well-being, and enhanced productivity and organizational success as a result. Engaged employees foster company success and the other way around, making engagement key for goal-directed energy [3].

Against this backdrop, radar surveillance conducted in Swedish company Saab emerges as an excellent case study to explore the complexities of work engagement within a high-stakes, technologically-driven environment. In Saab's work with Electronic Warfare, radar surveillance operations demand vigilance and analytical insight. Moreover, maintaining high levels of work engagement is essential for ensuring effective threat detection, making it an ideal setting to assess the interplay between work engagement and technological advancements.

1.1 Problem Statement

In Saab's work with radar surveillance, one important aspect is the analysis and identification of passively measured radar signals. Through the examination of radar data originating from external sources, such as radar pulses intercepted by Saab's sensors, potential threats can be pinpointed and assessed. This analysis equips Saab with information to execute efficient countermeasures, enhancing the protection of vital assets and territories.

Currently, Saab possesses a system capable of presenting aggregated radar data that has been passively measured. However, its functionality is limited in some aspects. The employees have expressed that what is lacking is a graphical representation of the so-called *track reports*.

In an Electronic Warfare (EW) system, a track report is a vital element, containing data essential for drawing conclusions about various emitter behaviors, emitters being systems that send out radar signals. For example, a track report may arise from an AI model processing extensive radar data, categorizing it into distinct emitter groups based on various criteria. Each track report contains aggregated data specific to a single emitter, including details such as frequency, pulse width, pulse repetition interval, and other relevant information arranged in a comprehensive matrix format. In the current system, employees rely on analyzing this data and comparing reports solely by scrutinizing matrix values while still maintaining focus on the task at hand. The track reports contain a vast amount of data, resulting in analysis often becoming tedious and lacking in engagement.

Moreover, the current system is highly complex, offering a multitude of potential interactions and analysis tools, not all of which are easy to grasp in terms of their purpose. Additionally, many of these tools are not utilized in everyday radar data analysis tasks. Thus, there is potential to improve the current system.

This study focuses on the development of a new web interface as a complement to the existing one, with the aim of facilitating easier and, at Saab, innovative analysis of some specific passively measured radar data. The potential to introduce a novel approach to user interface development, enabling new presentations of existing data, is valuable. If these important and demanding analysis tasks could become more engaging, the vigilance required could probably be maintained to a higher extent. Such a tool could also serve as inspiration for future advancements, benefiting not only Saab internally but also their clients.

One primary objective of this new interface is to enable comparison of two track reports within the interface, derived from aggregated data from the same source – that is, the same *track* – to discern and ascertain the type of emitter it represents. Another use case involves implementing a control function for classifications already performed by the AI model. A graphical comparison of the pre-classified track reports can help with controlling that the classification is correct. Patterns displayed in a graphical interface can also help Saab employees identify potential new emitter behaviors, creating emitter descriptions that can help with future identification.

This thesis is a collaborative effort between the two authors, who equally contributed to both the development of the interface and the theoretical aspects explored within the study and presented in this written work.

1.2 Purpose

In the development of the web interface, the methodology will draw from theories on *user-centered design*, evaluating and analyzing engagement in iterations based on previous research on *work engagement*. The goal of the interface is to facilitate easy and engaging radar data analysis by presenting the data in various graphical formats within the interface.

Drawing upon previous studies related to these theories and integrating work engagement throughout the design process of an IT system from start to finish addresses a potential knowledge gap. Current research often neglects to incorporate these theories iteratively into design processes, evaluations typically occur at the project's end, if ever.

With this objective in mind, the study is guided by the following research question:

- How can user-centered design methodology, enhanced with work engagement theory, contribute to the development of engaging and effective visualization tools?

1.3 Limitations

While this study aims to contribute valuable insights to the field, it is essential to acknowledge its limitations due to time and resource constraints. Recognizing these limitations helps create a nuanced interpretation of the findings and a clearer understanding of the study's scope. Here, we outline and discuss the notable limitations that may impact the generalizability and applicability of our results.

Due to company secrecy, the existing tool used for the analysis of radar data cannot be shown in this thesis. Consequently, this tool has not undergone evaluation in relation to work engagement prior to the development of the new tool. The absence of access to the current system obstructs a study on work engagement, thereby limiting the ability to conduct a comparative analysis of engagement levels before and after implementing the new tool.

Since the tool is mostly seen as a proof of concept and is not a direct integration of a new system into the actual work environment, there is a limit to the conclusions that can be made in relation to work engagement and productivity. The study provides indications of such tendencies but no more. Given that the main goal of this study is to integrate theoretical frameworks of work engagement into the design process, it aims to mitigate the impact of these limitations on the overall quality of the study.

A user-centered design process is typically performed in several iterations. This thesis presents three iterations with one medium to high-fidelity prototype, one beta and one final version of the system. Ideally, more iterations would have been included, thereby making the results regarding work engagement in the design process clearer and more robust. Given that a significant portion of the thesis's objective revolved around developing a design framework applicable to the user-centered design process, the scope of the thesis limited the number of iterations feasible.

Lastly, since the study is performed on a specific demographic, working in the same division at the same company, the results most likely lack generalizability in that sense. Also, given the tool's highly specific nature within the realm of IT systems and its limited functionality, the findings cannot be generalized to encompass all IT systems. This is the rationale behind the formulation of the research question.

2 Background

This background section of the study provides a concise overview of the case study company, Saab AB. The different business areas (BA:s), products and solutions along with some additional information on the radar data analysis tasks, collectively present a holistic view of the company. This broader perspective plays a vital role in situating the tool within the company's operations. The section concludes with concise descriptions of key concepts within radar analysis, providing valuable insights for comprehending design decisions and discussions in subsequent parts of the study.

2.1 Saab AB and the Business Area Surveillance

Saab was founded in 1937 with the primary aim and task of providing military aircraft for Sweden. Today Saab operates on a global scale, offering products, solutions and services related to military defense and civil security. Saab has about 22,000 employees, mainly in Europe and Sweden where research and development is conducted, but also in the USA, Brazil, Australia and more. Saab's operations are organized into four primary business areas, each specializing in distinct aspects of the defense and aviation sectors [4].

The *Aeronautics* division is dedicated to the production and supply of aircraft systems, aerostructures, and comprehensive support solutions for both civil and military aviation. The *Dynamics* business area focuses on providing a range of support, including weapons, missiles, sensors, deception and camouflage systems, air defense systems, and various training systems. In the field of naval systems, submarines, and surface vessels, *Kockums* stands out as a world-leading business area, excelling in the development and service support of these critical components [5].

The fourth business area, *Surveillance*, is the focal point of the thesis since it is in this BA the case study is conducted. This sector is dedicated to delivering safety-centric solutions, encompassing surveillance, decision support, threat detection, and protection. Notable offerings include AEW&C (Airborne Early Warning and Control) systems, with GlobalEye being a prominent example. GlobalEye is an aircraft that employs a mixture of modern active and passive sensors for long-range detection and identification of objects [5]. Modern AEW&C systems have detection ranges of about the order of 400 kilometers as a result of the high altitudes on which they can operate in combination with advanced radar systems. This means that a single AEW&C aircraft operating at an altitude of 9 kilometers can cover and detect targets on an area of about 312,000 square kilometers [6].

The surveillance division also provides surface radars, technology for air traffic management, signal intelligence systems, nose radar for fighter aircraft, and more [5]. At

Saab, electronic warfare is a key technology. Electronic warfare includes among other things self-protection systems, signal intelligence and analysis of radar and communication signals [7].

Within the surveillance division, the analysis of passively measured radar data equips Saab and its clients with insights into the types of emitters transmitting radar pulses toward their aircraft, facilitating a better understanding of potential threats. The system currently facilitating this analysis is, as previously mentioned, very complex and lacks graphical representations of detailed track report data. While it offers useful functionality, its steep learning curve often poses challenges for clients who may struggle to fully grasp all available features.

Introducing an interface as a complement to this system, incorporating graphical representations of radar data extracted from track reports, could significantly reduce integration time for both Saab's customers and new employees. Such a tool could streamline daily tasks for surveillance division employees, providing swift data overviews and simplifying the selection of suitable inputs for AI model training and other purposes. Figure 1 depicts a partially blurred image of a track report utilized for analyzing data recorded during flight and classified by an AI model as a specific emitter. The image effectively illustrates the challenges associated with data comparison and analysis, where analysis and comparison rely solely on assessing matrix values.

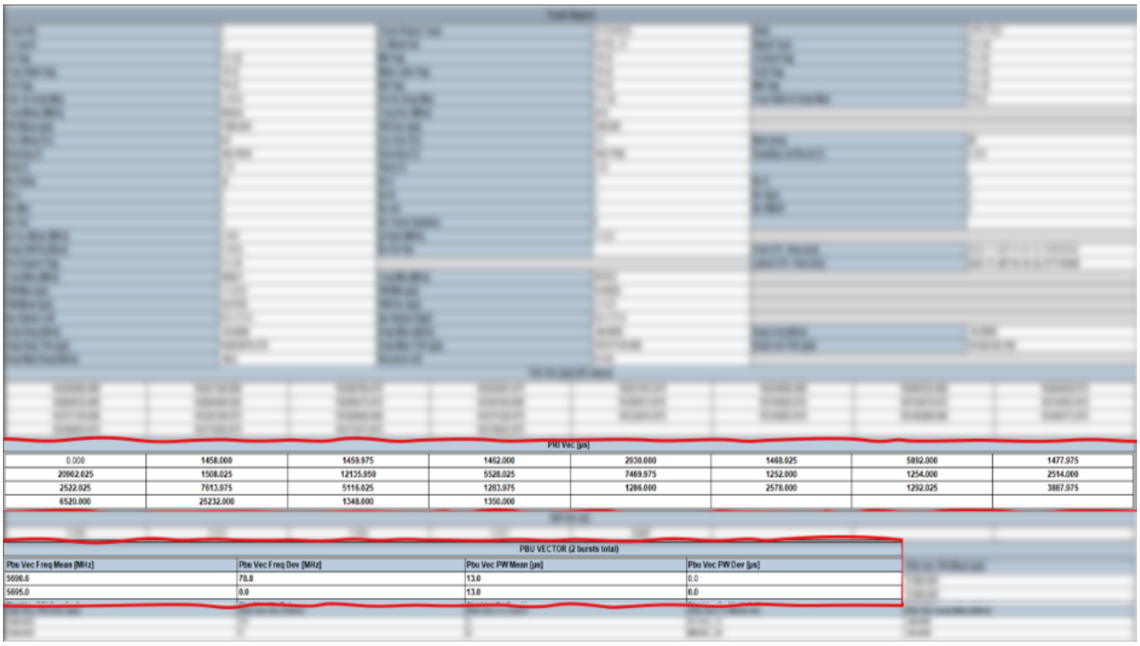


Figure 1: A track report displaying fabricated data, the red parts highlighting the PRI and PBU vector.

2.2 Key Concepts and Technologies

2.2.1 Electronic Warfare

The term electronic warfare (EW) describes military actions to reduce the effect of an opponent's use of electromagnetic systems. The purpose of electronic warfare is to gather information, hamper the opponent's lead, ensure the own leading abilities, increase the own survival and enhance the effect of actions [8]. There are three subfields of EW, *electronic warfare support* (ES), *electronic attack* (EA) and *electronic protection* (EP). ES is also called *electronic support measures* (ESM) [9]. EW includes signal intelligence, warnings, telemetry jamming, misguidance, false signaling, deployment of signal-seeking weapons and electromagnetic pulse weapons, electronic protection and electronic tactics. A common technology used in EW is radar [8].

2.2.2 Radar and Electronic Warfare Support

Radar is an acronym for RAdio Detection And Ranging, it consists of electromagnetic energy which a radio transmitter sends out. When the electromagnetic energy or radar signal reaches an item, it is reflected and scattered, and some of it returns back to a radio receiver. The transmitter and the receiver often share an antenna and to avoid interference between transmission and reception, the radio waves are sent out in pulses allowing the receiver to be turned off during transmission [9].

In ESM, radar is used in a more passive sense meaning it does not transmit its own signal, it only receives signals from others. The primary purpose of it is to acquire the necessary information regarding hostile signals and inform other parts of EW in order to improve their efficiency. A significant aspect of ESM involves the identification of hostile signals, determining their proximity to friendly assets, and understanding both the location of the emitters and their operational modes [9].

Radar signals contain information about the transmitter that sends it out. Some of the important characteristics of pulsed radar are frequency, pulse width and the rate at which pulses are transmitted [9]. These will be explained in the following section.

2.2.3 Frequency, Pulse Width and Bearing

The *frequency* of a radar pulse is the number of cycles the signal completes in a second. It is rarely constant but can be varied for different purposes. Between pulses, it can be increased or decreased. Within pulses, it can both be changed randomly or to follow a specific pattern [9].

The *pulse width* (pw) is the duration of the individual pulses, often represented with τ. The pulse width is of importance for separating closely spaced targets which can only be distinguished from each other if they are separated by more than the pulse width [9].

The *bearing*, also referred to as *azimuth* is the horizontal angle, measured in degrees, between true north and an object [6]. At Saab the bearing is defined as the angle between the nose of the airplane and the object.

2.2.4 Pulse Repetition Interval, PRI

PRI - Pulse Repetition Interval or *interpulse period* is the time interval between pulses, that is, the time between the start of one pulse and the start of the next pulse. Figure 2 shows a transmitted pulse and the interpulse period T [6].

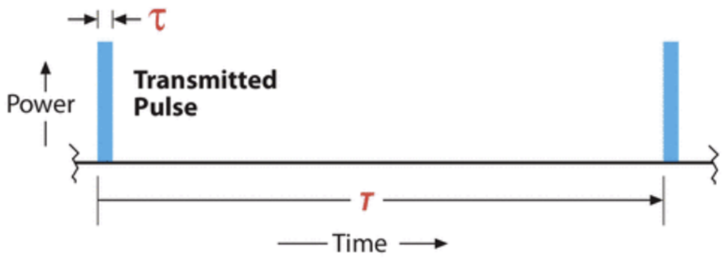


Figure 2: A visual representation of transmitted pulses and the interpulse period, T [6].

2.2.5 PRI Modulation

In EW and particularly in ESM it is a common issue that multiple radar pulse trains – a sequence of individual pulses – are being received at one receiver. To pinpoint a specific radar emitting a signal for further analysis, it is essential to disentangle and separate the distinct pulse trains from one another [10]. The PRI can be useful in the separation and identification of radar emitters. Recognizing the *PRI modulation* type can help with revealing the identity and purpose of the radar emitter [6].

For the most part, the PRI of a pulse train follows a specific modulation type, a pattern. The PRIs are often not repeated with the same interval, there are several different complex modulations of it. The recognition of PRI modulation is typically carried out by trained operators who observe and analyze these intricate patterns. The analysis is often done through statistical analysis, for example by looking at histograms of the recorded PRI values [10].

Some examples of basic PRI modulations are shown in figure 3 and 4. The figures display the modulations with different values on the axes, these different visualizations have their own advantages in relation to pattern recognition and in understanding the radar behavior. The visualizations are ideal case examples, in reality, there are electromagnetic disturbances influencing the PRI patterns making their identification more challenging.

The modulation types relevant to this study are the following:

- *Jittered* PRI involves random variations in PRI. It is a constant PRI sequence with a random jitter often following a Gaussian or uniform distribution [11].
- *Dwell and Switch* PRI modulation occurs when the radar system stays on one PRI for a short duration and then rapidly switches to another [10].
- *Fixed* PRI is a constant value [11].
- *Sawtooth or ramping* PRI modulation typically involves a monotonic increase or decrease in PRI [11].
- *Wobulated or sinus* PRI modulation is characterized by a sinusoid variation of the PRI [11].
- *Staggered* PRI changes between fixed values and is a combination of multiple constant PRI sequences [11].

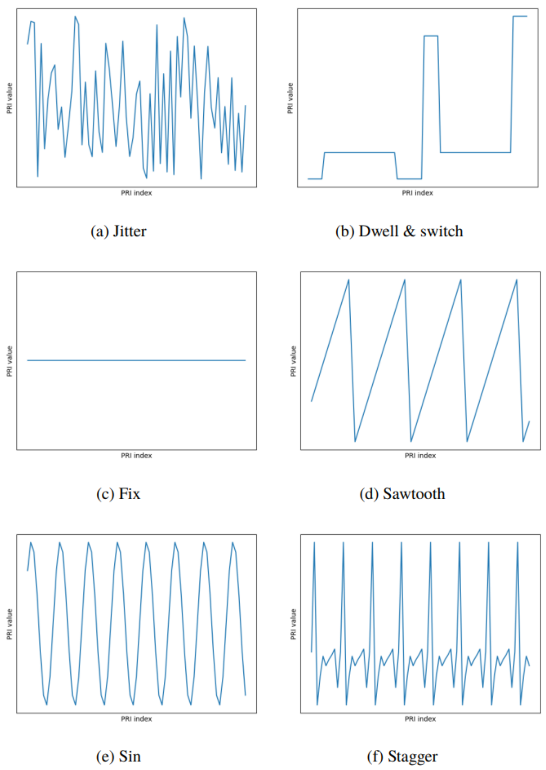


Figure 3: PRI modulations with index on the x-axis and PRI on y-axis [12].

Figure 4: PRI modulations with PRI at index n on x-axis and at index n-1 on y-axis [12].

2.2.6 Pulse Burst Unit, PBU

A pulse burst unit (PBU) vector consists of values with the most energy during a radar sweep. This implies that the PBU vector is a representation of the pulse data at its most significant or optimal state, providing the best measurement values.

The contents of a PBU vector can vary depending on radar system characteristics, but in this case study the PBU vector consists of frequency, pulse width and PRI values.

2.2.7 Background Summary

As depicted in the image representing a track report alongside the unique attributes of Saab's business domain, it becomes evident that the IT systems at Saab require a high level of engagement for effective utilization. These systems often entail complex tasks, demanding deep involvement from employees. Training individuals to identify complex modulation patterns and to do other tasks takes much time and resources. Therefore, it is crucial for the company's success to maintain employee motivation and engagement, preventing quiet quitting.

Incorporating innovative thinking and theory on work engagement into the design process of new tools within Saab could offer inspiration for future improvements of IT systems.

3 Theory

The upcoming chapter provides an overview of the theoretical framework developed from a literature review, focusing on theories deemed appropriate for achieving the study's objectives. The chapter commences with a discussion on the broader concept of engagement, particularly focusing on work engagement. Additionally, the relationship between work engagement and information technology within the workplace context is explored. Lastly, some previous studies on positive design and user experience (UX) goals are presented complementing the engagement theory with the aim of connecting them on emotional aspects.

3.1 Work Engagement

In 1990, William A. Kahn conducted two qualitative theory-generating studies to investigate the psychological dynamics of personal work engagement. Kahn delineated between personal engagement and personal disengagement, referring to how individuals express aspects of themselves in the workplace. When individuals are personally engaged in a task at work, they typically manifest these aspects. Conversely, when individuals are disengaged, they tend to withdraw and defensively distance themselves — physically, cognitively, or emotionally — during their role performances [13].

Personally engaging behaviors in relation to a task express and give life to both the authentic, individual self and the roles or responsibilities that are deemed necessary or obligatory in a given context. In other words, individuals are actively involved in tasks in a way that reflects not only their personal identity, thoughts, and feelings but also fulfills the expected duties or roles associated with a particular situation or context. When a task is not engaging, people tend to detach themselves from the role. In these cases one can observe the withdrawal of their expressive characteristics and the task is mostly seen as a role obligation [13].

Work engagement can be looked at as a motivational concept, when someone is engaged they feel the motivation to work towards a goal, striving for success, although it might require some personal commitment [14]. Khan describes the concept of psychological meaningfulness as the feeling that one is gaining a return on personal investments and commitment, these being physical, cognitive or emotional. The result of the study showed that people felt the most meaningfulness when the task needed both routine and new skills, when people could make use of their skills but also experience growth and when the task was varied, challenging, creative but still somewhat autonomous [13].

Committed employees play a pivotal role in shaping workplace performance, both on an individual and organizational scale. Engaged in enjoyable and stimulating tasks, they operate with heightened efficiency and vigor, contributing to increased productivity and value creation [14]. Job resources play a crucial role in fostering employee engagement. These resources can be either intrinsic, motivating individuals through personal satisfaction, growth, learning, and development, or extrinsic such as salary, interpersonal relations, supervision and security, as they are essential for accomplishing work-related goals. When tools and tasks are extrinsically motivational, the likelihood of successfully completing the task and accomplishing the work increases [14].

The goal of the study performed by Kahn in 1990 was to generate a theoretical framework for understanding people in the workplace and their behavior in relation to work tasks. Kahn's work engagement theory has been criticized for being similar to other concepts, such as job satisfaction [15]. However, this framework is still used as a basis in many studies on employee engagement. Work engagement theory is also lacking in consideration of cultural aspects. One study that compared the measurement of work engagement among Dutch and Japanese people showed that the measurement accuracy was different between the groups, meaning that work engagement might not be generalizable across cultures [16]. It is also worth noting that since Kahn's study was conducted in 1990, it is important to incorporate newer theories alongside this framework for a more fair evaluation concerning the current workplace environment.

3.1.1 Techno-Work Engagement

Many areas of work today include interactions with digital technologies such as IT systems. The digitalization of society yields both positive and negative effects on work engagement. When studying well-being at work from a technological perspective, technostress is often discussed. Technostress refers to an employee's negative experiences caused by technology used at work. The effects of technostress can be anxiety, fatigue, skepticism and beliefs about the use of technologies being inefficient [17].

Technostress focuses on the negative aspects of technology involved in work but there are also positive ones, one example is that technology can help with demanding or monotonous tasks. By using technology, the work can be more safe and more rewarding. This specific type of work engagement is called techno-work engagement and relates to *positive* situations that are connected to information and communication technology at work. Using information and communication technology at work can improve employee well-being by improving work performance, giving flexibility and assisting in information exchanges. Other positive aspects of these technologies include that they can help with providing good service quality, lead to better productivity and assist humans in complex data analysis [17].

Work engagement can be divided into three categories, shown in Table 1: vigor, dedication and absorption. Vigor means that employees want to invest effort into their work and have high levels of energy and mental resilience. Dedication means a feeling of inspiration, pride and enthusiasm, and also how well one identifies with their work. Absorption means being concentrated on the work, so that time passes quickly and consequently making it hard to detach from the task [18].

It is valid to note that there are other methods of measuring work engagement, for example one presented by Douglas R. May et. al [19], both these measures or descriptions have been used in previous studies. This means that findings in a study are specific to how it measures work engagement, limiting the generalizability across different studies. However, the measurement of vigor, dedication and absorption by [18] was proven to perform a little bit better in a study of validity [20] and has therefore been chosen as the measure of work engagement in this study. Thus, techno-work engagement is described as "a positive and fulfilling well-being state or experience that is characterized by vigor, dedication, and absorption with respect to the use of technology at work." [17, p. 2].

Table 1: Work engagement categories [18].

Vigor	**Dedication**	**Absorption**
Wanting to put effort into work, high levels of energy, mental resilience	Inspiration, pride, enthusiasm, identification with work	Concentration, time passes quickly, hard to detach from tasks

3.2 User Engagement

Within the sphere of engagement, general *user engagement* is a common area of research. User engagement is a term regarding users' interactions with technology. There is no exact definition of the term, but it is described as "a quality of user experience with technology" [21, p. 3] which is characterized by appeal, usability, novelty, focused attention, involvement and insurability. In a more general sense, it is described as the interactive user experience with a focus on what engages people and makes them continue using technology [21].

User engagement can be described in four stages. The first is the point of engagement, which means when the user invests themselves in the interaction or when a system captures the user's motivation and interest. The point of engagement can happen at any time during the interaction with the system and happens because of a novel or aesthetically pleasing interface. The next stage is to maintain the users' engagement. Engagement attributes are that the interface needs an aesthetic appeal, users need to get feedback from the system to know what it is doing and be in control, feel connected to the technology through interactivity or to other people as well as feel interest or positive emotions. The third stage is that of disengagement, when users because of different factors lose their engagement in the system. By disengaging, the user logs out of or stops using the system. It could either be because of positive emotions such as feeling satisfied or because of negative emotions such as frustration, feeling overwhelmed, loss of interest, uncertainty, that the task takes too much time or lack of novelty in the system. The final stage is re-engagement which means that the user can cycle through the previously mentioned stages of engagement [22].

3.3 Positive Design and User Experience Goals

The core of engagement is creating and maintaining positive experiences, something that is studied in other fields as well. Within human-computer interaction (HCI), positive psychology research has shown that positive emotions in the interaction with technology lead to improved well-being [23]. This theory based on positive psychology is the "Theory of Optimal Experiences, commonly referred to as Flow Theory" [21, p. 10]. Central to the concept is that people usually feel the most motivation and "flow" when the task at hand aligns with personal aspirations, feelings and thoughts. This theory is similar to that of *absorption* [18], and is often applied within HCI theory, focusing on the investigation of motivation of interactions with digital interfaces [21]. When designing for user well-being, positive emotions or experiences can thus be incorporated into design theory [23].

Golay, Sving and Cajander have conducted research in this area, delving into the formulation of UX goals tied to positive emotions in the context of healthcare professionals' interaction with IT systems [24] [25]. Their work underscores the importance of considering emotional aspects in UX design and its impact on burnout among medical practitioners. Furthermore, the study utilized principles of emotion-driven design in formulating UX goals, with the aim of fostering positive experiences rather than solely focusing on eliciting a broad positive reaction or avoiding negative reactions [24].

The UX objectives outlined in the studies were exclusively centered around positive experiences and emotions [24]. The rationale behind this is that when the design focus is on creating a system that users feel positively about, there is no need to prioritize avoiding negative experiences. This is because the absence of a negative experience does not guarantee a positive one for the user.

When designing IT interfaces, focusing on designing for specific emotions has advantages. It helps the designer capture important user insights and to understand and articulate specific design intentions. In the studies, it became clear that if the user experience goals are considered in the design of IT systems, the well-being of the workers improves and burnout becomes less likely [24].

The UX goals used in the studies are:

1) I feel joy as I complete my IT-supported tasks quickly and effortlessly [24].

2) The steps I carry out feel meaningful as I understand their purpose [24].

3) I feel confident on how to proceed to produce the outcome I want [24].
4) I experience relaxation as I feel supported in minimizing the risk of patient harm [24].
5) I experience relaxation as I feel supported in avoiding mistakes [25].
6) I experience relaxation as I feel I'll be able to access a computer or information if and when I need to [25].
7) I experience pride as I feel that I am providing the safest and highest-quality care [25].
8) I experience gratitude as I feel that others contribute to making my work easier [25].

These UX goals incorporate the many important aspects of work-engagement theory and serve as a usable tool for evaluating engagement in practice.

3.4 Theoretical Summary

In this study, the theory of work engagement serves as the overarching framework for integrating concepts related to the advantages of engaged employees. Later, this is further explored through the concept of techno-work engagement, which specifically addresses work engagement within a technological context, aligning with the study's objectives.

User engagement is also included to illustrate different attributes of technology that affect the user in positive and negative ways. This theory is also included to provide more background on the general concept of engagement, as well as to relate to various stages of engagement where emotions also come into play.

Finally, previous studies on positive design that explore the connections between UX and engagement are included. These goals will be utilized as a basis for creating a framework that combines user-centered design and work engagement.

4 Methodology

To explore the integration of work engagement theory into the design process of a visualization tool, a user-centered design methodology was employed. In this section, the theoretical approach to user-centered design is presented, derived from a comprehensive literature review on general methodology. Subsequently, the specific approach to user-centered design – incorporating work engagement – employed in this study is outlined in a step-by-step fashion.

4.1 User-Centered Design and User Experience

User-centered design (UCD) is a methodology in software design that developers employ during application creation. UCD is about design, but not entirely. Rooted in the principles of human-computer interaction (HCI), its primary objective is to align with and address the specific needs of users. It involves analyzing how design can assist users in achieving their objectives, rather than solely focusing on creating aesthetically pleasing applications with an abundance of functionality [26].

In "Fundamentals of User-Centered Design: A Practical Approach" [27], the authors outline commandments for achieving success in UCD. Prior to introducing these commandments, there is an explanation stating that UCD is often viewed more as a philosophy than a strict methodology, emphasizing the paramount importance of user needs. However, applying philosophical theories directly to practical design processes is challenging. The commandments serve as valuable guidelines for effective design, yet it is crucial to acknowledge that the design process is inherently contextual. Therefore, methodologies must be adaptable and tailored to suit the specific context at hand [27]. It is important to note the UCD is not subjective, it is rooted in scientific knowledge where the users are studied, data is collected and all design decisions are a result of engaging with the users [26].

One of the main takeaways of the chapter where the commandments are presented is that involving users early and often in the design process is of vital importance. It makes the time more efficient, reduces unnecessary design hiccups and makes it easier to understand the real-world context in which they use the system. By doing this and adapting the design to the user, not the other way around, it is also easier to incorporate existing mental models into the design. If a system is designed based on these theories the users can use their previous understandings to navigate the interface more easily [27]. Effective user-centered design enables developers to guarantee that the application provides a positive and satisfying user experience. This encompasses not only the functionality but also the overall experience of the system or product [26].

Although user-centered design is a well-defined and accepted design approach, it is sometimes critiqued for appearing to be easy and always successful, which does not correspond with reality according to [28]. In a workshop conducted in 1998, the attendees found many common problems with UCD. Some problems discussed were user participation-related issues, such as management's reluctance to involve users in the process, determining where, when and which users should be included for maximum efficiency during evaluation, and establishing the maturity level required for prototypes to offer valuable evaluations [28].

Although many problems were identified in the study, the solutions that were presented to fix them are practices that have been used during this study. Some of these solutions are to include the users, to ask appropriate questions during prototype evaluation and so forth.

4.1.1 UCD and Visualization

When designing an interface, it is crucial to prioritize data visualization alongside screen layout. Beyond mere screen design, effective interaction with the data becomes essential, especially if the application handles significant amounts of information presented in a structured manner. The tools provided for data exploration significantly influence the user experience within the application [29].

Interactive visualization refers to how visual information is presented to users through a computer in an efficient way. Many times, visualization systems are developed for specific user groups and their needs. Therefore it is important to analyze the users in their context of work to find out how they use their information and what they need from it. When users are understood in their work environment, visualization can be more effective as well as more pleasurable. Visualization design can be split into three iterative phases: first, the envisioning phase when users' needs are identified based on their current situation and the specification phase when solutions are proposed to the users on a global and then detailed level. All of these stages contain analysis, design, and evaluation [30].

Interactive visualization combines innovative interactions with novel data presentations, serving as a means to enhance cognition. Adhering to the principle of "Overview first, zoom and filter, then details on demand" [29, p. 349], facilitates users in grasping the big picture before delving into specifics. Furthermore, it aids in pattern recognition within data sets, encodes information within interactive tools, and minimizes the need for exhaustive search [29].

4.1.2 Steps in User-Centered Design

4.1.2.1 Collecting User Requirements

In user-centered design, users are frequently involved, and collecting user requirements is the first step in the process. As the designer and developer, one must keep in mind who the end user of the system is and what their needs are [27]. This stage holds paramount importance in the design process, as the requirements established here dictate subsequent steps. The crucial task of documenting and translating abstract user requirements into comprehensible needs is vital. During this step, the focus is on understanding and capturing user needs rather than delving into technical details. This part of the UCD is usually completed before any actual development is done [26].

4.1.2.2 Creating Functional Requirements

The functional requirements are the technical specifications of the product. When creating the functional requirements the focus is on specific behaviors or interactions the system should be able to perform in order to meet the user needs. These are often expressed clearly, for example as a list that the developer can come back to during the developing phase [26]. The functional requirements can and often do change as feedback is gathered from the users [27].

4.1.2.3 Prototyping

By creating prototypes of the application the user and functional requirements can be translated into something real that can be evaluated. It is a good method of involving the users in the development phase, ensuring that they will not be disappointed by the final product [26]. The prototypes can go from low fidelity to high fidelity to beta versions of the system. The purpose of low-fidelity prototypes is not to look or to behave like the final product, but to test early-stage ideas of design and functionality. A common way of creating low-fidelity prototypes is by sketching on paper. A high-fidelity prototype is much closer to the intended end product, simulating most of the functionality without the need for a full implementation [30].

Users often struggle to engage with a prototype when presented with it in isolation. Thus, it is advantageous to frame a narrative and assign a task to facilitate interaction. For instance, if the prototype aims to replace an existing system, the assigned task could involve performing one of the user's current activities. This approach enhances user engagement and provides valuable insights into the prototype's functionality and usability [29].

4.1.2.4 Collecting Feedback

Continually gathering user feedback is a way of knowing if the design of the system is moving in the correct direction. Feedback can be gathered in many different types of user studies, for example through surveys, interviews or task analysis [26]. There is no common agreement among UCD scientists regarding how many users should be included in the user study, the number largely depends on the purpose of the application

[26]. The usability researcher Jakob Nielsen did a study in 2000 [31], concluding that comprehensive usability tests are ineffective and a waste of both time and money. The study revealed that conducting usability tests with more than five users yielded almost no additional information. Typically, after the second user test, significant overlap occurs, already following the initial usability test, nearly one-third of all relevant usability insights are already known. This is true in most cases for somewhat simple applications, however, a website that will have users from several distinct user groups needs usability studies on more than five people [31].

4.1.3 Design Principles

There are many design principles related to UCD that have been created using scientific studies on humans and their understanding of their surroundings. These principles have been quite consistent over time and can be seen as guidelines for the designer as well as a guide on how to not make mistakes [26]. Some design principles from the book *User-Centered Design* [26], based on practical guidelines, are presented below.

The *principle of proximity* or *grouping principle* is a design principle based on the notion that people perceive relations between objects that are closer together. By grouping items with similar functionality, for example within a menu, it makes it easier for the user to navigate the interface. If an application is disorganized people are more likely to not find what they need and become frustrated as a result.

Visual feedback and prominence are principles that are used to bring attention or focus to a specific element. The focus can be directed using different typefaces, colors, contrast, opacity or sizing. One example is the changing of the color of a button when pressed. This principle proves valuable in situations where directing the user's attention to a specific element is important, facilitating a seamless interaction flow [26].

Mental models and metaphors is the notion that all users have previous experience using products, and consequently, they also have mental models that influence their understanding of how applications work. As a developer, it is crucial to design features like language and icons to align with the actual functionality and strive to correspond with users' mental models. A designer can also use *progressive disclosure* in an application to help reduce the cognitive load on the user. Options that are not available in a certain stage of the interaction should not be visible to the user but be gradually made visible as the user navigates the interface [26].

It is also important to make the design as *simple as possible*, to focus on the core functionality for easier use. Users like to be in control when interacting with a product. This is not necessarily achieved by adding functions where the user can make changes themselves, it can also be about creating a good situational awareness [27].

4.2 Implementation of User-Centered Design with Work Engagement Integration

This section outlines the execution of user-centered design with work engagement integration through two primary stages: firstly, a study of existing theory and the creation of a design framework, and secondly, the practical approach.

The theoretical approach encompassed the development of a design framework, integrating relevant theories derived from a literature review. A considerable amount of time was dedicated to thoroughly investigating diverse sources, aiming to establish a robust understanding of the current state of research in the field. The literature review not only served to familiarize the researchers with other studies but also laid the groundwork for constructing a design framework. During the literature review, the focus was on identifying theories capable of capturing feelings of engagement at work in a manner that was measurable and could be assessed quite quickly, aligning with concepts from the UCD methodology.

This stage was followed by the actual – practical – design process aligned with this framework. The design process consisted of multiple iterations. Each iteration encompassed phases of collecting user requirements, creating functional requirements, development and evaluation, all of which were ingrained with considerations of work engagement. The following subsections detail how work engagement was integrated into each phase of the design process.

The section concludes with a presentation of the aspects that vary slightly between the iterations of the approach.

4.2.1 Collecting User Requirements

When conducting user-centered design, the first step is collecting user requirements. In this study, there was a thorough conversation with the system users from the very beginning. The focus in this initial step was on identifying the user needs and, consequently, the issues with the current system, and determining how the new system could address them. Two system users actively contributed to formulating the requirements from the outset. Work engagement considerations were integrated into this phase by assessing how proposed features could enhance user ease of use, satisfaction, and task effectiveness.

4.2.2 Creating Functional Requirements

Functional requirements emerged through discussions with system users. Some requirements stemmed from users' existing understanding of desired functionality, while others were formulated during the exploration of user needs. These requirements were continuously developed and reassessed throughout each design iteration, reflecting the evolving insights gained by both users and designers throughout the design process. Work engagement principles were integrated into this phase by evaluating how each requirement could enhance user motivation, focus, and enjoyment of tasks within the system.

4.2.3 Prototyping

To include the users and evaluate the system from a work engagement perspective, prototypes were created. The very first one was a low-fidelity prototype created with paper drawings. This prototype was not evaluated officially but was rather used as a visual aid in the process of framing user- and functional requirements. After this, one medium to high-fidelity prototype and one beta version of the system were created. Finally, the development of the beta system continued to create the final version of the system.

4.2.4 Evaluation

The evaluation was conducted in iterations during the design process, using a small number of users in each evaluation. This method is called *formative testing* or *iterative testing*. The purpose of this method is to involve users and collect data about potential usability problems so that there is enough time to do something about them, and therefore hopefully avoid major usability problems [27]. This iterative testing also stems from the theory on visualization design [30] and its three iterative phases. The feedback from each iteration informs the redesign of the interface in the subsequent iteration.

User studies were utilized as the main feedback collection method for each design iteration. During the studies, the respondents were asked to perform some tasks. After doing so, interview questions about how they perceived the system were asked. The tasks were representative of those the users typically perform in their professional roles, as the mantra of usability testing is to evaluate the system using *representative* users performing *representative* tasks [27]. Due to variations in the developmental stages of prototypes, the tasks assigned to users differed slightly across iterations, although efforts were made to maintain consistency to the greatest extent possible.

The interviews were of a semi-structured character. While some questions were prepared there was also room for flexibility since the respondents might have things to say that the interviewer did not consider beforehand [32]. During the studies, the users were encouraged to think aloud while performing their assigned tasks. When users discuss their decision-making process while navigating the interface, they offer valuable insights into their mental models, as they often do not have the time to think about their comments [27].

4.2.4.1 Interview Questions

Out of the UX goals outlined in the theory, see section 3.3, four were selected based on their relevance to the study and assessablity based on interface characteristics. The initial study was performed in a medical setting and included goals closely tied to patient harm and medical care, these were deemed irrelevant for this study. Additionally, the UX goal centered around accessing a computer when needed was considered irrelevant, given that users in this study have constant access to a computer throughout the workday.

Interview questions were then crafted by the thesis authors, drawing from these UX goals in combination with the understanding that when evaluating visualization design, common factors to examine are efficiency, satisfaction, and ease of use [30]. Table 2 outlines the questions posed following the completion of the assigned tasks. Additional questions regarding the overall experience were also incorporated, these are presented in Table 3.

Table 2: UX goals and the corresponding interview questions

UX Goal	Interview Questions
1. I feel joy as I complete my IT-supported tasks quickly and effortlessly	▪ How did you experience the time required to complete the task? ▪ Was it easy to complete the task?
2. The steps I carry out feel meaningful as I understand their purpose	▪ Did the sequence of events feel natural? ▪ Do you understand why various steps are taken?
3. I feel confident on how to proceed to produce the outcome I want	▪ Did you understand what to do? ▪ Did you feel stuck at some point?
4. I experience relaxation as I feel supported in avoiding mistakes	▪ Did it feel easy to make mistakes?

Table 3: General interview questions

Interview Questions
▪ What do you think is positive with the system? ▪ Can you see yourself using the system? ▪ Could you think of any valuable additions that are currently missing?

To fully understand the users, asking about their opinions might not always be enough. Therefore, the users were observed as they performed their given tasks. By observing them, one can learn from the things that the user is not directly describing [26]. The data resulting from observations could be how the user navigates the interface or if they have any particular emotional reactions, for example using body language [27]. To be able to do this, the interviews were held on-site at Saab. Recording on Saab's premises requires certain permission which is not necessarily easy to obtain. Instead, one person was responsible for conducting the interview, while the other took notes of everything that was said, including expressions of emotion.

4.2.4.2 Respondents

The respondents were chosen through purposive sampling, which means basing the selection on the research question and thesis objective. Purposive sampling is a non-probability sampling method where the researcher instead uses their judgment to select cases [32]. Choosing respondents in this way means that there is some bias in the selection. However, it was necessary to select respondents familiar with the data or the previous tool, limiting the possibilities of who could partake. Thus, the respondents partaking in the study were individuals employed at Saab who possess some familiarity with the data and the old system. The respondents needed to be interviewed during their working hours, which also made the selection depend on who had time and was willing to partake. The respondents have been kept anonymous in this study. This decision stems from their shared membership in the user group relevant to the system under examination, which serves as the primary basis for their participation. Other aspects like age and gender are not seen as relevant in this study. In part, their anonymity is also a result of the attempt to not share any potentially sensitive information related to individuals working with the system and the data.

4.2.5 Medium to High-Fidelity Prototype - First Iteration

4.2.5.1 Prototype Development

The first iteration consisted of developing a medium to high-fidelity prototype based on the functional requirements. User-centered design principles were also included in the development process. The prototype was a mockup created with *Figma*, a web development tool that enables the creation of realistic clickable prototypes where no programming is needed [33]. The prototype offered limited interactivity; certain elements were clickable while others were not. Creating interactivity for the entire prototype would require significant time, and it was deemed unnecessary as it would not substantially enhance its usability. Instead, clickable paths of the most important functions were created based on the functional requirements.

4.2.5.2 User Tests

The first test of the initial medium to high-fidelity prototype of the system was conducted on February 20, 2024, and consisted of brief interviews with four individuals, all of whom had prior experience with the existing system. The interviews took about fifteen minutes each and were all conducted in Saab's office.

The respondents were asked to perform the following tasks:

- Select a data point and find detailed graphical information about it.
- Compare the PRI and PBU graphs from two different points with each other.
- Find a view for a side-by-side comparison of PRI.
- Find a view for a side-by-side comparison of PBU.
- Exit the comparison view.

4.2.6 Beta Version - Second Iteration

4.2.6.1 Practical Development

In the second iteration, insights from the user studies conducted during the first iteration were utilized to implement changes to the design. In this iteration, programming development began. The web application was developed in JavaScript using the *React* framework with Next.js, and the *Recharts* library was utilized for creating graphs. Recharts is built on React components and provides suitable, visually pleasing components for visualizing radar data. The beta version is a fully interactive web application.

4.2.6.2 User Tests

The user tests for the beta version of the system were carried out at the Saab office on March 12, 2024, involving five users. In the second iteration, the respondents were asked to perform the following tasks, which are similar to those of the first iteration but encompass more of the new functionality:

- Analyze the bearing of the different track reports.
- Select a data point and find detailed graphical information about it.
- Select a new data point and find information about it.
- Compare the PRI and PBU graphs from two different points with different ID with each other.
- Look at the graphs and find ways to interact with them to find more detailed information about the data.

- Compare the PRI and PBU graphs from two different points with the same ID with each other.
- Find a view for a side-by-side comparison of PRI.
- Find a view for a side-by-side comparison of PBU.
- Exit the comparison view.

4.2.7 Final Version - Third Iteration

The development process for the final version of the system involved refining the beta version further. In this iteration, just like in the previous ones, design choices were informed by insights gathered from previous evaluations. The final version was not evaluated as a full iteration. Given its close resemblance to the beta version, proceeding with a full iteration was considered unnecessary. This decision was based on the recognition that a full iteration would mean reiterating previously discussed points without offering additional scientific insights. Instead, the final version underwent evaluation through discussions with the same users involved in gathering the initial user requirements. In this discussion-based evaluation, the tool was available to users the entire time. They were asked to describe their final thoughts on the system: how it can assist them in their daily tasks and what aspects could be further developed.

5 Results

The result chapter is divided into two parts, first a presentation of the theoretical results regarding how theory on work engagement can be incorporated in a user-centered design process. This section aims to illustrate how theoretical frameworks can inform practical design methodologies. The second part of the chapter is a comprehensive presentation of the practical outcomes derived from each iteration. This involves gathering insights from user feedback and prototype evaluations. It also includes conducting iterative design refinements while integrating work engagement by analyzing user experience goals during the evaluation stage of each iteration. Together, these sections provide a holistic understanding of both the theoretical foundations and the practical applications, demonstrating how they complement each other in achieving the overarching research objectives.

5.1 Theoretical Result

The theoretical results begin with an explanation of the connection between work engagement and UX goals as per theory. Subsequently, it discusses how the UX goals have been employed to capture work engagement within the scope of this study. Finally, the design framework – based on these theoretical results – that was used in the iterations, is presented.

5.1.1 UX Goals to Capture Work Engagement

This study employs user-centered design principles and methodologies as channels for integrating theories of work engagement into the final design. One approach to achieving this objective was through the incorporation of the theory concerning user experience goals. Four specific UX goals were selected, chosen for their relevance to work engagement in the studied sector. Given that user engagement extends to involving users in a technological system across various contexts, it can also be viewed as influencing techno-work engagement. Therefore, attributes of user engagement were leveraged in the design process as well. The subsequent section explains the connection between user experience goals and the theories of work and user engagement.

The UX goal: "*The steps I carry out feel meaningful as I understand their purpose*" directly correlates with the theory of work engagement, particularly focusing on meaningfulness as presented by Kahn [13]. Psychological meaningfulness is attained when employees perceive a sense of return on investment in relation to their task performance. When users feel this way, they are likely leveraging their skills and creativity to tackle challenging tasks, thereby striving towards comprehending the steps required to achieve their goals. Doing so encapsulates dedication, feeling inspired and identifying with the work by understanding its purpose. This feeling of meaningfulness in one's work is an intrinsic job resource that fosters work engagement.

The UX objective that reads "*I feel joy as I complete my IT-supported tasks quickly and effortlessly*" aligns with techno-work engagement theory, wherein positive aspects of technology at work can alleviate tasks that might otherwise seem challenging, time-consuming, and monotonous due to the phenomenon of technostress as described by Mäkiniemi [17]. This in turn relates to the theory of user engagement, where frustration, uncertainty and lengthy processes can lead to disengagement. Conversely, when work feels effortless, it indicates absorption, with users fully immersed in their tasks, often losing track of time. This is similar to the feeling described as flow in human-computer interaction when the task is motivating due to aligning with personal aspirations. The feeling of joy in relation to a work task can also be identified when a person uses their own expressive characteristics, indicating engagement, as described by Kahn [13].

The goal "*I feel confident on how to proceed to produce the outcome I want*", if achieved, can reduce stress in the interaction with IT systems. When users successfully achieve their intended outcomes, they tend to feel confident in their abilities and find the task stimulating and enjoyable, potentially leading to extrinsic motivation through job resources [14]. This sense of accomplishment also fosters vigor, as users feel secure in their abilities, experience high energy, and are motivated to continue the work. Within user engagement, this understanding of how to navigate a system correlates with a sense of control, a key attribute of engagement [22].

The goal "*I experience relaxation as I feel supported in avoiding mistakes*" relates to work engagement theory regarding techno-work engagement; if the user feels supported in avoiding mistakes they can relax and experience a higher level of dedication and vigor [18]. This goal also relates to user engagement by making the user feel in control, get feedback and feel positive emotions. If the user does not have to focus a lot of their time on avoiding mistakes they have more energy left for the actual task at hand.

5.1.2 Crafting Interview Queries: Incorporating Positive Design Principles

Including theory on work engagement in the design process is a fairly unexplored research area. This approach involves crafting interview questions derived from the previously outlined UX objectives, associated with work engagement in different ways. The interview questions were asked after the assigned tasks had been completed in each iteration and later evaluated to draw conclusions regarding work engagement. The questions were presented in section 4.2.4.1.

Because the UX goals aim to evoke positive emotions during task performance on an IT system within a work environment, they inherently align with theories of work engagement. As such, they provide a suitable foundation for incorporating these theories into this thesis' approach. By posing these questions to users, and capturing their positive emotions, it is also possible to gather information and analyze work engagement as a motivational concept.

The main strategy for formulating the questions was to consider how they could capture the UX goals. Consideration also had to be given to what types of questions the user would be able to answer after performing their tasks. The central focus was not on the precise wording of the questions, but rather on their alignment with UX objectives and how the analysis of the answers was approached through the lens of engagement theory.

5.1.3 Suggested Design Framework

The results presented above illustrate a connection between the theories concerning techno-work engagement and the formulated UX goals. The framework in Figure 5 is a graphical depiction of how the relevant theories can be included in the iterative UCD methodology, which is described in more detail in section 4.1.2.

UCD theory on how to define user and functional requirements shapes the first step in each iteration. In the first iteration, this means communicating with the users to understand their needs and formulating the requirements based on these needs. In the following iterations, the evaluation results from previous iterations are used to reformulate the functional requirements, while keeping the original user requirements in mind.

UCD theory also influences the second step. During this step, the focus is on developing prototypes guided by the theory, such as following design principles, functional requirements and user requirements, with the ultimate goal of creating an interface that effectively captivates and engages users. This iterative method of communicating with the users often in the process draws upon the theory by Still and Crane [27].

In the final step, collecting feedback, the evaluation method is largely shaped by the UX goals which, as demonstrated, encompass most aspects of work engagement. Here, the users' feedback on the system is collected and analyzed with the help of the UX goals as described in the section above. This feedback is summarized and serves as the input for the first step in the next iteration, contributing to the regeneration of the functional requirements.

During this design process, the principles of user-centered design affect decision-making, emphasizing the user as the primary focus. This makes the UCD process effective and helps make the application a satisfying user experience, as stated by Lowdermilk [26]. The ultimate objective is to assist users in achieving their goals, which entails simultaneously prioritizing increased engagement.

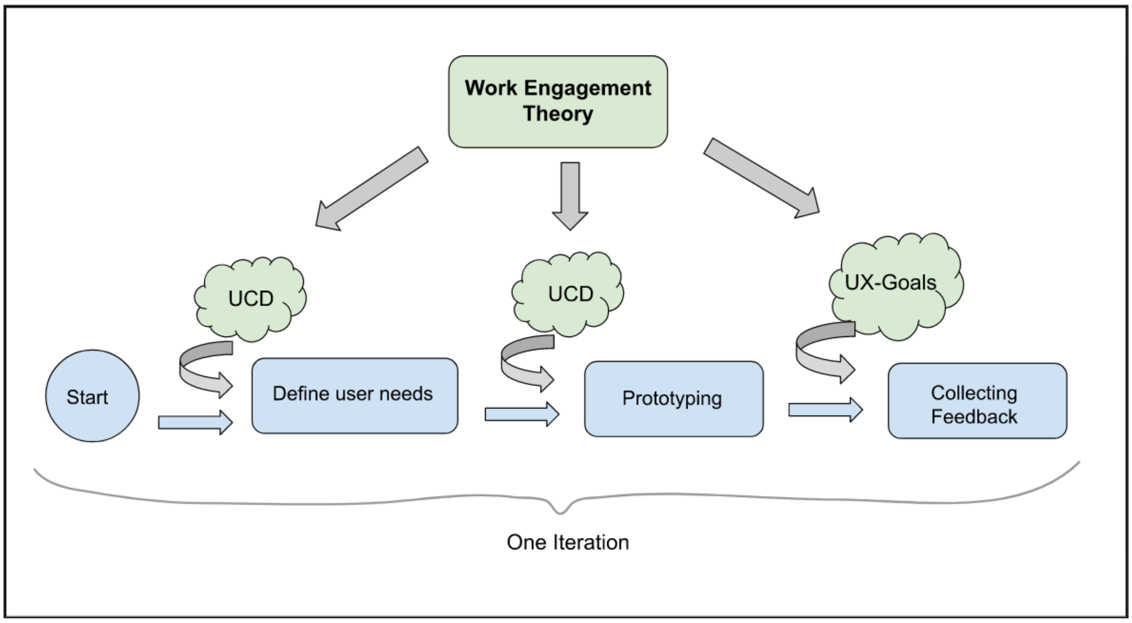


Figure 5: Framework of how the theory is used to incorporate and analyze work engagement in the design iterations of the tool. This image represents one singular iteration.

5.2 Empirical Findings

5.2.1 User Requirements

The user requirements articulated by the users were mainly related to the need for a graphical interface with the ability to display track report data through visualizations on both an aggregated and detailed level. The detailed level should encompass graphs for the PRI vector as well as the PBU vector. The PRI graph should feature suitable axes to ensure the visibility of various PRI modulations, while the PBU graph should highlight any noticeable "jumps" in the data.

The user requirements also include the preference to avoid switching between multiple screens when comparing data points. The present comparison process poses challenges and consumes excessive time, frequently requiring users to navigate through columns and rows in the track report table when comparing data points.

The system should primarily serve as a proof of concept, demonstrating various visualization possibilities, rather than being immediately ready for use and integration into the current work environment. It should have a front end separated from the back end, providing easy additions of new data for visualization in the interface. The tool should also be runnable directly in a browser, without the need for additional installations.

5.2.2 Functional Requirements

- Allow users to view frequency, pulse width and PRI depending on time in a left, aggregated perspective, and access more detailed information in a window to the right upon selecting a data point.
- A possibility to compare different aggregated data points (track reports) in the same window, using some type of overlay or side-by-side functionality.
- A view consisting of a comparison of the items in the PBU-vector: pulse width, PRI and frequency.
- A view that presents PRI modulation patterns side by side, with N and N-1 as values on the axes, facilitating easier comparison.
- Possibility to exit the comparison at any time.

5.3 First Iteration

5.3.1 Medium High-Fidelity Prototype

The first prototype created using Figma is the result of user requirements, functional requirements and discussion around the low-fidelity paper prototype. Figure 6 and 7 show the prototype. The prototype, focusing mainly on the overall user experience of layout, navigation, and design, is basic. The graphs lack interactivity, with only specific elements being interactive. Users were informed about which elements they could interact with.

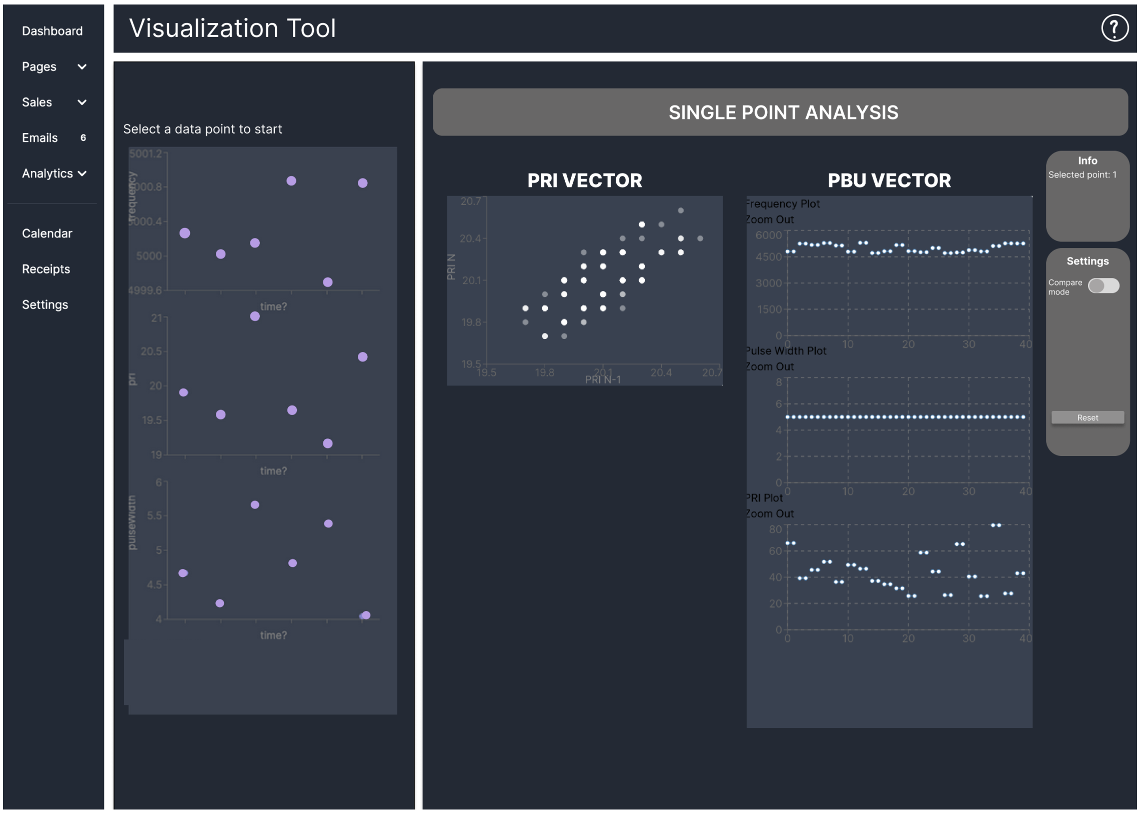
The prototype has a header as well as a menu to the left which are consistent throughout the use of it. They have no functionality but are there to give the user a sense of control when the actual content of the web application changes. Many user interfaces have a header and main menu, which may help the user feel familiar with it as well as being aesthetically appealing.

To follow the principle of proximity, where objects that relate to each other should be placed close to each other, the content of the web application has a left and a right view. The left view shows the data on an aggregated level based on frequency, pulse width and PRI. When a data point to the left is selected, the right view is filled with more detailed data on that specific point. When selecting another data point to the left, that point's detailed data is shown to the right.

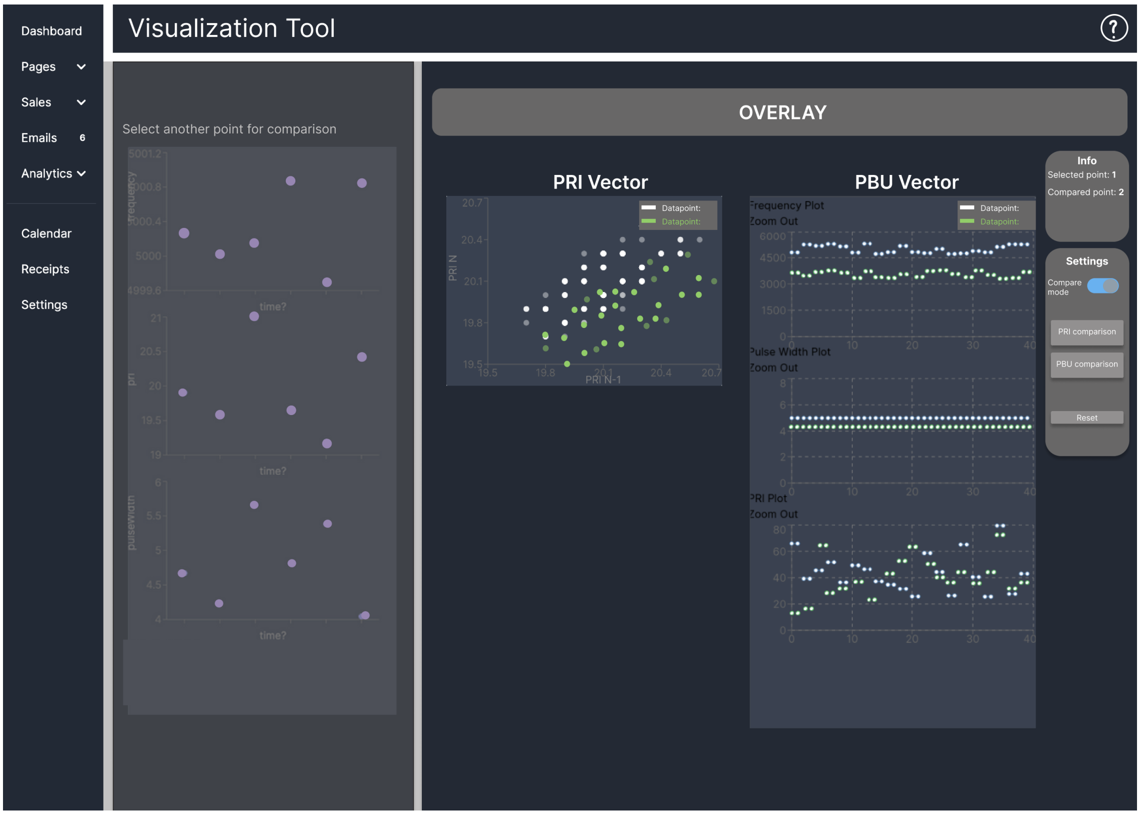
The settings menu positioned on the right side encompasses all functionality capable of modifying the content within the right view. Its proximity to the data emphasizes the principle of proximity. Here, the user can enter the *compare mode* using a slider. Once in the compare mode, the user is prompted to select another data point and once this is done, an overlay of the graphs for the selected data points is shown in the right view. The user can then choose to enter in and out of side-by-side views of either PBU or PRI data. These side-by-side views are a way of providing the user with another type of data visualization and in the PRI view there is also another type of pattern visualization not available in the "overlay" view. This design where the user can navigate deeper into the interface to see different visualizations follows the progressive disclosure method.

The buttons within the right-hand menu alter their color upon being pressed, along with the slider. Non-interactive pages at specific stages are visually muted, appearing grayed out to signify their lack of functionality during that phase. This design choice stems from a blend of anticipated user mental models and principles of visual feedback theory. Buttons are used to indicate which view the user is in so that if they are clicked again, the user is back to the overlay view. If the user at any time slides the compare slider to the left again, the right view only contains data on the first chosen data point. The menu also contains a reset button which completely clears the right view and allows for a fresh start.

The left and right views are displayed in separate colored areas in the application. This visual feedback is used to further give the user a sense of them being two different parts of the web page with content on different levels of detail.



(a) View after selecting one data point in the graph to the left



(b) View after entering *compare mode* and selecting another data point

Figure 6: First iteration prototype: Views for single- and multiple-point analysis.

(a) View after entering "PRI comparison" (b) View after entering "PBU comparison"

Figure 7: First iteration prototype: Side-by-side PRI and PBU views

5.3.2 User Interview Results - First Iteration

The test results from the medium to high-fidelity Figma prototype showed a high level of consistency across all users. The users found the prototype promising, yet they had minimal feedback due to its limited interactive features.

5.3.2.1 Positive Feedback

The overall positive feedback on the interface indicated that it could represent a substantial improvement over both the previous system and other systems utilized by Saab. This was largely attributed to the simplicity of the design and its restricted functionality, which facilitated easier navigation and comprehension. Unlike many existing systems at Saab, which feature excessive functionality, menus, and interactions, this design seemed to prioritize elements essential to users' daily tasks. The design exhibited promise in the incorporation of the user experience goals into the prototype design. Specifically, it hinted at its potential to contribute to UX goal three, which involves fostering user confidence in navigating the system to attain desired outcomes, in future iterations.

The implementation of clear labels on titles, buttons, and textual instructions facilitated straightforward navigation, making it easy for users to find their way around the system. This suggested that UX goal four had been incorporated within the design of the prototype. Users felt at ease during navigation, suggesting a positive alignment with the goal of experiencing relaxation and support in avoiding mistakes. The intuitive layout, with data selection on the left and visualization on the right, was quickly grasped by users, further reinforcing the alignment with this goal.

The answers to the questions related to the second UX goal, "The steps I carry out feel meaningful as I understand their purpose", were all positive. The simple design and clarity made the sequence of events feel natural and the navigation towards the goal of the assigned task quick and easy, helping the user avoid getting stuck. This informed the developers about the significance of keeping the design simple and incorporating only essential functionality.

Three of the users mentioned the color scheme as something positive, the darker design made the system feel modern and made the content in the graphs easy to grasp and patterns easy to see. Another user highlighted the clarity of the content on the various axes in the graphs as a positive aspect. All users found the time needed to complete tasks to be short and appropriate for the specific task, indicating a promising design approach regarding UX goal one, effortless and quick completion of work, in future iterations of the interface.

All users did to some extent display positive emotions while using the prototype, for instance by smiling or nodding. One user clearly expressed positive emotions while interacting with the system with words of appreciation like "Nice, this is really great!".

5.3.2.2 Suggestions of Improvements

The suggestions for improving the overall system layout encompassed a combination of points mentioned by users and observations made during task performance.

Three out of four users struggled with the task of comparing one point to another. They found it counter-intuitive that the comparison slider was positioned to the right when the data to be compared was situated on the left. Locating the menu on the right took some time for users, with many attempting to interact with the graphs unsuccessfully. This highlighted a deficiency in the design's alignment with users' mental models. However, during discussions following the interviews, users did not perceive this as a significant issue. After trying the functionality once, they grasped its purpose and understood why it was positioned where it was.

One user identified an issue in identifying which graph belonged to what data since the legend did not describe this. Several users also expressed a desire for zoomable plots to facilitate the exploration of detailed information. One user expressed the desire for additional graphs in the interface to display different visualizations of the data. However, multiple users experienced confusion when a new graph appeared upon entering the PRI side-by-side view from the overlay view. To mitigate confusion, one user suggested displaying all graphs in all views while in comparison mode.

Additionally, another user specifically requested a plot for the bearing in the left view, recognizing its potential usefulness after interacting with the prototype.

In the initial prototype, the content of the graphs was entirely fabricated. Some users voiced slight confusion regarding the interpretation of the data and suggested that displaying recognizable data to some extent would be beneficial. The data should contain more points and also be presented with different IDs that separate groups of data points from each other.

Two users also proposed enhancing the clarity of modulation patterns in the PRI graph with N and N-1 as axis values by adjusting the opacity of the dots to indicate overlap.

5.3.2.3 Additions to Functional Requirements after the First Iteration

- The data should be more realistic.
- Data with different IDs should be able to be shown and there should be some distinction between these.
- More data points should be displayed.
- A graph in the aggregated view displaying the *bearing* of the measured radar signals.
- Use different colors when data points with different or the same ID are compared to be able to tell them apart.
- The graphs should be zoomable.
- No new graphs should appear "out of the blue" between the overlay and side-by-side views.
- Include the graph showing PRI and index on all PRI views.
- Indicate overlap by changing the opacity of data points in the topmost PRI graph.

5.4 Second Iteration

In response to feedback from the initial iteration, all additional functional requirements were integrated into the web interface for the second iteration. The main objective was to maximize the tool's engagement factor while adhering to the design process and instructions outlined in the created framework.

Since the first iteration resulted in overall positive feedback, the general look of the tool in the second iteration is similar to that of the first. The idea of keeping aggregated data to the left and showing detailed data to the right remains, as does the overlay and side-by-side view logic. Figures 8, 9, 10, 11 and 12 show how it looks in this prototype. The design in terms of color and visual feedback principles remained largely unchanged as well. This decision was driven by its effectiveness in creating points of engagement with users, as many found the interface aesthetically pleasing. The main change is that the points in the left graphs follow a blue color theme while those to the right are colored yellow and orange to create a distinction.

In the initial iteration, a menu was placed on the left side, primarily for familiarity, although it lacked functionality. Upon reflection, the decision was made to remove this menu to create more space, allowing the settings menu on the right side, along with the header, to remain consistent across different views. This approach preserves the user's mental models while also providing a sense of control, an essential engagement attribute lacking in the unusable left menu. Some users experienced difficulty locating the settings menu, prompting the removal of the left menu in hopes of directing all attention to the settings menu on the right.

The data used for the second iteration has been updated. Despite still not being real due to company confidentiality, it has been generated with increased realism to allow for the detection of patterns within certain graphs, increasing alignment with the previous experiences and mental models of the system users. In accordance with the updated requirements, the aggregated data points in the left view of this iteration are now colored and labeled based on their ID. When two points are selected for comparison, the graphs in the right view are shown in two new colors with legends detailing which belongs to which ID. The selected points in the left view are also highlighted in the respective graph color to further clarify which is which. In addition to employing a different data structure, the beta version also incorporates a greater volume of data. This adjustment aims to more accurately mirror reality, further aligning with users' mental models, particularly when navigating through large datasets.

In this beta version, the decision was made to remove the reset button based on the principle of keeping the design as simple as possible. The reset button essentially duplicates the function of toggling out of the comparison mode, making the inclusion of both options seem unnecessary and potentially confusing for users.

In the detailed view, a new graph for PRI has been introduced. This plot was initially part of the prototype but was only visible upon entering the side-by-side PRI view, as depicted in Figure 7a. This arrangement proved confusing for most users. Therefore, it has now been permanently incorporated alongside the other PRI plot as is named "PRI vs. Index Plot", see Figure 9. The new graph contains numerous data points and is thus zoomable. With different values on its axes, it offers novel methods of visualizing and analyzing PRI patterns. Specifically, the x-axis represents the index, while the y-axis displays the PRI value, facilitating the identification of modulations, as illustrated in Figure 3.

Figure 8: Second iteration prototype: Start page.

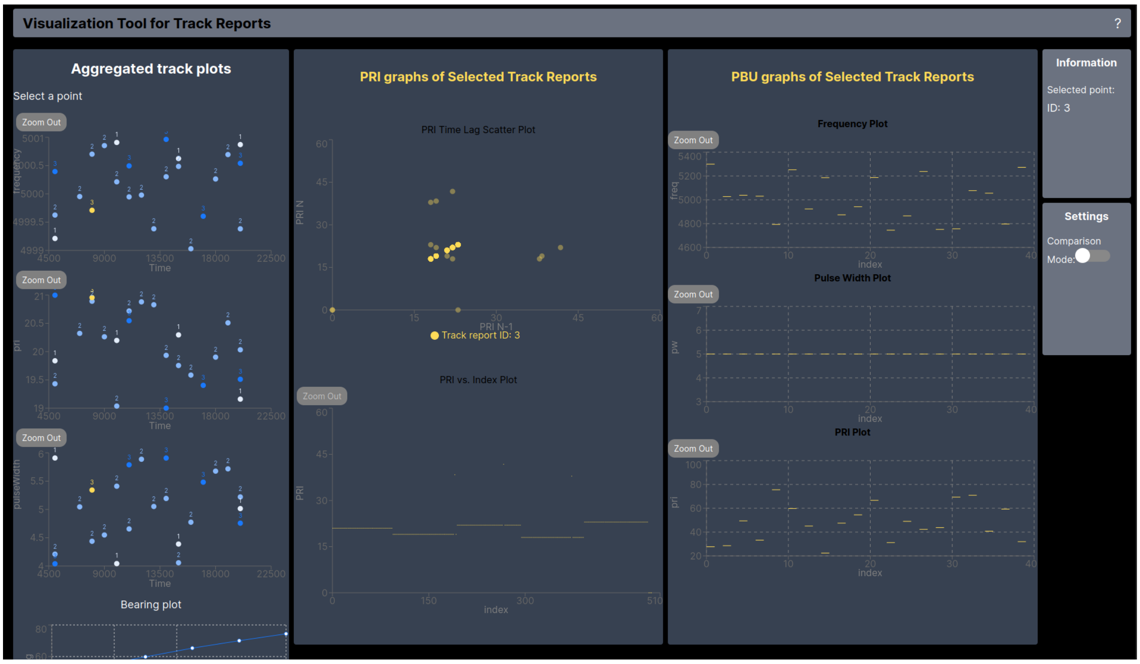


Figure 9: Second iteration prototype: Interface when one point is selected from the left view.

Figure 10: Second iteration prototype: Interface with overlay comparison of two points selected from the left view.

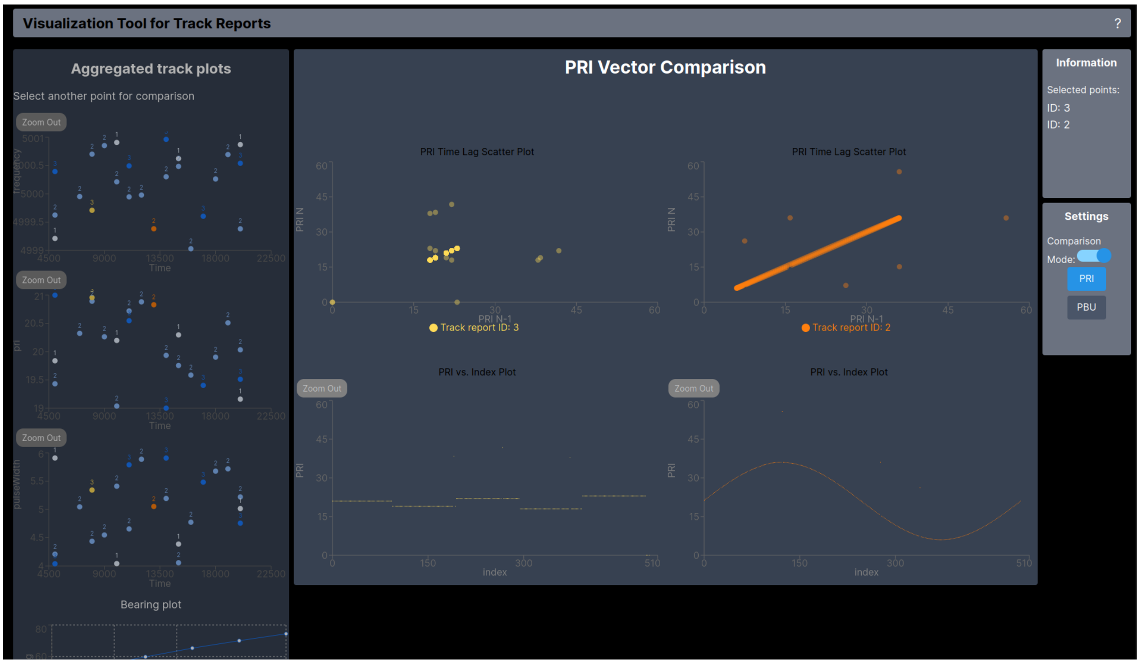


Figure 11: Second iteration prototype: Side by side comparison for PRI.

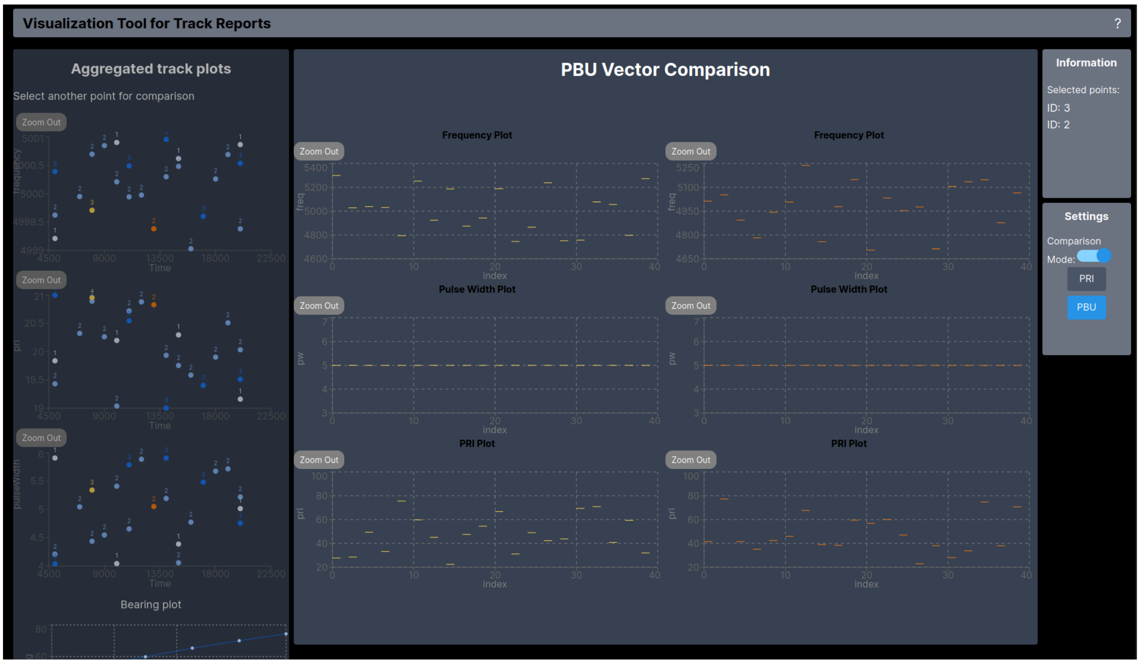


Figure 12: Second iteration prototype: Side by side comparison for PBU.

The header remains consistent across all views, featuring a clarified title to clearly convey the purpose of the tool. In the header, a help button is added with a question mark symbol. When clicking this button, a popup window is displayed with instructions on how to use the tool, shown in Figure 13. This is to make sure the user can understand how to interact with the tool to avoid frustration and ensure control. The placement of the help button as well as the use of a question mark symbol aligns with the design principle of mental models, as this is a common practice on many websites.

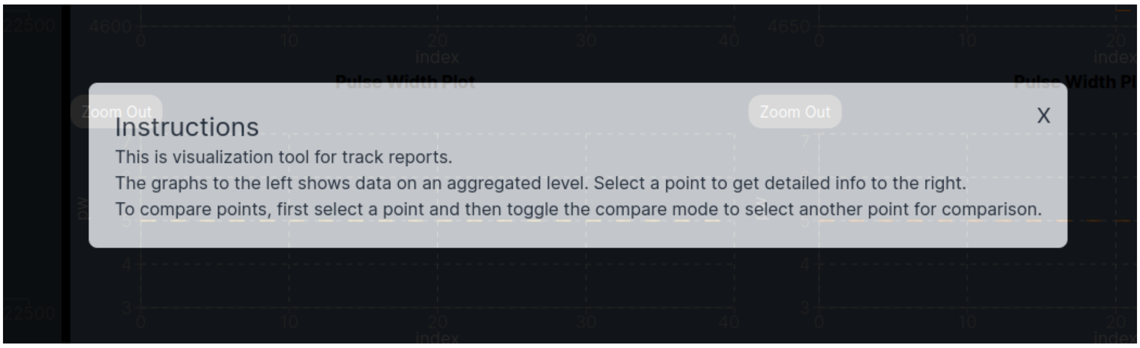
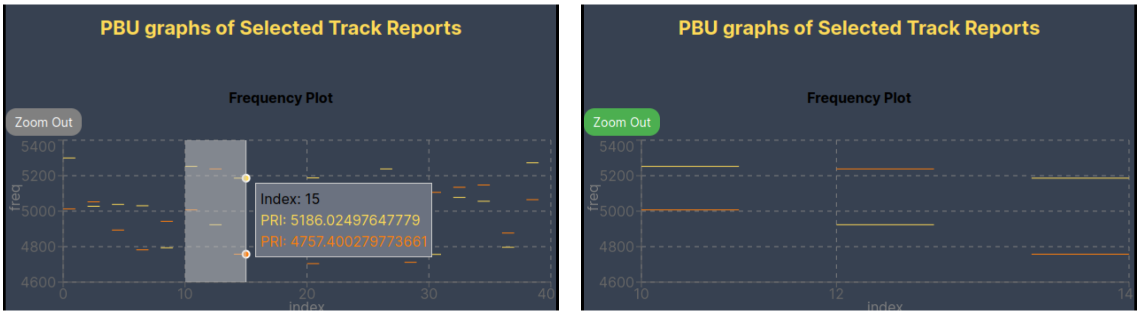


Figure 13: Second iteration prototype: Popup with instructions.

Zooming is available for the detailed plots as this was included in the functional requirements of the iteration, however only in the x-direction as a result of limitations in the Recharts framework. The data is initially displayed in a comprehensive view, presenting the entire dataset at once. The user can, by marking an area of the graph, zoom in. This draws on the interactive visualization principle regarding "overview first, zoom and filter, then details on command" [29]. Additionally, a "zoom-out" button is provided to return the graph to its original state. The button is colored green with a pointer cursor once it can be clicked, and gray with the default cursor when it cannot be clicked, drawing upon visual feedback principles. The zooming capability provides users with a greater sense of control compared to merely viewing a static graph with extensive data that may be difficult to discern. Furthermore, the zooming feature can be interpreted as a method to lessen the cognitive burden on users by employing progressive disclosure.



(a) Selecting area to zoom in on.

(b) Zoomed in area.

Figure 14: Second iteration prototype: Zoom functionality in the first PBU graph.

The aggregated left side now contains a fourth plot for the bearing, used to identify the direction of the signal, see Figure 15. This plot can assist the user in identifying the trajectory of targets such as other airplanes, this is helpful in assessing threats. The plot was requested by one user, and it was included as there still was space left before the tool would contain too many graphs. While there have been some wishes to include a variety of graphs from the users, it has also been important to keep the application simple and focus on its core functionality to ease the cognitive load on the user.

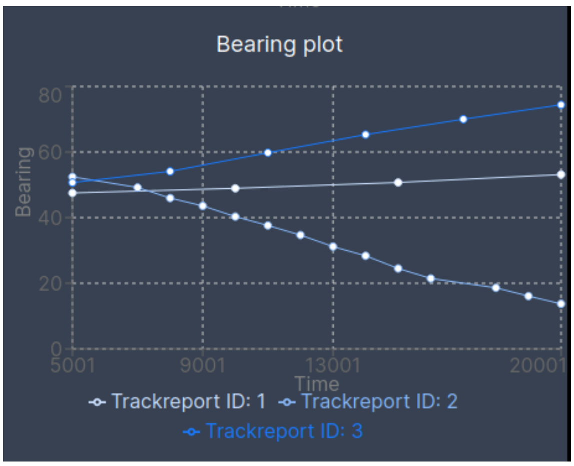


Figure 15: Second iteration prototype: Plot for bearing in aggregated view.

Considering visual feedback principles, the axis names and titles of the plots have been clarified. The tooltips displayed when hovering over the graphs in all plots have been updated to provide relevant information. Each tooltip design has been tailored to meet the specific requirements of its corresponding plot type. During the evaluation, one user noted difficulty in distinguishing between data points in the comparison view, which could lead to confusion. To address this issue, labels indicating which color corresponds to each data point have been added.

5.4.1 User Interview Results - Second Iteration

The beta version yielded consistent feedback from users as in the initial iteration. They generally found the interface to be user-friendly and straightforward. Additionally, they shared suggestions for additional functionalities they felt were lacking.

5.4.1.1 Positive Feedback

All respondents did to some extent express positive feedback on some aspect of the system. Many of them complimented the general look and choice of colors for the interface. As in the previous iteration, the respondents felt the tool was rather easy to interact with. Particularly, after their initial experience, users demonstrated a clear understanding of how to navigate the tool effortlessly during subsequent uses. The interface does not have many pitfalls and does a good job of preventing the user from making mistakes. The majority of users found it easy to navigate without making errors, and even if they did, the repercussions were minimal. These findings align with UX goal four (see Table 2), promoting a sense of ease and support in error avoidance, potentially fostering increased engagement. Users were able to concentrate on their tasks without being preoccupied with avoiding mistakes.

The second UX goal, which pertains to the perception that tasks are meaningful and purposeful, was utilized to evaluate the work engagement facilitated by the system. In nearly every task, users found the sequence of required actions to be intuitive, as they encountered minimal obstacles or signs of confusion, whether expressed verbally or through body language. From this perspective, the system appears to foster some level of engagement, with users largely recognizing the meaning of the tasks involved.

The users identified plots related to detailed PRI in the right view as the most valuable and comprehensible among all the provided plots. The scatter plots and the selected colors of the plot provided the users with a clear understanding of actual PRI patterns. The two variations of PRI visualizations offer complementary analysis possibilities as the data is displayed with different axis values, equal to those presented in the background section 2.2.5. Users also expressed positive sentiment regarding the changing opacity in the scatterplot displayed in the "PRI Time Lag Scatter Plot" (see Figure 16). Specifically, when multiple points overlap, this is indicated with a more intense color compared to areas with no overlap.

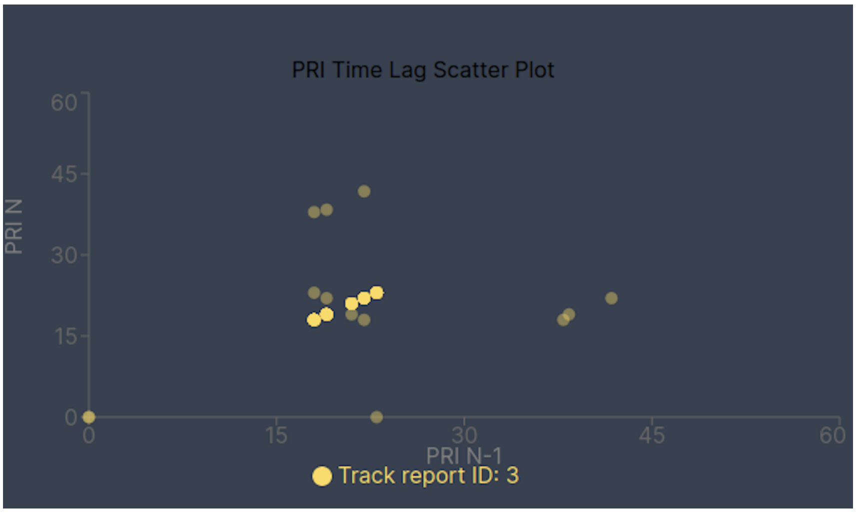


Figure 16: Second iteration prototype: Screenshot depicting the changing opacity when data points overlap.

The bearing plot was considered a nice addition, one user felt it brought a lot more purpose to the left side of the interface. The bearing plot can also be used as another method of analyzing interesting patterns of the track reports in a way the "aggregated track plots" cannot do as well. The user expressed that this feature would help in their work tasks and that this way of analyzing the track data would provide novelty in aspects related to identifying interesting patterns in the data. This indicates progress toward the UX goals one and three.

All users agreed that the time allocated for the tasks was appropriate in relation to their complexity, and they found the tasks easy to comprehend. Again this was probably a result of maintaining a large amount of the functionality, design and navigation from the initial prototypes. This relates to including engagement via UX goal one, feeling joy in the quick and effortless completion of tasks. The users successfully completed all assigned tasks without encountering significant issues. Moreover, three users continued to engage with the interface even after completing their tasks, remaining on the screen to analyze various track reports and experiment with zooming and overlay functionality. This behavior corresponds to the concept of absorption, as delineated by [17], wherein users become deeply immersed in a task, leading time to pass quickly. Additionally, this suggests a sense of flow and, consequently, alignment with personal aspirations and emotions [21], indicating the potential of the tool to cultivate positive experiences.

5.4.1.2 Suggestions of Improvements

Despite the majority of users having previously interacted with the prototype interface in its earlier version, two users encountered some difficulty in figuring out how to compare two track reports. After a moment of trying to select two points directly from the left view, they remembered how it was done. This confusion resulted in a slight delay in task completion, and likely impacted the users' experience regarding the UX goal related to feeling confident in knowing how to proceed to achieve the desired outcome. It is possible that this led to users feeling less in control during their interaction with the system, which is a disengagement attribute. However, after solving the task related to comparing two track reports the users who struggled for a few moments most likely felt they were getting a "return of investment" as Kahn puts it [13]. The users encountered a minor obstacle during navigation, but upon achieving the assigned comparison, they frequently responded with positive emotions, expressing appreciation for the qualities of the compare mode's functionality.

One user expressed frustration with the settings menu being located on the right side of the interface. They found it illogical that the slider for entering and exiting compare mode, which was placed to the right, contrasted with the selection of track reports, positioned to the left. It is worth noting that this user was not part of the initial iteration and had never seen the interface before. Users who had previously interacted with the interface did not raise this as a big issue. However, considering that this was observed as an issue in the first iteration as well as in the second one the decision was made to include the relocation of the settings menu in the updated functional requirements. This re-positioning of the menu relates to the *grouping principle* as described by [26], the users found that the menu and the left side of the interface were features that belonged together.

Two users suggested incorporating histograms near the PBU plots in the right view as a beneficial enhancement. Histograms can efficiently visualize the distribution of PBU values, assisting in the categorization and identification of track reports. This recommendation was also motivated by the presence of histograms in other tools, thus facilitating user navigation towards the desired outcome, aligning with UX goal three (see Table 2).

The same two users were confused with the PBU plots, they had trouble understanding their purpose since no clear patterns were visible. This is because the data generated for the PBU plots is randomized. They suggested that the data in those graphs should be modified to facilitate clearer identification of patterns, which would in turn help them understand the purpose of the PBU graphs. The PBU graphs also stirred some confusion about what kind of data they are displaying. Since the interface is displaying pulse data on an aggregated level it is sometimes confusing what is plotted in the graphs. The users who were confused by this suggested this be clarified in some suitable manner. The important aspect to clarify is that the lines in the PBU plots are not based on individual pulses, but many aggregated pulses. This likely influenced UX goal two, which focuses on understanding the purpose of the steps performed. Although users acknowledged the potential of the PBU graphs, they were somewhat unsure about their relevance in this version. Since they could not fully grasp the displayed data, it was not entirely clear to them how these plots would be beneficial in their work.

In addition to this, the users had some feedback related to the zooming functionality in this iteration. Most users expressed a need for multiple levels of zooming functionality to better visualize individual data points. They found it challenging to distinguish and select track reports that were similar and overlapping without sufficient zooming capabilities. All users also found it frustrating that when they slightly missed a point while attempting to select it from the left view, the graph would automatically zoom in. This bug probably affected the achievement of goal number four as outlined in Table 2. Two users also suggested the possibility of enlarging the graphs to the left to a full-screen mode as this would help analysis.

Some users experienced the interface as rather slow and not as responsive as they had hoped. They suggested this as a future improvement. The users expressed that they would appreciate the ability to compare more than two track reports at the same time. If more than two reports could be compared at once, it would enable further analyses to be done and some parts of analysis could be done faster.

One user suggested adding a toggle option to enable or disable the display of point labels in the left view, showing the ID of each track. Similar to this, they proposed an additional toggle option to reveal or conceal colors and lines within the bearing plot. This toggle could serve to demonstrate the tool's functionality and its data visualization capabilities in conjunction with the current system. Although the current system can display certain aggregated data similar to that of the left view, these visualizations only feature dots without coloration or connecting lines.

Additionally, users requested a more comprehensive data presentation to better reflect real-world usage of the existing system. Some users believed that it would be preferable for the various modulations of the PRI patterns to more accurately reflect reality. This adjustment would provide a more effective demonstration of the tool's functionality. Furthermore, a user suggested enhancing color contrast in the aggregated view to make it easier to distinguish different track reports.

5.4.1.3 Additions to Functional Requirements after Second Iteration

- Add histograms in the right view, displaying the occurrence of intervals of values of PRI, frequency and pulse width.
- A higher distinction of colors between different track reports in the left view of aggregated track reports.
- The ability to select a track report from the bearing plot in the same way as from the plots above it.
- The ability to toggle the visibility of the number displaying the track-id on versus off.

- The possibility to toggle the coloring of the data points as well as the lines between points in the bearing graph.
- Move the settings menu closer to the center of the interface.
- The ability to zoom in on the y-axis as well as on the x-axis.
- The ability to zoom more than once.
- Adjust the data so that patterns are visible in the PBU graphs.
- Adjust the data so that PRI modulation patterns are more clearly visible in the PRI graphs.
- Create a way to display the individual pulses captured by the aggregation.
- The possibility of looking at the left graphs in a full-screen mode.
- The ability to compare more than two track reports at the same time.
- Make the interface faster and remove bugs.

5.5 Third Iteration

The suggested improvements and functional requirements derived from the second iteration do not greatly affect the overall look and functionality of the interface. Therefore, the full graphical results of the final iteration are not presented here but can be found in appendix A.

The biggest change in this iteration is the relocation of the menu. It is now placed between the left and right view, due to the confusion during both the first and second iteration's evaluation. The idea is that by having the menu closer to the left view, it will be easier to find and as a result, easier to toggle the comparison mode.

In the menu, a button for *details* has also been added. When clicking the button, a new window is displayed to the right with detailed information on the selected track report or reports. All available information in the reports is displayed in a table, with some presented in a radar plot. This allows the user to examine all available data, aiming to provide the user with the opportunity for manual analysis. This provides the user with control over both numerical and visual data, thereby combining familiar data analysis methods from the current tool with new visualizations. The aim of this was to work towards UX goal three, see Table 2, which relates to feeling confident on how to proceed to produce the wanted outcome. By incorporating familiar aspects that the user recognizes, the aim is to prevent users from feeling stuck.

In this final iteration, more data with more IDs is displayed. As requested, data with different IDs are displayed in different colors. The colors have been chosen to create a distinction between different track reports while also following a mellow color theme which has previously been appreciated as aesthetically pleasing. The data has also been adjusted to show patterns in PRI and PBU that correspond to a certain ID. The look of the PBU graphs was also slightly changed. From being displayed as short lines, which led to confusion among the users, they are now represented with points instead.

For the PRI vectors, the data now reflect actual PRI modulations, detailed in the background section 2.2.5. For example, all data points with ID 2 have a similar sinus modulation, and all data points with ID 3 have a similar stagger modulation, see Figure 17. This relates to UX goal two, in Table 2, which captures the importance of understanding the purpose of performing certain steps. Involving realistic modulation patterns in the tool shows the users how the interface could be helpful in a real-world scenario.

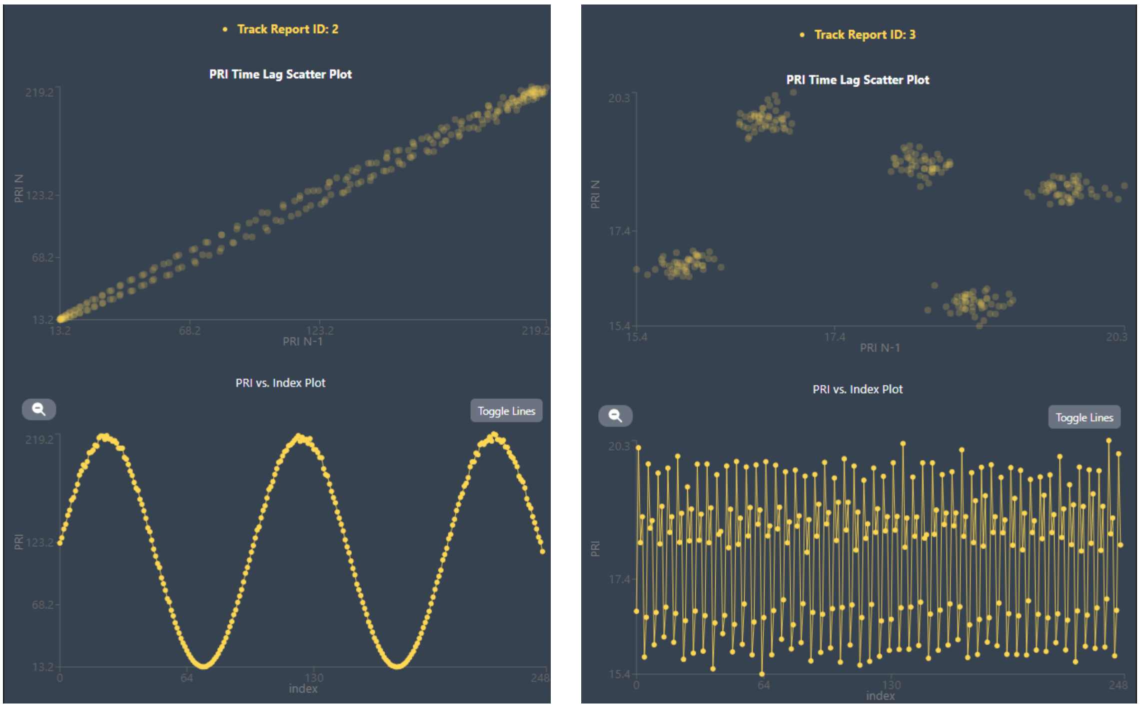


Figure 17: Third iteration functionality: PRI vectors with sinus modulation to the left and stagger modulation to the right.

Adding all the new data made the left view look more cluttered than before, to fix this issue some features were added. Now the user can toggle the ID label of the track reports on and off, as well as filter on IDs. This allows the user to remove data that is not relevant to the specific case they are investigating in the graphs, easing the cognitive load. There is now also a possibility to completely remove the coloring in all graphs to the left, as well as the lines in between points in the bearing graph. As requested, the left view can now also be displayed in full-screen mode.

The bearing plot is now clickable and the selected points are highlighted in it, the same way as for the other plots in the left view. Zooming is now also available for the bearing plot. The zoom functionality has been refined to allow users to zoom on both the y-axis and the x-axis multiple times, providing them with complete control over data exploration. Bugs related to zooming have been addressed; for instance, clicking once no longer triggers a zoom-in action.

In the right view, a recent addition is the inclusion of histograms positioned below each PBU plot, illustrating the frequency of specific values within the data. These plots occupy minimal space and are not expected to impose significant cognitive load. Another new feature is the pulse view, accessible from the menu, which displays data at the pulse level. While this data may not always be present in the datasets, it serves as a proof of concept for potential visualizations.

Some users raised the idea of comparing more than two track reports simultaneously within the interface. However, this functionality was not considered essential for the application's primary goal of facilitating thorough analysis and comparison of aggregated pulse data. Due to time constraints, it was decided not to implement this feature.

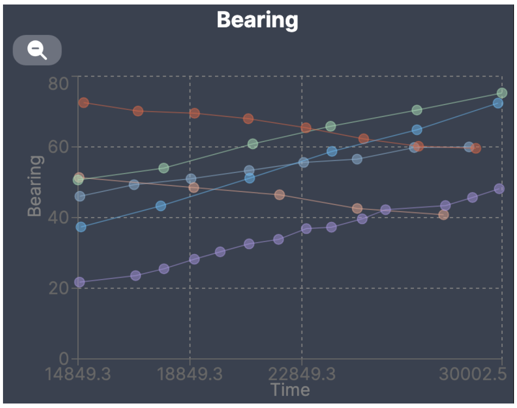
As a final adjustment, bugs were addressed and efforts were made to enhance the system's efficiency, aiming to improve user experience in accordance with UX goal four outlined in Table 2, which focuses on eliciting joy as tasks are completed quickly and effortlessly.

5.5.1 Feedback and Final Thoughts

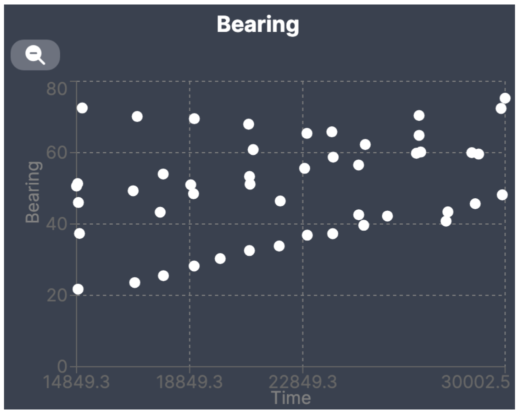
The interview results of the final iteration mark the final evaluation of the system in this study. The results are gathered under one heading which presents both positive and negative feedback. In this final evaluation, no official user interviews were conducted as this would not provide any significant value or content to the study. The assessment was made that the main focus of the study had been achieved through the two existing and thoroughly documented iterations; a third iteration would not have contributed to a better research report.

The application stakeholders, who were also supervisors for the report, emphasized the importance of this visualization tool as a proof of concept, highlighting what is lacking in the current system. They particularly underscore the positive aspect of the tool being easy to interact with, which shifts the focus from navigating a complex interface to the actual task. The various graphs displaying different functionalities provide users with many analysis opportunities that are not available today. The ability to select a track report from the left view, highlighted with color and ID according to type, and then view more detailed information about it, is an innovative visualization approach that many at the company would likely appreciate.

The ability to toggle the color and lines connecting the data in the bearing graph was a suggestion from the stakeholders and is a significant display of the importance and value of this data visualization. When the color and lines are removed, patterns become much more challenging to discern compared to when they are visible, as illustrated in Figure 18.



(a) Bearing graph with lines and colors visible.



(b) Bearing graph with lines and colors not visible.

Figure 18: Third iteration functionality: Toggle feature in bearing visualization.

The stakeholders offered suggestions for enhancing the tool that they believed would be beneficial. They suggested implementing a feature to display track reports in a scrollable list, enabling users to view statistics for an entire track instead of just one report at a time. Additionally, they envisioned the tool having the capability to graphically compare an unclassified report with one classified by a trained AI model. However, due to time constraints, these suggestions could not be incorporated within the scope of this thesis.

6 Discussion

6.1 Integrating Theory and Practice: Bridging Work Engagement and User-Centered Design in High-Tech Environments

The results of this thesis contribute to the research field by introducing a design framework that combines work engagement with user-centered design. It adds to work engagement research by utilizing Kahn's [13] older but established framework for understanding workplace motivation as the basis for a case study in a modern, technological context. Specifically, this framework contributes to techno-work engagement, an area less explored compared to general work engagement.

The study draws from existing research on positive design, using UX goals formulated in previous studies but implementing them in a technological context, that is, a work environment highly influenced by technology. Establishing a connection between UX goals and theories on techno-work engagement allows for continuous evaluation of engagement in line with principles of user-centered design. This evaluation involves investigating various engagement attributes, including those described by [22], through signs of technostress [17] and via techno-work engagement categories [18].

Effective user-centered design holds significant potential for fostering positive UX. By leveraging UX theory, we managed to establish a connection between techno-work engagement and UCD research – two domains traditionally studied separately. This fusion of techno-work engagement and UCD, where the emphasis is on boosting engagement, coupled with the integration of positive emotional design through UX goals, generates a synergistic effect within the iterative methodology. The approach captures heightened engagement and unifies insights from two distinct theoretical perspectives.

The results of this effect show tendencies that support previous research [24]. Designing IT systems with a focus on promoting positive emotions has proven effective in capturing and articulating design intentions.

By contextualizing our design framework at Saab, we also show its practical potential in direct connection to its creation. We have investigated the subject within a context characterized by advanced technology and high-stakes operations. In such environments, work engagement plays a pivotal role in motivating and retaining employees, whose expertise and skills are often hard to replace. Moreover, considering that the company operates in Sweden, where only about 13% of employees are actively engaged, it serves as an excellent case study for this thesis. During discussions with stakeholders at the company, this assertion was further validated as they expressed that IT systems at Saab are often disengaging, frequently lacking development with the end user as the primary focal point.

6.2 Assessing the Framework: Strengths and Limitations

Reflecting on our practical implementation at Saab sheds light on both the strengths and areas for refinement within the framework. Throughout the implementation, the framework proved to be a reliable resource when making design decisions. Having the option to reference a framework built on previous research is beneficial, especially for individuals less familiar with UX design practices.

The development of this interface stemmed from the early and consistent involvement of potential future users in the design process. This resulted in the functional requirements being regularly updated when the understanding of the tool's potential changed during the prototype evaluations. The stakeholders had an idea of how they wanted the end result to look, as mentioned in the initial requirements, but no clear vision of the final product. This factor further established this case as a suitable test for the framework, there was the possibility for a lot of flexibility in not having to adhere to strict boundaries. When users expressed the need for a certain feature or frustration over something, we had to navigate the feedback by following the design framework, working towards possible solutions together with the users.

By leveraging this collaborative approach, we gathered valuable insights directly from end users, ensuring their perspectives were incorporated into the design, and iteratively refined the interface based on their feedback using the framework as a guide. This was evident in the third iteration when users expressed a desire for the data to display patterns in a way that better reflects reality. This allowed for a better understanding of the real-world context in which they use the system, and by adjusting this, we were able to more easily incorporate mental models as described by [27].

Despite the helpful aspects of the framework we still made our own, sometimes misguided conclusions about theory stemming from UCD, for example when navigating different design principles. One example is when selecting the appropriate location of the menu in the interface. In the first iteration, we considered the menu to be positioned according to the principle of proximity since it was close to the modified data. In later iterations it was shown that the mental models of the users did not align with this placement and so it was changed to better fit their preferences.

The iterative nature of the design process however helped us capture this and correct it for the final version. The design framework, in other words, is rather forgiving of misinterpretations early on and helps to design with the user's needs as the main focus.

6.3 Evaluation of UX Goals

Undertaking the task of creating a design framework based on previous research, coupled with user-centered design and UX goals in each iteration, alongside the actual design and building of the web interface, is a comprehensive endeavor. The design of each iteration has taken the UX goals derived from positive design principles into account, incorporating insights from employee inquiries and observations of emotional expressions. However, incorporating engagement has proven challenging, given the abstract and elusive nature of emotions and experiences, making them difficult to quantify.

This difficulty became clear during the evaluation of to what extent the different UX goals were achieved. Individuals expressed varying levels of emotions, this could either be due to their experience or simply their personality traits. Additionally, users were prompted to think aloud during the tasks, something many forgot and therefore had to be reminded about.

Consequently, definitive conclusions regarding the attainment of UX goals proved difficult. Rather, we can only identify indications of progress toward them. Despite being labeled as goals, they are not employed as quantifiable metrics for IT-system interaction but more as aspirations to strive for. The goals have provided us with valuable indications of the positive versus negative aspects of our design ideas, and the questions posed based on them have, upon analysis, provided indications of how well we were designing toward the goal.

All goals have contributed to pinpointing positive design choices, emphasizing emotional impact while also encompassing engagement attributes. Throughout the various iterations, all four UX goals have been discernible, although their visibility has naturally varied depending on individuals and tasks.

6.4 Final Reflections on Process and Methodology

Upon reflecting on the integration of engagement into the design process, it became apparent that the methodology was quite complex. Throughout this process, we had to juggle numerous aspects and theories. We evaluated the attainment of UX goals, adhered to design principles and UCD theory, conducted user observations and encouraged users to articulate their thoughts aloud and considered spontaneous ideas, among other tasks.

While the goal has consistently been to follow design principles and prioritize user input while also considering work engagement, it does not entail enough information to objectively design an entire web application. Thus, parts of the design process naturally included bias through our personal opinions as designers of the system. It is however hard to imagine any system being designed without the designers' personal ideas to some extent being present.

Additionally, conducting user-centered design in a manner that encourages users to freely express their thoughts, without becoming overly fixated on the prototype at hand, can be challenging. The users were instructed to articulate their thoughts while navigating through the interface; however, this directive was largely overlooked once they began working on their assigned tasks. The risk of bias in the original definitions of user requirements and functional requirements is also significant, given that they were based solely on discussions with two users.

Finally, an outcome of this extensive scope pertained to the division of labor we needed to undertake. With the study divided into two primary tasks – creating the design framework and subsequently implementing it in the development process – we allocated equal time, 50% for each task. If more focus and time had been spent on developing the design framework, it would probably be more insightful. The framework would then be based on a more comprehensive literature study where a larger quantity of previous studies would be incorporated. This however would result in less time spent on development and user studies, which has a similar result. Had there been more time, more user input could have been collected. However, increasing the number of user studies does not always ensure a better or more engaging interface as research suggests that about five users usually offer adequate insights [31]. Given that our approach allocated half of our focus to user studies and the remaining to development, the aim was to strike a balance between the two. This strategy aimed to optimize resources with the goal of producing the best interface possible, compared to allocating more time exclusively to either user studies or development.

7 Conclusion

After considering the methodology and design framework, we believe we have crafted an approach to fulfill the study's purpose by finding a middle ground, prioritizing the most essential aspects and placing user needs at the forefront. By conducting a design process based on user-centered design, its associated design principles and using UX-related goals for iteration-based analysis we were able to incorporate theory on work engagement through a design framework when developing this new visualization tool. The theoretical part of the thesis along with the actual practical implementation of the design framework complement each other in achieving the research objectives.

The case study was conducted in a setting where technology is a vital part of the daily tasks of the employees. The analysis conducted at Saab requires focus and careful attention, making it a great setting for this case study. The incorporation of positive design in the design process is an innovative and appreciated method. The stakeholders were happy with the end results and saw big potential in the effective visualizations of the tool and the iterative evaluation-based methodology serving as inspiration for future developments.

Consequently, this offers insight into how theories on work engagement can be integrated into a design process in a way that avoids unnecessary design hiccups by understanding the real-world context of operation. The framework incorporates diverse theoretical approaches, originating from different research areas, yet maintains interconnections in their relevance to engagement. The resulting tool holds the potential for engaging employees in their daily tasks and therefore capturing potential quiet quitters, amplifying well-being and increasing organizational success as a result.

However, the design framework should not be perceived as a directive on how to proceed with implementation but more as a base for future research.

7.1 Future Work

A comparative study with a before versus after evaluation of work engagement would be a valuable addition to the research field. It would also be interesting to evaluate a tool that is actively used in the workplace. In this study, the new tool has been developed and evaluated as a proof of concept, or a potential system to implement in the workplace. It is thus not possible to conclude whether the work engagement was increased after the development process using our suggested design framework, only that we saw indications of it. Further conclusions on work engagement could be drawn by studying its implementation in the workplace.

Another valuable study would entail crafting updated UX goals by leveraging research conducted on users within the corresponding industry, particularly in the defense sector, and subsequently revising the UX objectives accordingly. This reconstruction would focus on the human-computer interaction of users who are probably more accustomed to navigating user interfaces and would make the design framework more bulletproof. Furthermore, it would be beneficial to expand the scope of research beyond the defense industry to encompass a more diverse range of IT systems. By conducting studies in various industries and user demographics, the generalizability of the design framework can be enhanced across different contexts.

We encountered some difficulties in assessing whether the tool effectively fostered engagement, mainly because emotions and experiences are inherently abstract. Therefore, we suggest that future research focus on developing a framework that allows for continuous and measurable assessment of engagement. For instance, this framework could include goals that are defined in a way that facilitates such measurement.

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Appendix A. Images of Final Version

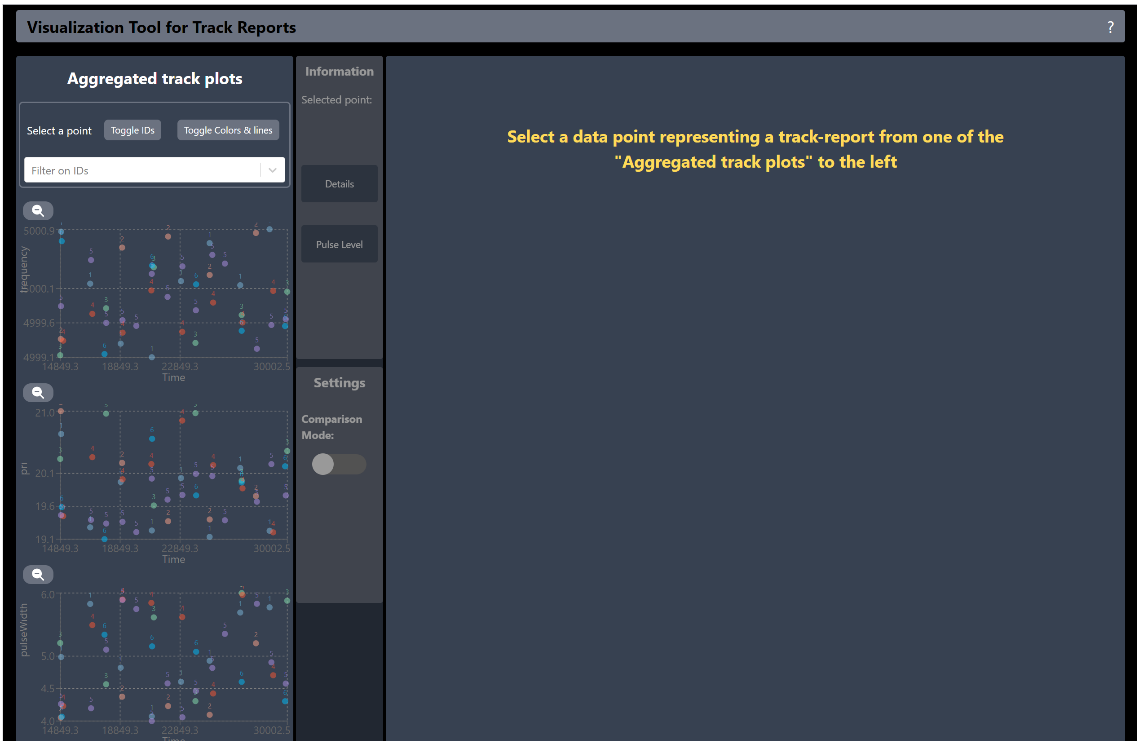


Figure 19: The starting view of the tool, with aggregated plots to the left.

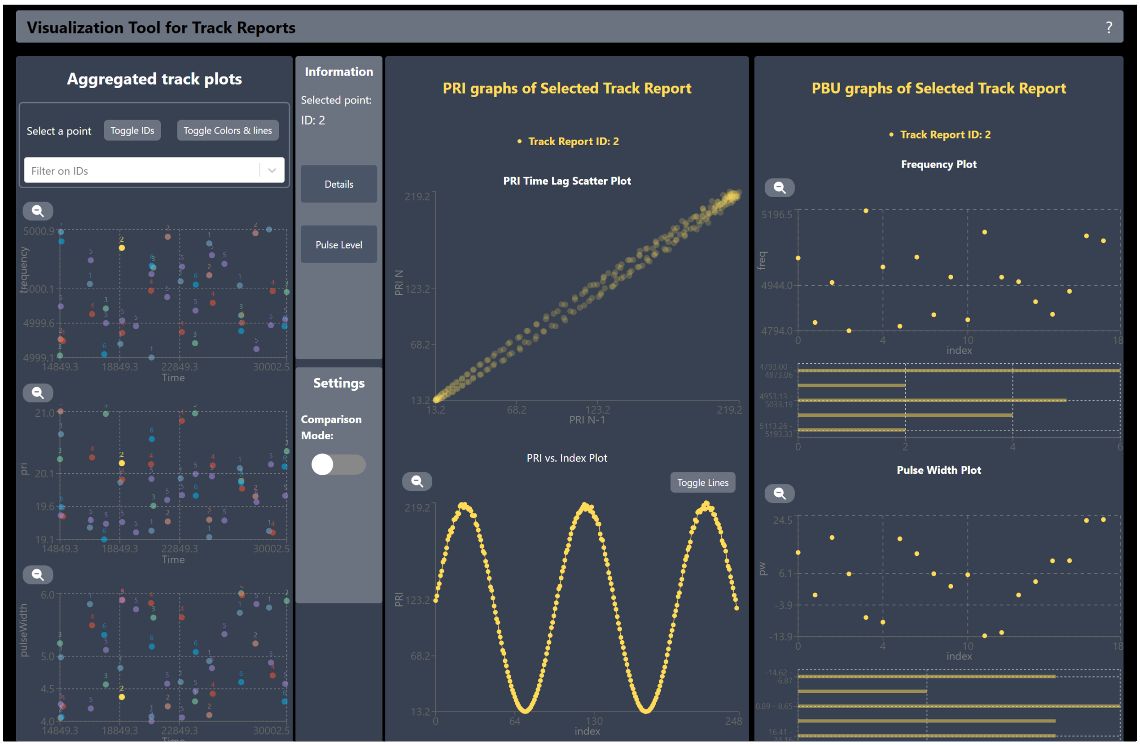


Figure 20: View of one selected point, with detailed track report data to the right.

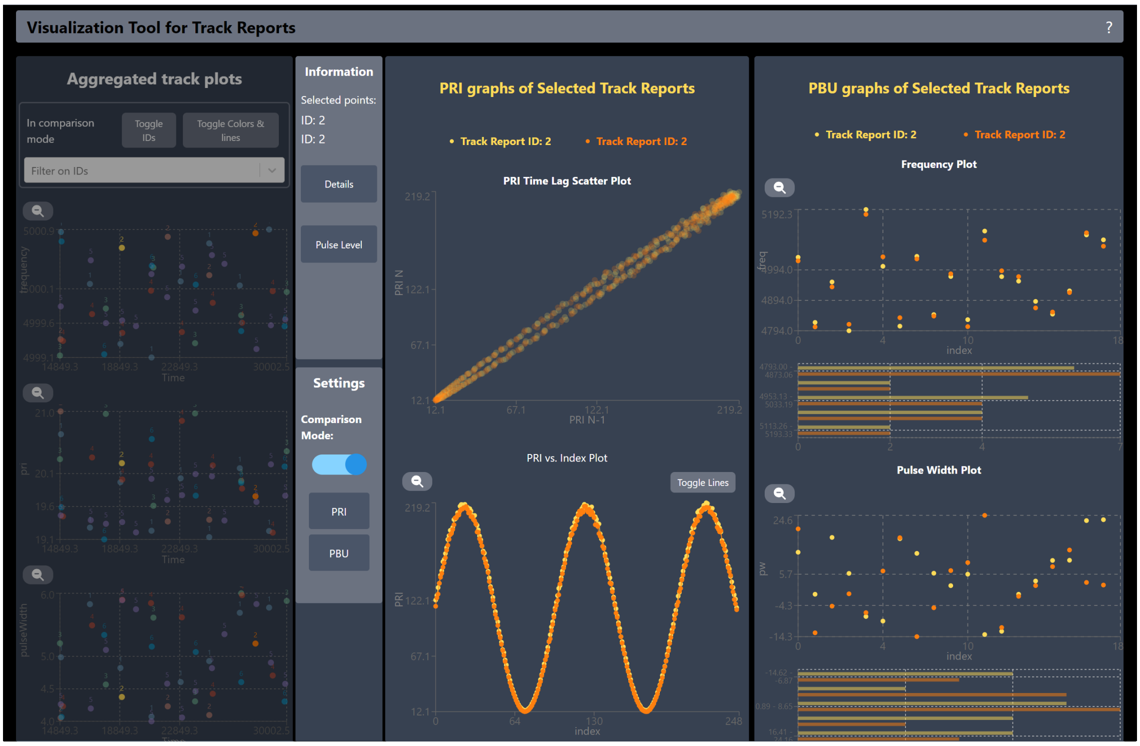


Figure 21: View of two points being compared

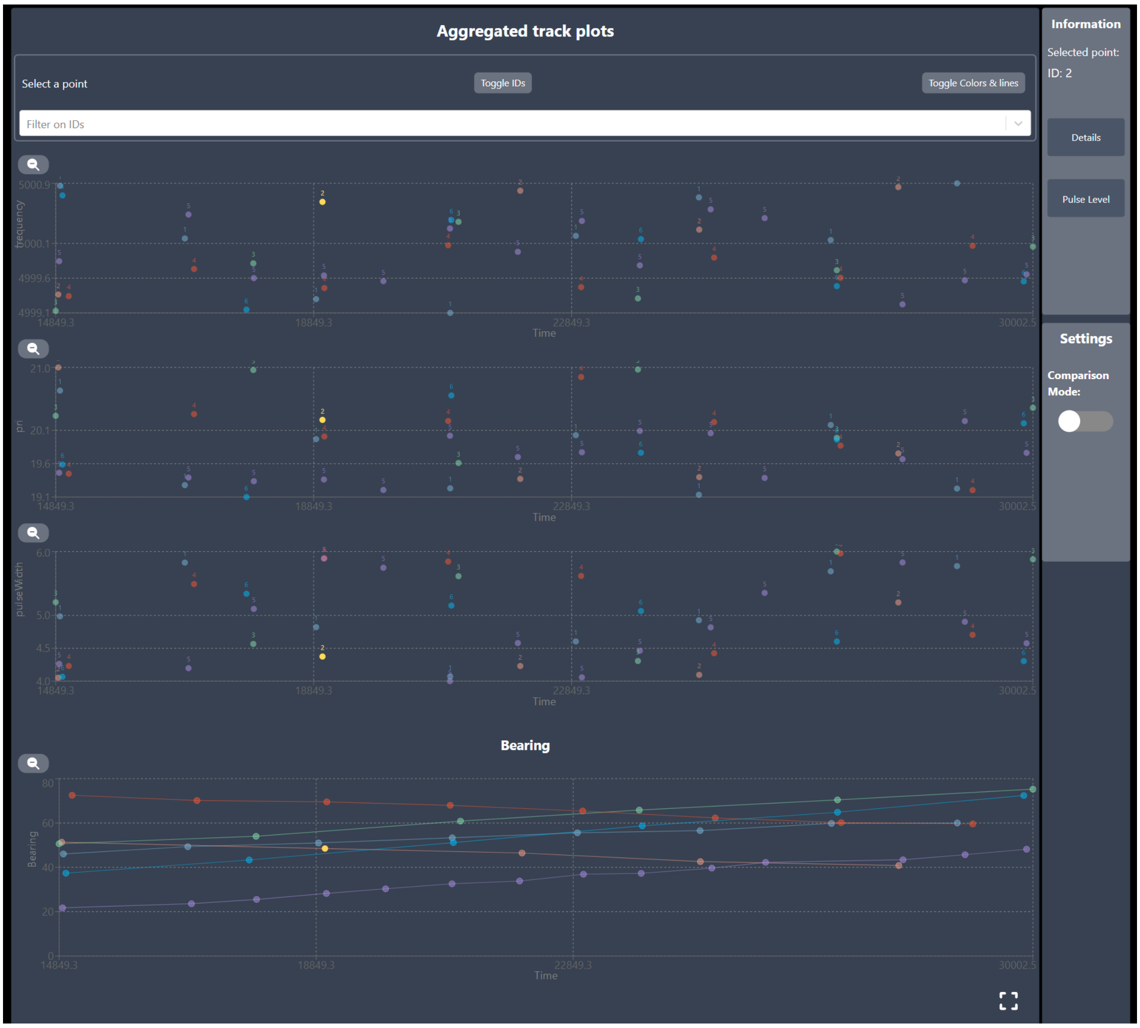


Figure 22: Full screen of the left aggregated view.

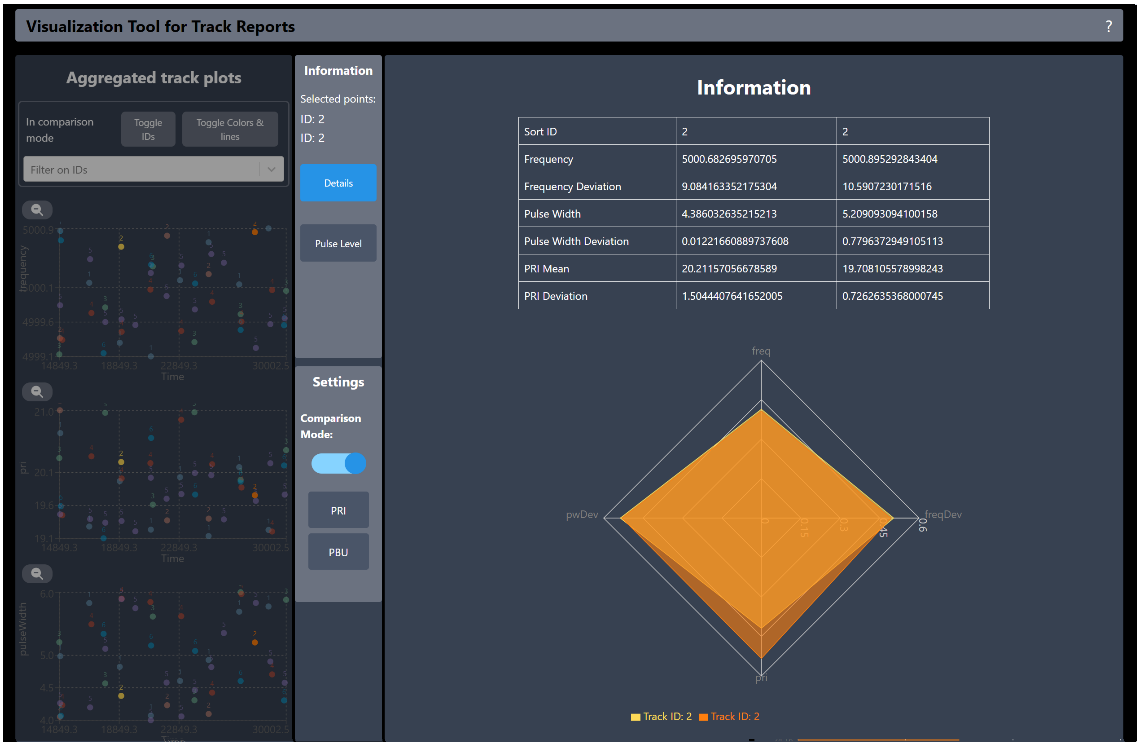
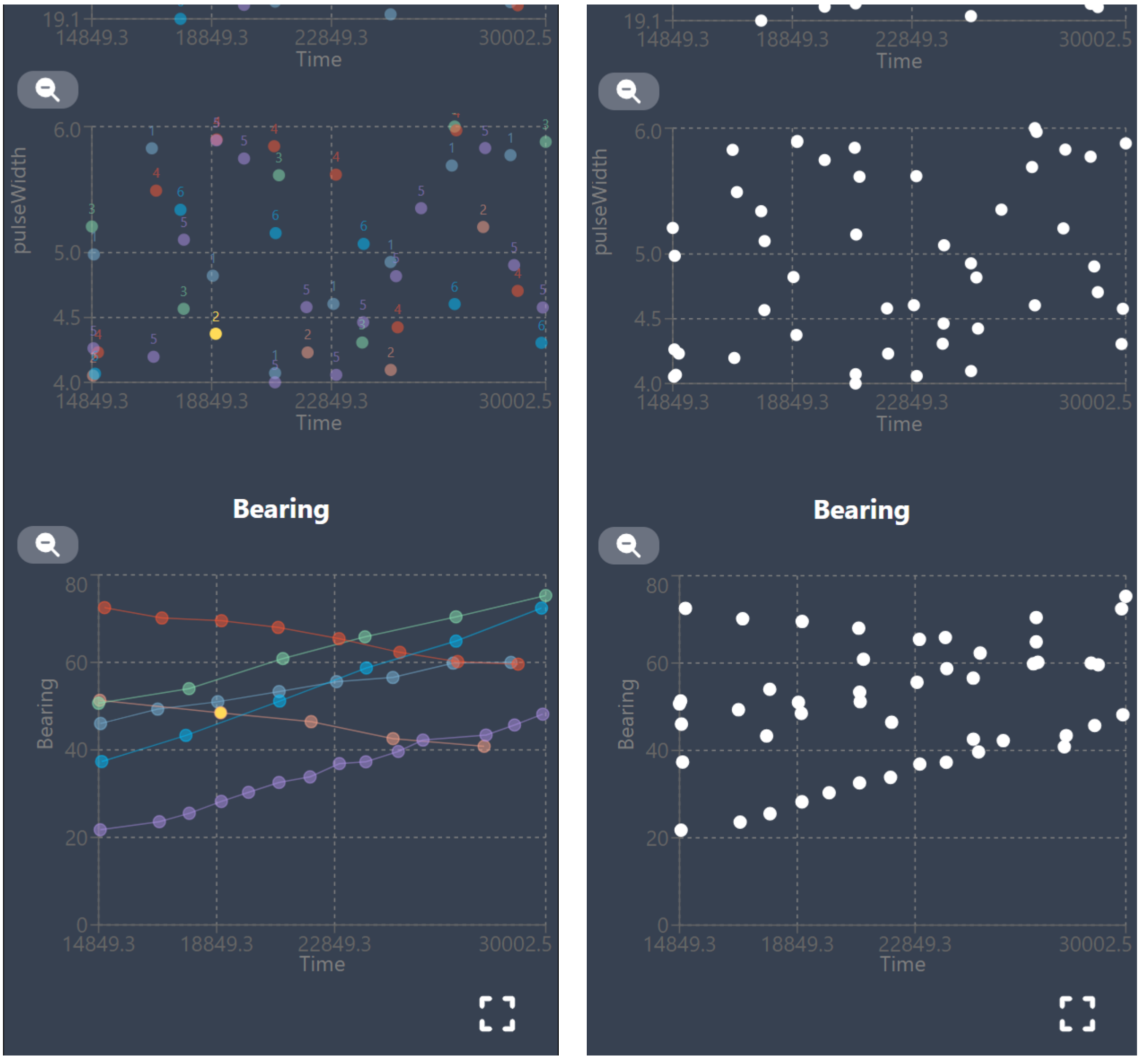


Figure 23: Detailed view of track report data in comparison mode.



(a) IDs, colors and lines toggled on. (b) IDs, colors and lines toggled off.

Figure 24: Aggregated pulse width plot and bearing plot with details toggled on and off.

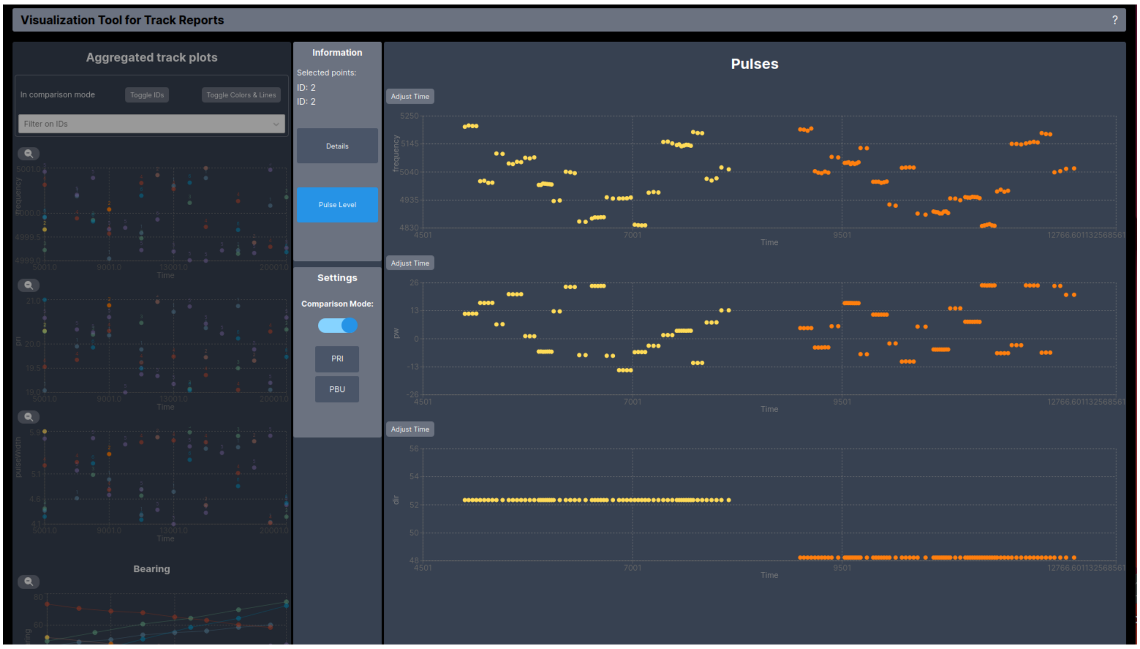


Figure 25: View over pulse data.

(a) Marking are to zoom by clicking and dragging.

(b) Zoomed in area.

Figure 26: Zooming feature.