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Supporting Facility Management and Operations through User-Centered Design

Johanna Holmqvist Larsson
Fanny Tapper

UPPSALA
UNIVERSITET

Teknisk- naturvetenskaplig fakultet
UTH-enheten

Besöksadress:
Ångströmlaboratoriet
Lägerhyddsvägen 1
Hus 4, Plan 0

Postadress:
Box 536
751 21 Uppsala

Telefon:
018 – 471 30 03

Telefax:
018 – 471 30 00

Hemsida:
http://www.teknat.uu.se/student

Abstract

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Johanna Holmqvist Larsson & Fanny Tapper

Today the building sector is focused on improving the energy efficiency in order to meet climate and financial business goals. Technical facility managers work with indoor energy use and one aspect of their work is to optimize the facility performance according to goals set by the company. Their work role involves technical and financial facility management, covering for absent colleagues by acting as back-up support, as well as managing tenant relationships. To perform their work, they must be able to access disparate digital tools, facility information and automatic control systems across various facilities.

The purpose of this thesis was twofold. The first was to evaluate the potential need of a portal that connects various systems and supports information exchange among technical facility managers. The second was to disclose what this portal should include and from that formulate a design solution.

A contextual design approach was used to investigate the work domain of the technical facility managers through interviews and observations. A first insight from the interviews was that technical facility managers had to navigate a broad range of tools, accessed from separate platforms. Importantly, their automatic control systems were provided by various suppliers and accessed in disparate ways. Vital information was scattered in different systems, supporting neither daily work nor efficient retrieval of information. Additionally, much information was kept in individual records, which made back-up supporting more difficult. The interviews and observations uncovered 7 user requirements that concerned 1) a holistic view, 2) easy access to automatic control system, 3) customization, 4) information creation 5) information retrieval, 6) statistics and analytics and 7) structure.

Handledare: Andreas Bergensund
Ämnesgranskare: Mikael Laaksoharju
Examinator: Elísabet Andrésdóttir
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Sammanfattning

Denna studie resulterade i en prototyp i stil med en Minimal Viable Product (MVP), minsta livskraftiga produkt, av hur en portallösning skulle kunna se för att underlätta driftoptimering av fastigheter. Denna designversion syftar till att möta användarbehoven i ett tidigt användarsskede, samtidigt som den genererar tillräckligt mycket feedback för framtida vidareutveckling. För att ta reda på användarbehoven och vad portallösningen skulle innehålla hölls intervjuer och observationsstudier med den avsedda användaren, vilket var fastighetsansvariga teknik (FAT) på fastighetsbolaget Vasakronan. Portaldesignen innehåller dels de digitala verktyg som FAT använder i sitt yrke, men täcker även andra omkringliggande aspekter av den breda yrkesrollen. De digitala verktygen som FAT använde sig var kopplade till kommunikation, finansiella samt operationella mål samt skapande och inhämtande av information. Eftersom en stor del av arbetet utförs i byggnadens styr- och reglersystem var också dessa en central del av portallösningen. Överlag innebär rollen som FAT ett driftansvar över flera fastigheter med olika styr- och reglersystem, men utöver de egna fastigheterna inkluderar även rollen vikariat för kollegors fastigheter. För att underlätta kunskapsöverföringen mellan kollegor och minska systemanvändarens minnesbelastning utformades en loggboksfunktion i portalen. När prototyp-lösningen sedermera presenterades och testades av FAT var den mycket uppskattad. De ansåg att portallösningen fångat in deras arbetsroll på så sätt att den inkluderade de viktigaste digitala verktygen, presenterade fastighetsrelaterad information mer lättillgängligt och kändes intuitiv att använda.

Att inkludera användaren av det utformade systemet i själva skapandet av systemlösningen är en essentiell designaspekt. Detta utgör själva grunden i användarcentrerad design och är applicerbart inom många relaterade områden. Att utforma systemlösningar utan användaren i åtanke riskerar att skapa förvirring. Detta kan vara orsaken till att systemanvändaren begår misstag och i slutändan används inte systemet av användaren. För att minimera risken för detta bör istället systemet designas utefter användaren, så att denne upplever att det nya redskapet är intuitivt och meningsfullt. Genom att ta användarens behov, insikter och åsikter i åtanke kan systemdesign utformas så att det går i linje med användarens bild av systemet. Denna aspekt blir ännu viktigare när man designar stora, komplexa och tekniska system.

Inom fastighetsbranschen används idag tekniskt avancerade system som inger användaren begränsad insyn i systemets funktioner, processer och utveckling. Samtidigt förväntas användaren ha förståelse för just hur systemet fungerar, kunna navigera mellan dess processer med syftet att optimera styr- och reglerinställningarna för att nå en viss driftsutveckling. Därutöver så finns det olika leverantörer som förser byggnaden med system och graden av uppkoppling varierar mellan dessa. För att ge användaren bättre förutsättningar att utföra det dagliga arbetet, bör därför systemen utvecklas med den tänkta användaren i åtanke. Att applicera ett användarcentrerat designtänkande kan därför ses som en väg framåt.

Nyckelord: Usability design, Human Computer Interaction, Contextual Design

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1. Introduction

In Agenda 2030, the United Nation has outlined 17 sustainable development goals. One of the goals concerns creating sustainable cities and societies. Working with resource savings and energy efficiency are also incorporated in the 17 goals (UNDP, 2020). As a necessary mean to accomplish these goals, Bodén et. al. (2020) advocate the creation and implementation of digital solutions for automatic building operation. Historically, buildings have operated independently but with the modern communication technology they have become increasingly connected (Mossberg Sonnek & Lindgren, 2015).

However, Bodén et. al. (2020) identify weaknesses in the construction sector concerning the implementation of digital building automation. It is a conservative industry, and on that note, the digital facility automation is based on the facility's prerequisite. The implementation of digital solutions in older buildings can be cost demanding since the technical maturity levels among their existing systems vary. Hence, digital desiderata are much easier realized in facilities under construction (Bodén et. al., 2020). Nevertheless, this increased level of connectivity also opens for potential security threats since the information and signals are accessible from the internet (Mossberg Sonnek & Lindgren, 2015). The security threats are in relation to the tenants located in the building, the level of digital facility automation and what the different functions need to be protected against (Bodén et. al., 2020).

According to Mossberg Sonnek and Lindgren (2015), the term *Building Automation Systems* entails automatic control systems that manage operational functions such as heat, ventilation, air conditioning, lightning, elevators and access control installed in buildings. Advancing it further, Bodén et. al. (2020) state that *digital* building automation systems refer to systems that are coupled and interlinked to create a flexible and optimal indoor climate. Bodén et. al. (2020, p.16) claim that "the whole facility becomes smarter" and purport more efficient facility management. *Smart buildings* are further discussed by Mossberg Sonnek and Lindgren (2015) who state that smart buildings have undergone an expansion during the last years due to the rapidly growing demand on energy efficiency and energy savings.

Thus, a digital facility is more than just a coherent, principal control system. It is a software with several operating functions and entities that are intertwined and communicating. However, this poses difficulties if aiming to create a principal control system and maintaining it over time. Since buildings have various subsystems installed that use disparate programming languages, connecting them through a principal control system means that it must handle the communication among them. The main reason why the buildings have systems with separate languages is due to the wide range of market actors and the lack of standardization (Bodén et. al., 2020). Another associated issue is that the main contractor who constructed the requirement specification of the system may not be the same actor who administers the systems in practice. Thus, there is an associated system maintenance problem. Also, the technical facility managers working with the technology can be replaced, which highlights the greater demand for documentation and a seamless automatic control system (Mossberg Sonnek & Lindgren, 2015).

Despite these stated difficulties in managing a principal control system, Bodén et. al. (2020) state that creating one is a meaningful mean in order to establish a digital building automation system. For the owner of the buildings, the energy optimization and greater control over the facilities' resources provide future savings potential and facilitate prognosis work. For the ones operating the buildings, the *technical facility managers*, digitalizing the systems imposes a greater *flexibility* regarding planning, optimization and better insights into past, present and future operations. In such digitized systems, the facility houses physical components that are connected to a remote-control unit which, in turn, is connected to an interface. Thus, the technical facility manager can control the components through the interface and thereby conduct maintenance optimally without being geographically bounded to the physical facility (Bodén et. al., 2020). Furthermore, this decentralized setup may entail greater profits since several buildings can be controlled and monitored from one place. Hence, the troubleshooting and maintenance can be conducted remotely by the company's employees or suppliers of the system (Mossberg Sonnek & Lindgren, 2015).

Today, most of the technical facility managers at Vasakronan are able to study components in their buildings through a principal control system. Nevertheless, these principal control systems vary in connectivity and complexity since the automatic control systems are installed from various suppliers. At Vasakronan, the technical facility managers have the responsibility for tenants and the facilities, both operationally and financially. Thus, they need to possess knowledge concerning the technical systems coupled to facilities as well as monitor budget and financial results. Furthermore, their duties include optimization of operations, maintenance and minimizing the energy consumption within the facilities to meet Vasakronan's sustainability goals. This also includes the analysis of and follow-up on errors reported by tenants. In their daily work they ought to use digital tools in order to enhance the facility performance and delivery to tenants, order and follow-up on operation duties and government inspections (Almquist, 2018).

When creating a tool, it can be designed so that it is *enabling*. Enabling design put focus on usability and aims at enhancing and mobilizing the user's capabilities as well as utilize their intelligence and expertise. As Adler and Borys (1996) claim, "equipment is seen as inherently limited and the goal of design is to ensure the operator can intervene effectively to rectify problems" (ibid, p.67), meaning that with increasing complexity, the objective to create faultless machines becomes incessant. As the role description discloses, the technical facility managers at Vasakronan need to be flexible in their work practice, analyse and solve the range of facility related problems that arise and work in line with Vasakronan's goals by identifying and implementing improvements. To support their work coupled to operations and various automatic control systems, a tool could be designed such that it suits their daily tasks and ongoing processes. One way to structure and support their work practice is through a portal, since it enables access to a wide set of content and tools. Importantly, the portal should be constructed and designed in a structural manner to provide the user with clear visualization and operations (Sullivan, 2003).

1.1 Aim of the Thesis

Hence, this thesis aims to investigate the *need of a portal that connects various principal control systems and related tools among technical facility managers.* If such a need exists, the thesis work aims to *disclose what this portal would cover and provide a design suggestion that assist the users in their work.* Hence, the initial focus point of the thesis is directed to the current existing tools and system along with their use. This is followed by a theory section concerning good system design and its implications for design, then how to design to access as well as share vital knowledge. After the theory section, the methodology and used methods for identifying the user needs are brought up followed by a presentation of the gathered data coupled to user needs. Thereupon, the used methods for creating, testing and evaluating the design solution is described. Here, the results from the iterative usability tests are presented and also the proposed design solution. Finally, the thesis brings up enhancements of the prototype and implications for further design work together with system improvements.

2. Background Description – A Description of Systems

Firstly, this section contains a general description of the various levels in building automation systems, and serves to outline the technical function of the studied system. Secondly, a description of the various systems and tools which Vasakronan houses is presented combined with their associated function and intended use. The existing portals that links to the automatic control systems are mentioned, followed by a description of all the tools that the intended user operate in on a regular basis. Due to the massive number of tools and portals, the user's navigation among them might seem unstructured. However, this section attempts to bring order to their use, connection and function.

2.1 General Description of the Automatic Control System Structure

A building incorporates various kinds of systems with operational purposes. Building automation systems entail *automatic control systems* that control the heat, ventilation, lightning, elevators and access control installed in the buildings. Additionally, it includes central control and monitoring systems as well as control systems and information of individual functions within the building. The technical installations in buildings are categorized into climate control versus building service installations. Installations coupled to *climate control* regard heating, cooling, air conditioning and ventilation systems. Installations coupled to *building service* regard e.g. sewage, electricity and access systems (Mossberg Sonnek & Lindgren, 2015).

The building automation system can be divided into three sub levels: information, automation, and field level (Gustafsson, 2013). These levels are visually shown in figure 1.

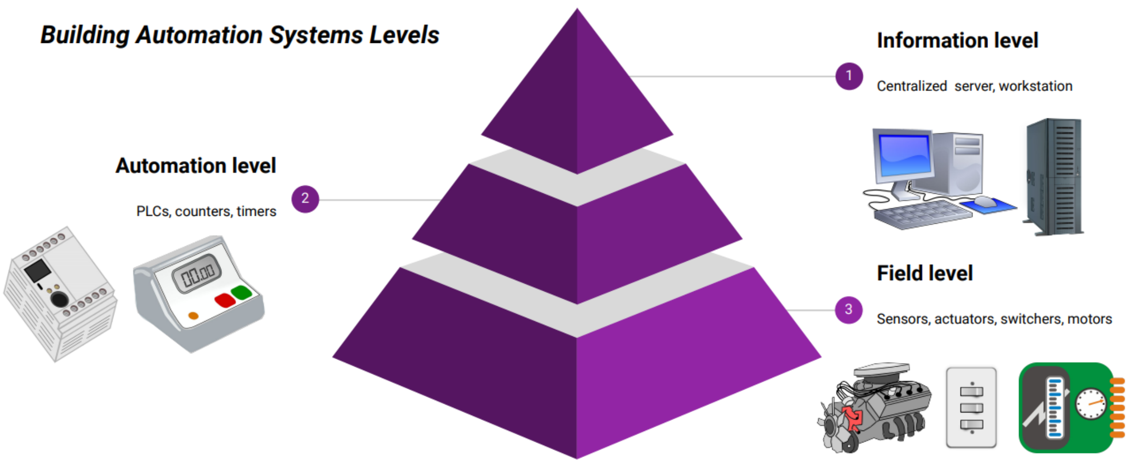

Figure 1: Illustration of the building automation systems levels, showing the information level, automation level, and field level.

The *information* level manages information processing and deliver data on energy use, error statistics and information about maintenance. Starting, stopping and justification of set-point values occur at the information level of the system. The set-point value is the desired value. Other functions that operate on the information level are energy use optimization, representation and analysis of measurements and operation points. Not only that, the transmission of informative messages about operation status, errors and alarms are also included. However, the data processed on the information level becomes visually noticeable through representations on e.g. screens at the automation level (Gustafsson, 2013).

The *automation level* controls and manages the operation installations that are installed in electrical and mechanical sites. Operations on the automation level are autonomous to some degree, which entails that the operative parts of the system are unaffected by errors that occur on the information level. Hardware at the automation level is often physically located in service rooms and can be controlled manually. Functions on automation level regard e.g. measuring, controlling and monitoring (Gustafsson, 2013). A common way to arrange automatic controlling and surveillance in buildings is by installing a *programmable logic controller* (PLC), more commonly denoted as DUC, a *computerized under central* (Mossberg Sonnek & Lindgren, 2015). The DUC is an industrial controller that receives information from electric sensors about the process to be controlled. These sensors, which belong to the field level, consist of e.g. a pushed button, digital sensors such as a thermostat, or analogous sensors such as a thermometer. Through various control gears, the DUC can control various actions in the system (Von Zweigbergk & Von Zweigbergk, 2015).

The automation system has various interactive system components. The *regulator* has two input signals referred to as the *set-point* and the *output*. The set-point is the desired value, while the output is the current value. The function of the regulator is to compare the set-point and the output, compute the deviation, and reduce the deviation by control. The DUC can function as a regulator. The *transducer* converts to and from electrical signals in order to be able to combine various *actuators*. The *actuator* is the module that moves and controls the controllable mechanism or system. The *sensor* recognizes varying quantities and sends information to other parts of the system. The *signal converter* converts digital signals to analogue signals (Von Zweigbergk & Von Zweigbergk, 2015).

The *field level* covers instruments for measurement, positioning, connecting and signaling of the operation systems. Field level also includes controllability of individual rooms or zones. The current operation status is identified through sensors and is modified by actuators (Gustafsson, 2013).

2.2 Vasakronan’s Portals for Automatic Control Systems

There are various manufacturers of automatic control systems on the market and installed in Vasakronan’s buildings. Some of the systems installed are provided by

Nordomatic, *Exomatic*, *Larmia*, *Siemens*, *TAC Vista*, *Citec*, *Schneider* and *Lindevent* (Operations Portal, n.d.). They serve as principal automation systems, a *Supervisory Control and Data Acquisition* (SCADA), but also supply with a Human-Machine Interface (HMI). At Vasakronan, these systems installed in buildings can be accessed at an information level through Vasakronan's *Operations Portal* or *Technology Portal*. There are no differences between the two portals concerning when they can be used, but both provides the user with a link to the facility's SCADA system. In that way, they coexist and share the same function. As aforementioned, the automatic control systems are provided by various suppliers, thus they can be more or less advanced at an automation level.

2.2.1 Operations Portal

The *Operations Portal* is a unified platform that connects various automatic control systems installed in the facilities. The portal view can be seen in figure 2, with all the links to principal automatic control systems in buildings with remote access. These systems include the building automation control systems, access systems, information boards, presence detectors, lightning and elevator systems. The *Operations Portal* can be accessed remotely in two ways, either by using the web browser or by a remote desktop (RDP). The purpose of the *Operations Portal* is to foster the remote access, facilitate administration, reduce dependence on the individual and improve safety (Holmström, 2020).

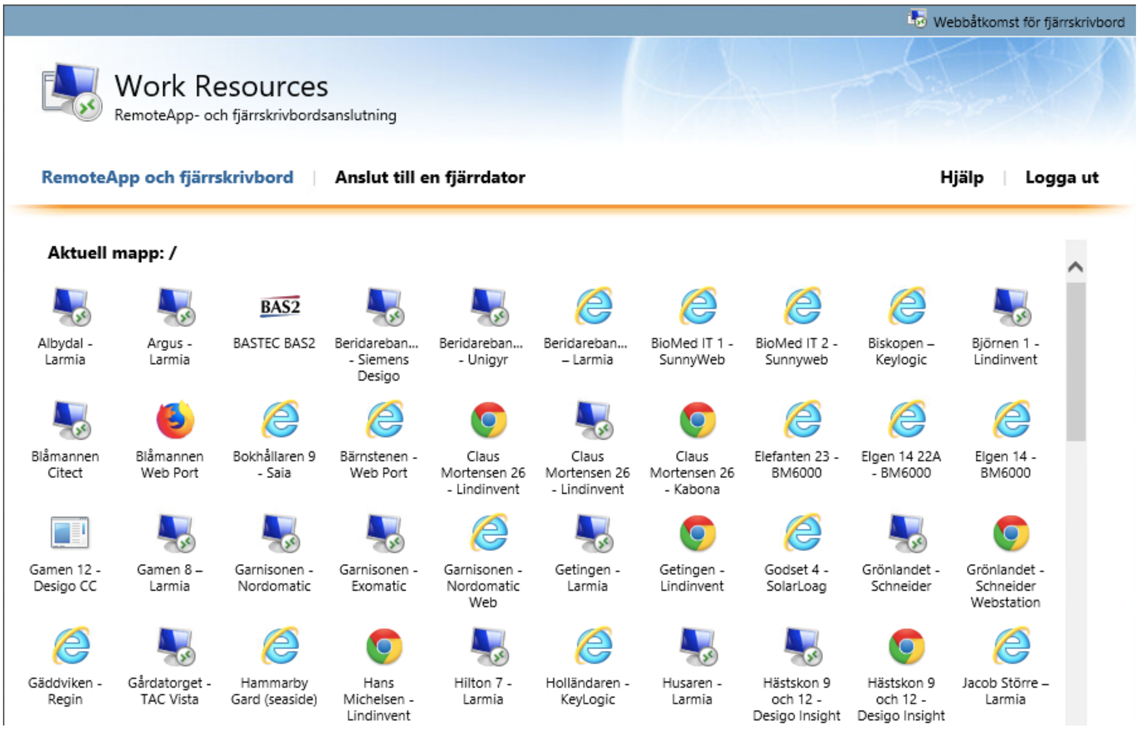

Figure 2: Having logged into the Operations Portal, the illustrated view over the automatic control system which could be accessed.

2.2.2 Technology Portal

The *Technology Portal* is created by Vasakronan to assist their employees who work with facility service or technology. From the portal, the employee can reach their building automatic control systems as well as reach other's through remote access. A list of links is displayed when applying a filtering search. The employee can also see their maintenance projects as well as when tenants move in or out of their facilities. Hence, compared to the *Operations Portal*, it holds more information as it houses links and documents. For instance, it entails links to *Q3web*, the suppliers' agreements log and links to the results from error report inquiry (Nordlund, 2019a). The portal can be seen in figure 3.

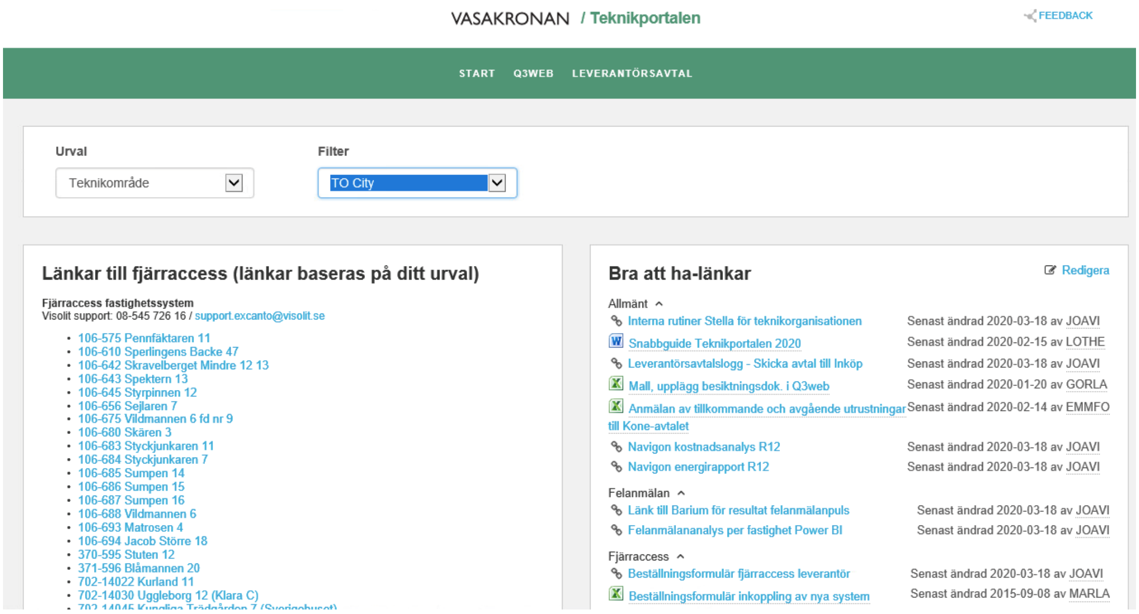

Figure 3: The Technology Portal with the "good to have links" and all facilities with remote access, filtered on region. Also, there are two tabs to the Q3web and contracts with suppliers.

2.3 Description of Common Existing Tools at Vasakronan

Vasakronan distributes many digital tools. These serve various purposes and relate to the technical facility manager in different ways. Additionally, there are artifacts and system components that influence the common work practice among technical facility managers. To help the reader outline which of these tools that are most relevant, an attempt to categorize them according to their information flow to the technical facility manager, artifacts and different system components is seen in figure 4. This is followed by descriptions of the tools.

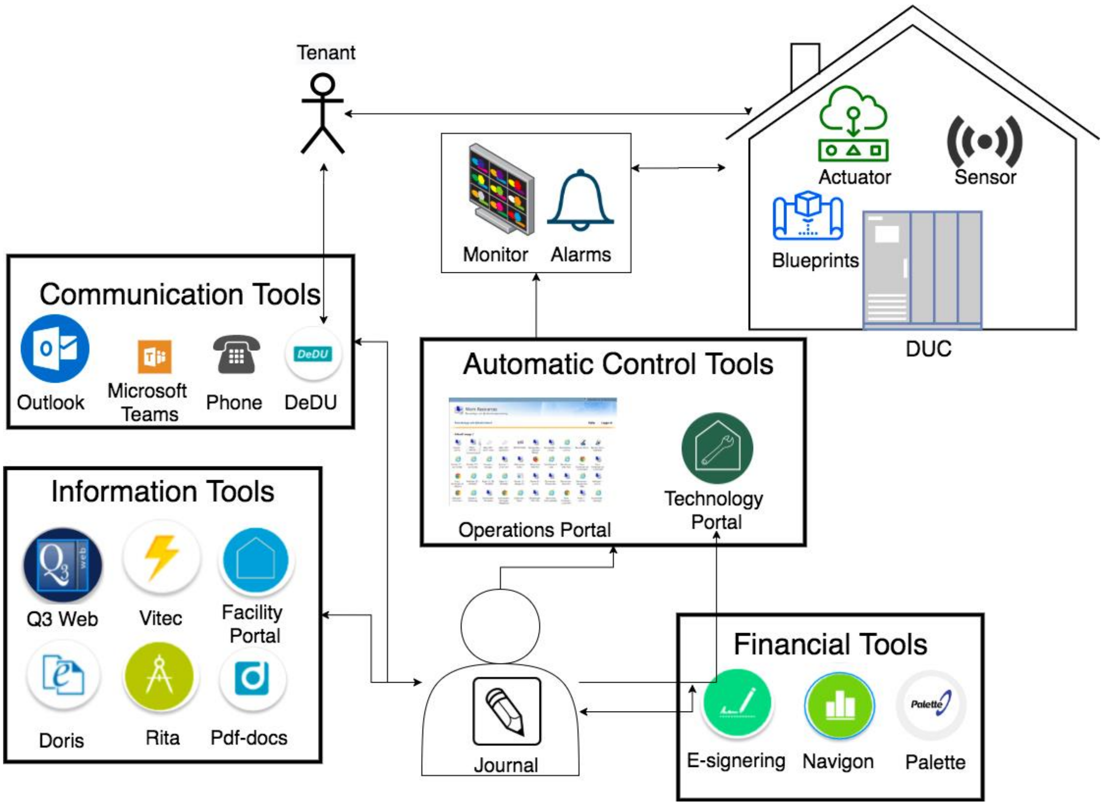

Figure 4: The technical facility manager's most vital tools and system components to manage their work practice.

To start with, some tools are accessible through their intranet *Sofia*. In *Sofia*, internal as well as external news are published, as well as information about co-workers, Vasakronan and supporting systems. *Sofia* holds several parts. An employee can find Vasakronan's complete set of tools but also create shortcuts to them in "my applications" and mark their favourites, as in figure 5. Notably, some digital tool icons are linked to a software program, while some are linked to an information page concerning the program and have to be opened in other ways. Commonly, the user alone needs to identify what tools they need in order to conduct their work.

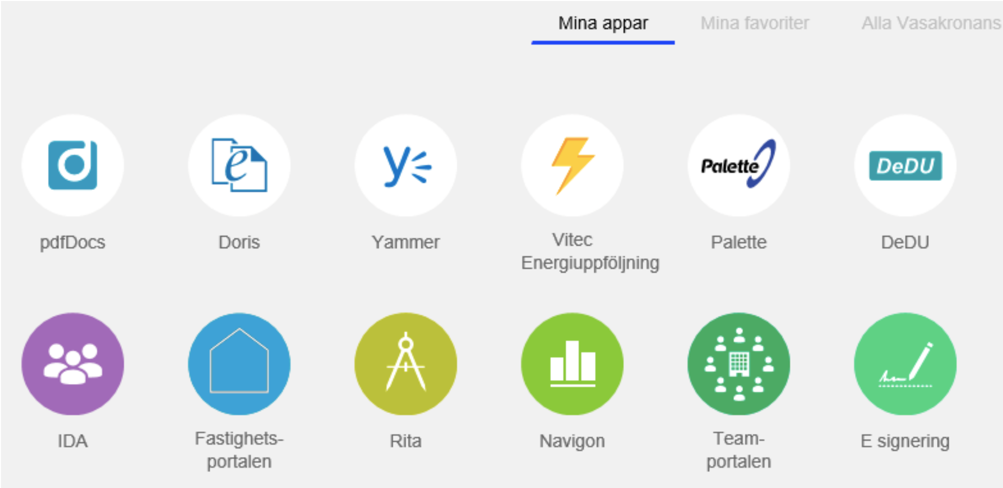

Figure 5: Various tools in Vasakronan, which have been added to 'my applications' in the intranet Sofia (Vasakronan, 2020).

2.3.1 Communication Tools

Yearly, Vasakronan receives approximately 40 000 error reports from tenants. The tool *DeDU* is described as Vasakronan's IT-support to handle error reports and internal inspectional tours. These internal inspectional tours include observations on a facility's proper function, and subsequent error reporting if any deviations were discovered. Inspections are conducted to ensure a facility's performance quality and discover deficiencies in operations at an early stage. Furthermore, depending on the technical field, the field inspections are conducted by either the technical facility managers or Vasakronan's service partner company *Coor*. *Coor* manages about 70% of the error reports. The error errands are sent via email or mobile telephones. Vasakronan's ambition is to give personal feedback within 24 hours (Nordlund, 2019b).

Teams, PowerBI, Yammer, Word, Excel, OneNote and *Outlook* are Microsoft tools which are used at Vasakronan (Sandell, 2020). *Teams* is a tool for collaboration and is chat-based. Business partners, colleagues, project content and various applications are integrated. Also, Microsoft offers a tool for emailing, meeting management and calendar that is called *Outlook*. *Yammer* is a social network tool, and entails a multiple tool for collaboration (Microsoft, 2020).

Besides, Microsoft's communication tools, Vasakronan has created their own communication portal. The *Team Portal* is functioning as a supporting system for business and customer teams. The idea with the *Team Portal* is to unify the workflow among team members. Also, the team has their own noticeboard in *OneNote* (Hellstrand, 2019a).

2.3.2 Information Tools

The following section presents the tools that are connected to information maintenance at Vasakronan. Among these is Doris, which is the documentation handling system that *is used across the entire organization, Vitec, which address statistics and Rita, where all blueprints are storable and retrievable.*

Doris is the name of Vasakronans documentation handling system. According to Vasakronan, the purpose of *Doris* is to simplify the finding of documents and avoid duplications of documents. Documents that hold information about tenants, Vasakronan's facilities, an employee's division or other work-related documents are managed in *Doris*. Some technical documents and management documents should not be stored in *Doris*, but in *Rita*. For storing, there are special instructions and guidelines for name conventions. Vasakronan states that "instead of storing documents in various folder structures, the documents are stored in *Doris* in a database" (Hellstrand, 2020).

As a supplement to managing the documents accessed or placed in *Doris*, *pdfDocs* can be used. As indicated, *pdfDocs* is used for managing PDF-documents. The tool is integrated with *Doris*. Some of the most utilized operations include scanning rental agreements, bids, contracts and closures. Additionally, documents can be repositioned, splitted, commented or stamped with a watermark (Hellstrand, 2017).

Vasakronan's system for storing and updating blueprints or management documents is called *Rita*. *Rita* should be used for every building, facility management and technical or service project initiated by Vasakronan. The employees at Vasakronan can use *Rita* through a link in the *Facility Portal* or from support systems (Nordlund, 2017a).

2.3.3 Facility Portal

From the *Facility Portal*, seen in *figure 6,* the employees can reach some information from underlying systems. Systems as *Vitec*, *Navigon*, *Doris*, *Rita* and *DeDU* can be accessed from the *Facility Portal*. Hence, information coupled to the latest facility news, contracts with suppliers, error reports and documents can be viewed (Hellstrand, 2018).

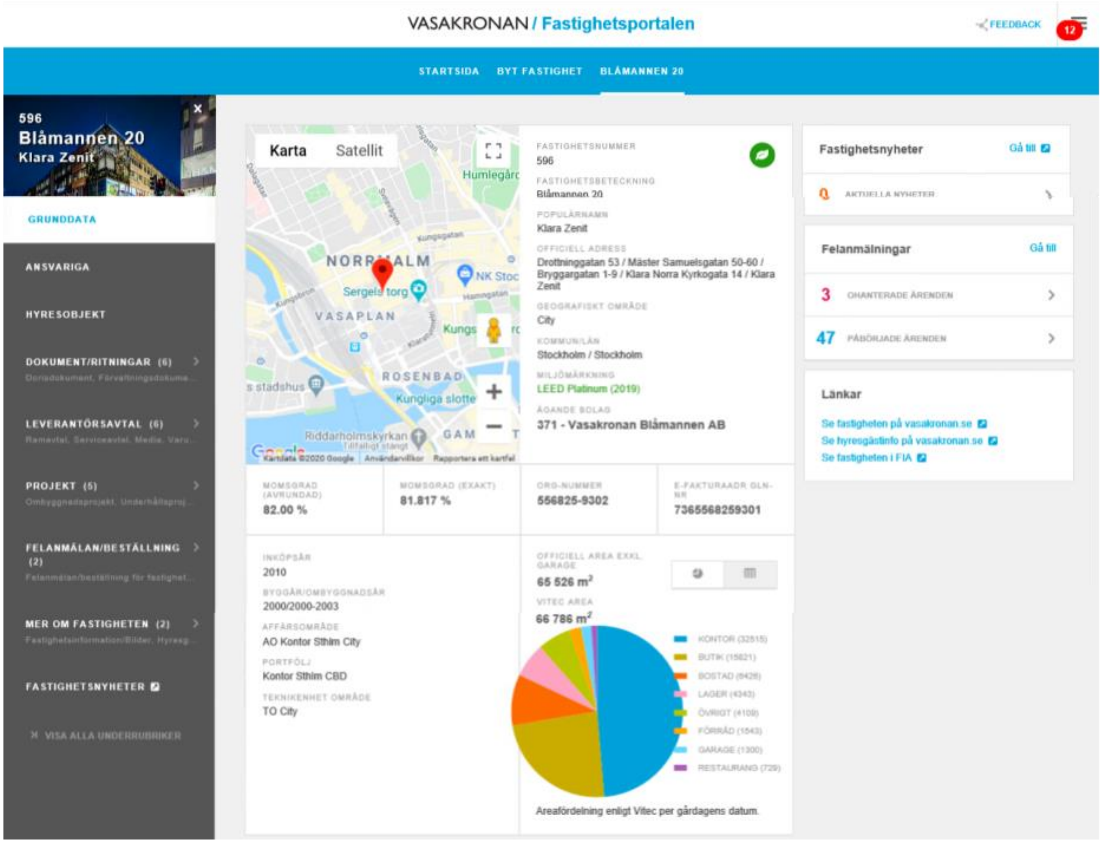

Figure 6: An image showing the Facility Portal, and the information about the selected facility.

2.3.4 Q3Web by Kiwa

The company *Kiwa* ensures that the safety and regulations are followed in buildings, makes inspections of the systems functionality and provides the facility companies with certificates and requirements. According to agreements, *Kiwa* should provide a document management system for government inspections at Vasakronan. The planning and documentation coupled to these inspections are managed in *Kiwa*'s system *Q3Web*. Technical facility managers are responsible for monitoring and viewing the status in a web application, which is updated daily. Objects that are subject for inspection are e.g. elevators, escalators, air, ventilation and installations coupled to fire prevention (Walldan, 2020).

2.3.5 Statistics in Vitec

Another tool for information maintenance is *Vitec*. *Vitec* functions so that technical facility managers and employees working with operations and services review and update output values for water, electricity, heating and cooling and thus, are able to verify that the facilities work according to its prerequisite. Hence, Vasakronan uses *Vitec* for energy and media optimization. On a monthly basis, the output values that have been entered to the system are controlled and verified. If the registered values deviate from the set-up values, there is an investigation and energy use follow-up. The technical facility manager is responsible for the monthly control (Hellstrand, 2019b).

2.3.6 Financial Tools

Yet an associated tool, is *Navigon* which is used for follow-up on processes, budgets and thus, to ensure that Vasakronan reaches their financial goals. Navigon receives energy figures from *Vitec* but presents them in financial terms (Nordlund, 2017b). In order to manage invoices that have been sent to suppliers and later on registered in Navigon, Vasakronan uses Palette (Nordlund, 2018; 2019).

3. Design Theory

This section aims at presenting the theories that were used to understand, categorize and make use of the collected data. The first part brings up what makes a good systems design and functions as epistemological guidelines when designing systems. It raises some issues of concerns related to the design process. The second part presents some principles for general design and contributes with practical implications for systems design. Lastly, the third part touches on how to access vital knowledge.

3.1 The Means of a Good Systems Design

When designing computer systems, we need the instrumental theory of how to design, as well as the fundamental theory about the phenomenon of design (Ehn, 1988). The science of design typically considers the rational design of the system, and the technical functionality of the system. According to Ehn (1988) the design and use of computer systems and artifacts should consider societal and historical processes as well. Thus, Ehn (1988) proposes that the means of design and use of these should incorporate the human practice. In his dissertation '*Work-oriented design of computer artifacts*', several noteworthy remarks on what makes up for a good systems design are presented.

Ehn (1988) states that the aim of designing computer systems and artifacts is to make them useful to the user in their everyday activities. The designer should emphasize the *use*, rather than the system or artifacts themselves. Ideally, the design should aim at enabling the user to use their practical understanding in new situations. Norman (2013) agrees with this and states that there should be a focus on activity - not tasks, and people - not individuals. By this, Norman (2013) emphasizes that the design should capture the more general aspects rather than isolated details.

According to Ehn (1988), the main underlying question in designing concerns the contradiction between *tradition* and *transcendence*. Tradition refers to what has happened historically, and transcendence refers to the evolution of new systems. This contradiction occurs in several dimensions of the design process, such as in the *artifacts to be used*, *professional competence, division of labour and cooperation* and *the objects to be produced.* The contradiction regards whether the design should support the already existing practice or create openings for new practices (Ehn, 1988). By adding an additional perspective, Norman (2013) says that many systems are facing a *legacy problem*, meaning that the current standard is adopted and indoctrinated. This implies that new devices will not be able to integrate into a system and that it is expensive to make the comprehensive transition to a new system (Norman, 2013).

3.2 Implications for Design

Within industrial design, systems and their concepts should be constructed for the bilateral benefit of the user and the manufacturer. This design thinking aligns with *interaction design*, which addresses how individuals interact with the created systems.

Norman (2013) claims that “the goal is to enhance people’s understanding of what can be done, what is happening, and what has just occurred” (ibid, p.4). A good designer thus aims to grasp the underlying issues of problems, not solving what has been stated. Studying people, their goals and actions ought to be at the centre of this work process. A similar point is made by Ehn (1988) who understands systems as computer artifacts, and suggests that the functionality of a computer artifact ought to be studied through the relation between the user and the artifact. This yields some important implications for designing a user interface, since it suggests that the user interface should be comprehended in relation to the intention of the use activity. As Shneiderman and Plaisant (2004) state, “effective interfaces generate positive feelings of success, competence, mastery, and clarity in the user community” (ibid, p.12) and by this, users can focus on their work. This strongly suggests that the design should encounter contextual aspects in order to be convenient in work practice and support the user experience.

When a design is *enabling*, meaning that it is intended to enhance and leverage the user’s skills, the usability design approach is that users will face unpredicted contingencies. If such arise, the equipment should have an *internal transparency* that provides the user with the requested information concerning the internal logic of the equipment's’ functioning as well as their status, which support the user’s work with rectifying errors (Adler & Borys, 1996). In that regard Shneiderman and Plaisant (2004) state that “the goal of system design in many applications is to give operators sufficient information about current status and activities so that, when intervention is necessary, they have the knowledge and the capacity to perform correctly, even under partial failures “ (ibid, p.80). A similar point is made by Adler and Borys (1996) who claim that “enabling procedures provide users with visibility into the processes they regulate by explicating its key components and by codifying best-practice routines” (ibid, p.72) so, the user can understand the fundamentals. The user should gain feedback on their operation and be given a chance to evaluate their performance through comparing with historical metrics. What is more, Adler and Borys (1996) bring up the aspect of transparency as *global,* thereby providing the user with insights at a broader scale. In this way, the user does not only get information concerning their part of the work but also contextual information of the entire process. Hence, they can optimize their own performance but also recognize and review local and holistic aspects of enhancements. Yet a design aspect that Adler and Borys (1996) address as an enabling approach is to include *flexibility,* since “flexible systems encourage users to modify the interface and add functionality to suit their specific work demands” (ibid, p.74).

What should be considered when designing computer systems in practice is the two-dimensional limitation of displays. This means that displays cannot entail the richness and complexity of the intricate reality. In his work ‘*Envisioning Information*’, Tufte (1990) mentions the dilemma of using computer displays for information transfer. Separately, both the human and the computer possess high information-processing capacity, yet their interaction has to occur through a limiting display. Thus, Tufte

(1990) stresses that displays which are rich on data and hold more relevant information within eye span, are optimal for the human capacity. This is especially the case if the task includes choice, disparity and comparison.

A way to display data-rich information is by creating a portal. Sullivan (2003) discusses these aspects in his work *'Proven Portals: Best Practices for Planning, Designing, and Developing Enterprise Portals'.* However, Sullivan (2003) stresses that presenting data and information in a portal is a complex task due to that the user can get overwhelmed by information. To reduce this information overload, Sullivan (2003) suggests to adapt visualization tools that map "content to visual representations that aggregate content while highlighting significant relationships ". In this respect, Sullivan (2003) proposes the *focus-contexting* technique. It means that by highlighting one area, it takes the focus as the relationship between the emphasized area is displayed in its context with others. Similarly, Shneiderman and Plaisant (2004) bring up the advantages of using highlights, add background shading, colours and certain fonts to illustrate how items are related. However, labels ought to be in close proximity to its items such that their connection is understood. All in all, Shneiderman and Plaisant (2004) argue that establishing a visual structure through *grouping* supports task performance. On the topic of structure, Sullivan (2003) points out the importance of keeping a structural integrity. By this, Sullivan (2003) states that single features cannot compensate for the fundamental architectural structure. Thus, understanding how users think about its content and resources is crucial in its development and design.

There are various aspects to consider in order to create a good systems design. Norman (2013) suggests that the two most vital ones are *discoverability* and *understanding*. The possible actions and their performance need to be understood as well as their meaning and supposed function. Pertinent components should be detectable, and they need to provide factual communication. As interaction with a product takes place, discoverability occurs. It derives from fundamental psychological concepts: *Affordance, Signifiers*, *Constraints*, *Mappings*, *Feedback* and the *Conceptual Model*.

3.2.1 The Concept of Affordance

The term *affordance* addresses the relational connection among agents' competencies and the entities of a physical object. So, affordance relates to the ability to perform an intent. Both the affordance and the anti-affordance, where anti-affordance is seen as the contrary of an affordance, should be revealed in order to be sufficient (Norman, 2013). As an example, Norman (2013) mentions that "Glass affords transparency/.../ glass affords seeing through and support, but not the passage of air or most physical objects" (ibid, p.11). In this example, the anti-affordance is the blockage, since it prevents the air to pass through.

3.2.2 The Concept of Signifiers

The components that illustrate an affordance are called *signifiers*. Norman (2013) states that "Affordance determines what actions are possible. Signifiers communicate where the action should take place. We need both" (ibid, p. 14). The role of a signifier is to provide cues of operation, structure and possibilities to the recipient. The signifiers carry a higher importance than the affordances since they are instructions regarding the usage of a design. In addition to this, *visual language* can be used for displaying relationships, structure and interactivity. Also, icons can be used to portray an object or action. However, the range of icons that are applied should be used sparsely and selected icons should be distinguishable from the unselected ones (Shneiderman & Plaisant, 2004).

An associated topic is presented by Sullivan (2003), who discusses the visible structure of a portal's interface and how to display possible actions in a salient way. Sullivan (2003) makes a suggestion of the portal's design, the grouping of pages, as well as the overall portal structure. The suggestion shows the dissemination of information, applications as well as navigation tools at a page-level. Commonly, a three-panel structure is used where the top panel encompasses global information, the area to the left consists of options related to navigation and includes links to regularly visited objects, and the substantial central area is filled with the portal's main content (Sullivan, 2003).

In the three-panel outline suggested by Sullivan (2003), the top panel covers the entire portal interface and remains fixed while the other areas are dynamic. Usually, it presents links to a home page, regularly used applications and contact information. As regarding the side panel for navigation, Sullivan (2003) states that it "provides a localized context for users" and that the role of the side panel is "to provide an immediately visible and easily accessible path to related components in the portal while keeping the user from being overwhelmed by the full breadth of the portal". Lastly, the main area, where the substantial content is displayed, possesses the information and operations that users request.

3.2.3 The Concept of Mapping

Mapping is the term used for denoting a relationship between a set of things. It refers to the layout between controls and the entities being controlled. To support the mapping between objects and their functions, Sullivan (2003) advocates the use of labelling *standards*. On the same note, Shneiderman and Plaisant (2004) advocate *consistent* design when integrating terms, actions, colours and sequences of actions. This consistency consists of that the language or actions invoked should be organized and expected to the user, thus becoming simple to grasp and maintain.

According to Sullivan (2003) "well-designed systems aid navigation and should be almost unnoticed by end users" which implies that devices with possible actions clearly stated are easier to use. When the relationship between the entity that is to be controlled and the control is obvious, it is denoted *natural mapping*. There are three degrees of mapping, presented in decreasing performance. The best mapping has controls implemented *on* the device which they target. The second-best degree is when the controls are in *close proximity* to the object to be controlled. The third best degree of mapping mirrors the *spatial configuration* of the device to be controlled (Norman, 2013). This implies that a good design has taken an individual's behaviour into account and facilitate their mapping. However, *inconsistent* mapping between properties of the process and the signs provided by a display may also make controlling more difficult. This occurs when the representation of the system is imperfectly correlated with the state of the system, hence pointing out the importance of the mapping between perception and action (Vicente & Rasmussen, 1992) as well as frequent updates of the labelling scheme (Sullivan, 2003). Likewise, Sullivan (2003) proclaims that the aforementioned labelling standards ought to be selected in line with their use, industry standards and controlled vocabularies. Also, the constraints of the work domain should be mapped consistently and uniquely to cues or signs provided by the interface.

3.2.4 The Concept of Feedback

Feedback refers to the communication of the outcome of a user's action. The feedback results should be *informative, prioritized* and *communicated* instantly, else the user might drop the task. However, indigent feedback could be worse than no feedback at all. Feedback should be given correctly, without incompatibility or excessiveness. Additionally, warning signs should carry information about the action or event itself. Yet, they should not cause disturbing distractions (Norman, 2013). On this topic, Shneiderman and Plaisant (2004) bring up *direct manipulation,* where the representation is continuously illustrated and instantly manipulated through a user's action. In this way, the user can obtain instant feedback.

Besides the importance of providing the user with feedback, Norman (2013) also points out the value of providing *feedforward*. Feedforward refers to the aid of answering questions about actions by suggesting what the user can do at a given stage. Both feedback and feedforward need to match the user's intent, goals and align with their *conceptual model* of the system.

3.2.5 The Concept of Conceptual Models

Conceptual Models are useful means to express the ways in which something works in a highly simplified manner. In design, conceptualizations may serve as instructive signs that make things easier to use. They can provide indications that guide the user and enable predictions. Devices can rely on several conceptual models which often are deduced from the artifact itself. A narrower application of conceptual models is discussed by Sullivan (2003), who mentions that conceptualizations can be used to classify the content of a portal. Favourable conceptualizations are thus the ones that map to the user's model of the system as well as its procedures.

However, there are risks associated with falsely derived conceptualizations. As an important reminder to the designer, Sullivan (2003) states that “our primary focus must be on the way users think about their domain, not what third-party experts have decreed and not on the output of automatic categorization algorithms”. Furthermore, Norman (2013) problematizes a blindfolded reliance on conceptualizations in design and says that “simplified models are valuable only as long as the assumptions that support them hold true” (ibid, p.26). Norman (2013) notifies that humans draw assumptions and come up with explanations regardless if they possess the sufficient knowledge or not. These assumptions and explanations can be based on theories or knowledge of the devices function, which might be wrong and generalized incorrectly. Thus, to reduce the risk of constructing incorrect explanatory conceptions, information needs to be provided while the user works on the device. If the user creates an incorrect conceptual model and consequently things do not work, humans are prone to self-blame. This might occur due to that the whole process that fails undergoes a conspiracy of silence where others might experience the same problems and make the same mistakes but the mutual issues are never revealed. Still and all, the device does not provide with the sufficient information to establish a correct conceptual model (Norman, 2013).

Norman (2013) denotes the common term for wrong actions *errors*, and proposes that errors can only be diminished if their existence is admitted and knowledge about them is assembled. Meanwhile, the society commonly puts the blame on “human error” by referring to manuals, training or existing information. Although, errors can occur due to poor system design and because there is a *system error* where communication is lost. Instead of putting the blame on the user, Norman (2013) emphasizes that the technology roots the problem. If errors were to happen, they need to be studied in order to find their underlying cause, so that the device can be redesigned accordingly. Norman (2013) means that devices need to be designed according to this thinking, thus not putting blame on users and take difficulties as areas of improvement. Most commonly, errors occur when individuals are forced to act in unnatural ways. Interruptions, unsupportive designs and systems that assume full awareness and undivided attention are also prevailing erroneous explanations to errors (Norman, 2013; Shneiderman & Plaisant, 2004). Originally, *modal dialogs* have been used to alert the user of a potential error. As Fessenden (2017) clarifies “a modal dialog is a dialog that appears on top of the main content and moves the system into a special mode requiring user interaction”. So, when the user has interacted with the modal dialog they can return to the main view. Norman (2013) suggests something similar arguing for that error messages are replaced with help and guidance that enable the user to instantly correct difficulties. When designing, the designer should emphasize positive thinking by assuming that users are on the right track. However, there are some advantages and disadvantages with using modal dialogues. When used inappropriately, they can interrupt the user’s workflow, causing the user to forget information concerning their ongoing task. On the contrary, they can be used in user-initiated processes that attract a user’s attention and direct their awareness to relevant information. Thus, they can streamline the fulfilment of the present task (Fessenden, 2017).

3.2.6 The Concept of Constraints

According to Ehn (1988), design is the interaction between understanding and creation. Emphasizing the use of computer artifacts, Ehn (1988) claims that when designing these, we design the artifacts themselves as well as the *conditions* for using them. Artifacts can support communicative and instrumental activities, externalize human activities, mediate activities towards other humans or objects, and replace human activities. Thus, the user's activity is both *augmented* and *limited* by the artifact (Ehn, 1988). Norman (2013) expounds that *constraints* provide powerful indications of the possible actions that the systems hold. Thus, constraints can guide the user by limiting the set of feasible actions or distinguish the desired ones. According to Sullivan (2003), these underlying structures must be addressed when designing since they tend to go by unnoticed when functioning well but are revealed in their absence. Constraints in physical, semantic, cultural and logical actions are all important aspects a designer needs to be aware of as well as make use of. *Logical constraints* refer to the logical relationship between layout of various functional components and their inflicted outcome or initiation (Norman, 2013). As an example, Sullivan (2003) brings up underlying architectural structures. Structures such as access control and authentication entail constraints that might prevent the user from making errors (Sullivan, 2003). With *cultural constraints,* Norman (2013) argues that "each culture has a set of allowable actions for social situations" (ibid, p.128). The mind holds knowledge structures with rules for various situations, and those structures have behavioural implications. Additionally, each culture has their specific convention, which itself is shaped by the cultural constraints. These conventions could decide activities to be pursued, dissuaded or restricted actions. At the level of the individual, Schön (1995) proposes that various individuals bring *constants* into their work practice. These include e.g. languages and repertoires that the individual uses to describe reality, the considerate systems that the individual brings to the problem setting, general theories by which the individual comprehends the phenomena, and their role frames in which they operate. Likewise, Schön (1995) proclaims the existence of *framing problems,* meaning that the attention to a phenomenon is bounded. The frames bear a resemblance of what Norman (2013) denotes as *semantic* constraints, which Schön (1995) states determine what strategies the practitioner will adapt and thus "the values that will shape their practice" (ibid, p. 309). Alas, as a new way of doing things is presented, individuals will invariably protest. Hence, most new learning is enforced. Consistency is therefore recommended when the proposed new approach is just marginally better compared to the current strategy (Norman, 2013).

3.3 Supporting the Access to Vital Knowledge through Design

The interpretation of design made by Norman (2013) and Ehn (1988), who both stress the importance of designing systems and artifacts in respect to their intended use, directly suggests that the design should support work activities in various ways. In turn, work activities relate to competence and knowledge. This implies that when designing user interfaces that ought to be used in work practice, they should support associated perceptual processing (Vicente & Rasmussen, 1992). Notably, designers can place a lot of knowledge in the world and enable good performance even in absence of previous knowledge. Norman (2013) states that “knowledge in the head is knowledge in the human memory system” (ibid, p. 144) and thus suggests that required information should be placed in the world so it does not overload the memory system. Importantly, the users should not have to remember the information from one-page view that is needed on another since interruptions can cause the user to drop the information. Information can also get lost with delays. Delays may cause frustration and consequently, the quality of service can be perceived as low by the user and they might drop out (Shneiderman & Plaisant, 2004).

Auspiciously, modern technology has designed systems in order to reduce the need of storing information in the head by facilitating their retrieval and connection. As Norman (2013) puts it “our technology does it for us: phone numbers, addresses and postal codes, Internet and e-mail addresses are all retrievable automatically, so we no longer have to learn them” (ibid, p.87). However, security codes are still a struggle since they have to be kept a secret and be hard to remember. Thus, Norman (2013) states that people “use simple passwords” which are easy to remember and could be used with ease. Often a user has a small set of passwords which they alternate between. Several of the security requirements are overly complex and redundant. Some of the information needs to be kept secret but according to Norman (2013) “the problem, however, is the lack of proper understanding of human abilities”. Likewise, Vicente and Rasmussen (1992) discuss the issue regarding where things-to-be-remembered ought to be placed. They proclaim that design should not “force cognitive control to a higher level than the demands of the task require, while at the same time providing the appropriate support” (ibid, p. 598). Nevertheless, for the external knowledge to be a valuable tool it must be accessed timely or the memory will be used.

Moreover, Norman (2013) implies that by creating simpler models where only the sufficient knowledge needs to be accessible in order to conduct a task, successful application could be found. He also states that” knowledge in the world is usually easy to come by. Signifiers, physical constraints, and natural mappings are all perceivable cues that act as knowledge in the world” (ibid, p.79). So, by combining external and internal knowledge as well as the constraints, the need of acquiring new knowledge and burden the memory is reduced. As a way to place knowledge in the world, Tufte (1990) stresses the use of colours as means to utilize the human skill to distinguish colour nuances and thus, being able to encode the information that the colours serve. In this matter, Shneiderman and Plaisant (2004) state that “colour speeds recognition for many tasks” (ibid, p. 511) and furthermore stress that it should relate to the user’s tasks and appear in an automated fashion. There are four principles for how colours can serve information. Firstly, strong colours that are pure and intense can have negative effects when they are combined and overused (Tufte,1990). Therefore, monochromatic forms should be applied, and colours used judiciously (Shneiderman & Plaisant, 2004).

Reversely, using colours sparsely can bring about outstanding effects. On this note, Tufte (1990) recommends that “a palette of nature's colours helps suppress production of garish and content-empty colourjunk” (ibid, p. 89). Secondly, closely fusing colours that are bright and light with white text creates undesirable results. Thirdly, smaller areas ought to catch the eye and the larger background work more silently with muted colours. Furthermore, Tufte (1990) clarifies that “colour can improve the information resolution of a computer screen” (ibid, p.89) and that it may function as a distinguisher of information as well as a provider of information. The principal value of colours in information design is that they can be used as a noun, quantifier and for representation. In this manner, colours can be applied on icons to provide more detailed information. For instance, shadows or thickness can work as quantifiers, colours provide an indication of age, animation can illustrate progress and variations can inform status changes (Shneiderman & Plaisant, 2004).

As just revealed by Tufte (2003), colours can distinguish and provide information as well as place knowledge in the world. What kind of information to place in the world, is something which Norman (2013) discusses and states that “if the event is not personally important and several days away, it is wise to transfer some of the burden to the world: notes, calendar reminders, special cell phone or computer reminding services” (ibid, p.108). In order to reduce memory lapses and consequently avoid errors, tools such as a checklist could be used. Checklists have been proven to enhance the accuracy of performance. Also, Ehn (1988) adds that various forms of descriptions, models and prototypes may serve as *reminders* for reflection on existing and future use as well.

The learning process encompasses the accumulation of knowledge over time and require conscious attention. When the initial learning has passed, it is followed by a long period of practice and study. As time passes, the performance is eventually conducted effortlessly, in an automated manner. This is what Norman (2013) denotes as *procedural memory.* Furthermore, by experiencing many variations of a limited number of cases, an individual gathers a *repertoire* of expertise, techniques and images that are useful. Through their practice, the individual learns what to keep an eye on and how to react in related situations. Thus, Schön (1995) proposes that an individual makes sense of a unique situation by reflecting it in something from their inner repertoire. Thus, the new problem is seen as a version of an old one, allowing for both similar as well as different problem-solving to occur.

Related to the procedural memory is the phenomenon of *tacit knowing.* The phenomenon of tacit knowledge is coined by Polanyi (2009), who states that “we know more than we can tell” (ibid, p.4). Polanyi (2009) proposes that tacit knowing is an act of comprehending by execution. Polanyi (1958) points out several characteristics of this tacit knowledge, the first being that it is *personal*. He states that tacit knowledge involves an “active comprehension of things known, an action that requires skill” (ibid, para. 3). Personal knowledge is thus seen as a form of practical knowledge coupled to skill, and professionals depend on this tacit knowledge in their workaday life (Schön, 1995). This interpretation of tacit knowledge as personal, entails that the tacit knowledge of professionals is *contextually dependent* because it refers to executing a skill in a certain context. Professional practitioners recognize phenomena that they cannot describe in complete or accurate ways, make everyday judgements on quality without formal criteria, and display skills without knowing the exact rules or procedures. These actions, recognitions and judgements are various forms of practice (Schön, 1995).

4. Methodology

Research in the Human Computer Interaction field, abbreviated as HCI, investigates the human behaviour related to computers or computer related devices (Lazar, Feng & Hochheiser, 2017). But closely intertwined with the HCI field is User Experience Design, which is commonly denoted as UX design. Nonetheless, the human need is at the centre. *User experience* is the aggregated user interactions with a service or product (Gothelf & Seiden, 2016). A part of the UX design is the field of *User-Centered Design,* abbreviated as UCD. The UCD field entails usability and accessibility (Rubin & Chisnell, 2008) and in particular, the *contextual design* process in UCD addresses the complexity of designing a system. Contextual Design purposes to understand how users work, then use these insights to form an optimal design that supports the studied user's in their work. Furthermore, it aims at uncovering individual variations and needs, then integrate these abundances of variations into a unified system. In this way, the system of concern can be used by various users (Beyer & Holtzblatt, 1998).

The proposed method for identifying the design problem and verify the design solution is through conducting interviews and observational studies, aiming at revealing the contextual essences of current system use. To produce the design solution, the proposed methodology is iterative and relies on a circular process of identifying the problem, testing and evaluating, and refining the proposed design solution based on the iterative feedback. This follows the *Test-Driven Design (TDD) model*, which is seen in figure 7. In this way, the final design solution is redesigned iteratively to support the user in their context of use. The initial method how this thesis discovered, defined and decided the outcomes, initial assumptions and hypotheses are brought up in the following section *'5. Data Gathering'*. The methods concerning the designing, the creation of a *prototype* as well as the testing, are brought up in the section '*7. Framework for the Designing Phase'*. Yet again, it should be emphasized that the model is iterative, meaning that stages span across the entire work.

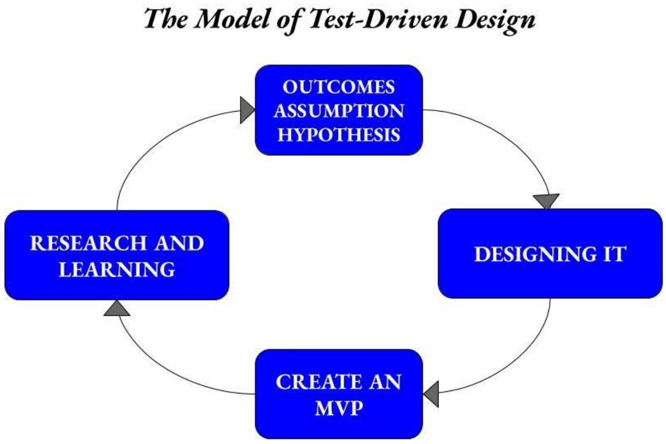

Figure 7: The model of Test-Driven Design which is iterative across the parts (1) generation outcomes, assumptions and hypothesis, (2) initiating a design phase, (3) create an MVP, which instead is called prototype in this thesis, and (4) testing which address research and learning.

4.1 Qualitative Research Methodology

This thesis is based on qualitative research methods. The qualitative research methods focus on inductive theory creation, which means that a theory is generated from a qualitative selection of observations that has created generalizable results. Hence, the aim is to *create* and not test theories. Qualitative research methods stand on interpretivism along with constructivism, and the focal points are words and their interpretation (Bryman & Bell, 2017).

Since the purpose of this report is interpretive, aiming to investigate the need of a portal that connects various principal control systems and related tools among technical facility managers and use these findings to support facility management and operations, qualitative research methods were appropriate. In order to understand the user needs, qualitative interviews and observational studies were used. Interviews and observations were conducted both in person and virtually.

4.1.1 Research Ethics

All research involving user activity is subject to ethical and legal considerations. Courage and Baxter (2005) divide the ethical ones into a triad of considerations and thereby force that the participants, the company and the data ought to be protected throughout the research project.

The ethical considerations concerning the *participant* and the *company* were highly intertwined in this thesis, since all participants were employed at the company who invoked the thesis work. In order to make participants feel comfortable in participating in the study, their privacy was protected in various ways throughout the thesis work. The users were informed about the authors' ethical obligations by an informed consent form, which is found in *Appendix 2*, which described how their data would be handled in the study. The consent form stated that the data was exclusively treated by the researchers and that the participants' names would be anonymized in the final thesis. Hence, all presented and categorized data in the thesis was anonymized by referring to the user as a generalized single one, denoted as 'the user'. The data privacy measures covered all artifacts, statements and information that would reveal the users' identities as they were either abstracted into one representative user or excluded in the results.

4.1.2 Data Quality

To ensure data quality, the conducted research embraced several important quality aspects. First is *credibility*, which corresponds to validity and includes the reassurance that the conducted research goes in line with existing rules. In order to gain credibility, the results should be reported to the research participants so that they can confirm the scientist's interpretation of the reality. This is called *respondent validity*. In this thesis, after analysing the interviews that constructed the requirements, the requirements were validated with the users. Not only that, the findings were presented and validated by a new set of users.

The second quality aspect is *transferability*, which is comparable to external validity. It addresses whether the results align in other contexts or situations, or in the same context but at another time. Qualitative researchers should produce *thick descriptions*. These are detailed reports of a culture. A thick description can provide something that resembles of a database where others can verify how transferable the results are to another environment (Bryman & Bell, 2017). The consolidated work models in '*Appendix 1'* can be seen as a part of the thick descriptions. They illustrated the context that this work was embedded in.

The third quality aspect is the *dependability* aspect, which corresponds to reliability. It ensures that a complete and available record of all the phases within the scientific process are presented. From formulation of scientific research questions, selection of participants, field notes, interview material, decisions regarding the data analysis and so forth. Scientific fellows can just like auditors review the material and determine the quality (Bryman & Bell, 2017). In this thesis, the data assembled from interviews was thoroughly presented along with the consolidated work models.

The final quality aspect is the *conformability* aspect, which is related to objectivity. This implies that the researcher understands that there is no objectivity in social science research, and thus try to ensure that he or she acts in good faith. With other words, it should be obvious that the researcher has not allowed their personal judgements or theoretical orientation to affect the execution of and conclusion from an investigation (Bryman & Bell, 2017). Followed from this, considering biases becomes extensively important in UX design. Since UX design is all about the user and their needs and experience, there are several possible biases to be aware of in user data as well as in the researcher role.

Firstly, there is the *false-consensus effect*, which is a self-centred bias that implies that individuals assume that others will think and act the same as them if they were put in the same context. In reality, this does not hold true. To deal with this bias, this thesis work relied on continuously including the user in the design process and conduct frequent testing during the design phase to verify identified assumptions. The authors worked according to the “you are not the user”-mantra (Budiu, 2017) which emphasizes that the user’s needs should be at the centre of the design.

Secondly, there is the *availability bias*, which is a cognitive bias. This refers to that individuals adopt and apply what quickly comes to mind and thus consider those thoughts and ideas as more representative. To avoid that the availability bias would narrow down the users’ responses during the interviews, issues of interest were confronted with questions from different point of views and observation of the factual case. However, the availability bias was also applicable on general tendencies to stick to those design ideas that came first to mind. To handle this bias, the researchers designed iteratively with feedback from the thesis reviewer.

Thirdly, there is the *bandwagon bias* which addresses the impact that group thinking has on objectivity (Warren, 2017). The authors tried to tackle this bias by making a clear statement at the beginning of each interview and observation session about the comprehensive purpose of the thesis work. The user was reminded of this if they seemed insecure and hesitated about something throughout the sessions.

Fourthly, *anchoring bias* which can also be termed *focalism*, means that the initial single piece of information becomes an “anchor” and too much weight is focused on it in the decision making. This judgment heuristic works in an automatic fashion (Fessenden, 2018). To deal with this matter, several preventive measures were taken by the authors. The authors worked iteratively with continuously acquiring new knowledge and data, as well as sequentially reassessing the accumulated information and design choices. As for the users, they might be biased to their previously known systems. This emphasized the importance of asking questions that uncover the underlying needs of the users and not only evaluate the current system.

5. Data Gathering

The research design of this thesis originates from the proposed HCD standard for interactive systems (ISO 9241-210:2019). The ISO 9241-210:2019 proposes that the following activities should take place in the HCD process:

1) comprehension and specification of the context of the intended user
2) specification of the user requirements
3) production of a design solution
4) evaluation of the proposed design solution

According to this standard, the HCD process is based on some general principles. These principles state that *the design should be based on the understanding of users, tasks and environments*, and that *the users should participate throughout the design and development*. The *design should capture the whole user experience* and be *driven and iteratively refined by user-centred evaluations*. Finally, *the addressed design team should possess a wide range of skills and perspectives* (ISO 9241-210:2019). The following sections describe the ways in which these principles were operationalized throughout the thesis.

To start with, this thesis has two more distinct phases. Initially, the focus is set on the segment where the problem is discovered and defined where the initial *outcomes*, *assumptions* and *hypothesis* are established. This initial step in the TDD can be seen in figure 7. The initiation of a design starts with a hypothesis statement which is seen as a strategic vision and an assumption. In this thesis work, the initial hypothesis was that the technical facility managers needed a tool, such as a portal, that connects various principal control systems and related tools. However, as suggested in the ISO 9241-210:2019, an HCD-project begins with defining and understanding the user whose problem the design aims to solve.

5.1 Comprehension and Specification of the Context of the Intended User

The first activity that is proclaimed by ISO 9241-210:2019 is to comprehend and specify the context of the intended user. This activity should involve a description of the context of use, which e.g. involves the various stakeholders and users, what characterizes them and what their goals are. Furthermore, the description should involve the environment of the system. The ways in which these descriptions were composed are described below.

The University of California in Berkeley (Eriksson & Wiedersheim-Paul, 2014) suggests a gradual strategy in the search for data. At first, the subject should be *analysed* in order to find where to start. This involves finding the typical key terms and synonyms that can be used in the search for already conducted research within the field. One should apply abbreviations, synonyms and various spellings, and use multiple combinations of words or exclusion of key terms when doing this. Secondary sources, which are information that has already been collected, can be used both in the phase of planning as well as in the search for empirical data (Eriksson & Wiedersheim-Paul, 2014). By reviewing existing research, one may find areas for further studies and build upon previous findings, as well as strengthen the reliability of one's research. Furthermore, relevant concepts, ideas and theories can be analysed as well as the previous methods and scientific strategies that have been used. A literature study is a way to create an initial scope of the theme where a deeper understanding is sought (Bryman & Bell, 2017).

5.1.1 Gaining Initial Insights through Secondary Sources

Hence, the very first step in conducting this thesis was to gain knowledge about the area of concern and what was defined as the user's *work domain* (Hartson & Pyla, 2012) or *context of use*. A first attempt to approach this was through acquiring insights in the research field in order to investigate how the user can be studied. To gain this understanding, various related key terms were used; *human-computer interaction*, *human interaction design*, *user experience design*, etc. This helped to uncover proper data gathering methods. The groundwork helped to identify the context of work, which is defined by "the characteristics of the users, tasks and organizational, technical and physical environment" (ISO 9241-210:2019).

Since the aim was to propose enhanced design which would incorporate the existing system (ISO 9241-210:2019), a lot of time was invested in browsing the existing system to understand the information flows and components. Thus, systems such as the document management system *Doris*, the automatic control systems and tools found on the intranet *Sofia* were explored. This was considered as crucial due to that the system of concern is a *domain-complex system* (Hartson & Pyla, 2012), meaning that it is a system with a high degree of complexity and technical content. After browsing methods, theories and the existing systems, focus was placed on defining and understanding the user.

5.1.2 Characterizing the Intended User

The success of a systems design is depended on a deep understanding of the user. This emphasizes the importance of identifying any intended user and stakeholder of the designed system (ISO 9241-210:2019). In HCI, interviews serve to create a more profound understanding of needs, practices, preferences, concerns and attitudes of the users who interact with the computer system. Interviews can be used in several stages of a project, ranging from the initial exploration of understanding users' goals and needs, to the evaluation phases. In the very beginning of a project, interviews can be helpful to gather user requirements (Lazar, Feng & Hochheiser, 2017). Thus, the first couple of interviews in this thesis work served to gain information addressing how the system should be designed (Portigal, 2013) and to gain comprehension of the intended user and the user context, as well as initiating the *specification of user requirements*.

The intended user and their role were pre-defined by the thesis assignment. Here, the primary users were *technical facility managers* at Vasakronan. This user group was identified in alliance with the supervisor of the thesis, who argued that technical facility managers ought to be the most prominent to acquire the competence and authority to access and modify the automatic control systems. For the first couple of interviews, the supervisor assisted with contact details to some intended users that were positioned in Stockholm. The remaining interviews were arranged by the authors.

Despite that the primary users had varying levels of work experience and technical curiosity, they shared some common characteristics and traits. The primary user was recognized as a problem solver with a large interest in and understanding of the mechanical aspects of facilities. Many of them had worked as technicians before they were employed as technical facility managers. Furthermore, they had operated in many different buildings and accumulated knowledge about energy and facility management from work experience. These characteristics were outlined in mutual discussion with the supervisor and functioned to ensure that the full scope of needs among primary users were covered when specifying the user requirements. Moreover, the supervisor suggested that technical facility managers from other offices in Sweden ought to be included as they too were intended users. In addition to the primary users, the *secondary users* and *off-stage actors* were identified as well. Secondary users were other employees who had access to the automatic control system, but lacked monitoring or controlling authority. In some cases, external parties were potential secondary users as well. The off-stage actors could be employees from other divisions at Vasakronan who supervised the system architecture but did not use it in their work. In total, 8 primary users, 1 secondary user and 2 off-stage actors were interviewed. These worked in Stockholm, Uppsala. Gothenburg and Malmö. There were both female and male interviewees. The sample of interviewees reflected the demographic profile of the primary users, meaning that male participants were overrepresented. This was due to that there are more male than female technical facility managers at Vasakronan.

5.1.3 Gaining Further Insights through UX Workshop

At the very beginning of the data gathering activities, the authors participated in two and a half days of workshop with a focus on UX design. Some noteworthy methodological insights were acquired through the workshop. These insights helped setting the tone for the method design and how to operationalize the activities presented in ISO 9241-210:2019. The workshop was arranged by an IT, management and UX design company called Zington. The supervisor also participated in the workshop. Among other things, the workshop identified that the project in which this thesis makes a part of, takes a stand in three cornerstones: the *business value*, the *user value* and *technical feasibility*. Noteworthy, this thesis exclusively focuses on *one* of the three aspects, namely the user value. The overall purpose of the workshop was to gain knowledge in UX methodology and receive exclusive advice from an expert within the field. Foremost, the workshop helped to realize that the many methods in HCD share a universal theme that entails an iteration through four distinct phases: *observation*, *generation*, *prototyping*, and *testing*.

5.1.4 Understanding the Goals, Tasks and Context of the Intended User

As stated by many (Lazar, Feng & Hochheiser, 2017; Courage & Baxter, 2005; Hartson & Pyla, 2012), gaining input from users is a crucial part of designing. This is particularly emphasized in order to understand the needs of the user. One of the best ways of doing so is through *contextual inquiry* which implies that the full usage context is considered (Hartson & Pyla, 2012). As the UX workshop had taken place and more knowledge was acquired of the field, the following interviews focused more on user requirements and practical use, and less on general aspects of work practice. Hence, the descendant in-depth interviews also served as demonstrations of how main user tasks were conducted and what tools or systems that were used. In order to gain insight, the full usage context along with the complexity of a user's full scope of work were analysed. This was done by constructing work models which are mentioned in '*The Use of Consolidated Work Models*'. These work models were built on data collected from interviews and observations. They are fully described in *Appendix 1*.

Sometime in to the thesis work, two interviews were also held with an IT project manager and the chief of the IT-division at Vasakronan. These interviews served to yield an understanding of the underlying purpose of the systems of concern and how Vasakronan manages and implements IT projects today. Furthermore, the interviews with the off-stage actors helped reveal the company's vision for system development and integration. These interviews contributed to the thesis work by disclosing potential issues for implementation of the design, thus improving the long-term survival of the proposed design solution. As an example, the interviews revealed that the intended users were not usually involved when developing new tools. These insights unveiled the importance of involving the intended user in this thesis work. Moreover, it spoke to the importance of creating a user customized tool *with* the user, as opposed to current systems and tools.

5.1.5 Interviews

As stated, receiving direct feedback from the users is fundamental within the HCI field. There are several methods for receiving this feedback. In this thesis, users were actively involved in both specifying the requirements and in the progression of the proposed design. In order to receive feedback, this thesis relied on interviews but also usability test which will be further mentioned in section *'7. Framework for the Designing Phase*'.

Commonly applied methods for receiving feedback from single users are through conducting interviews and surveys. Surveys are broad but not deep. On the contrary, interviews are deep but not broad. Trying to understand the goals, tasks and needs of users through surveys is more restricting since the users have limited response options. When gathering data from an interview, the researchers can get insights, yield comprehensive answers and helpful data which would have been lost in a survey (Lazar, Feng & Hochheiser, 2017). Since this thesis aims at investigating the need and propose a design that fits that need, its success lies in the deep understanding of the user's goals, needs and undertakings. The primary source of data was therefore interviews and observations. Also, since proposed design should attract a limited scope of users at Vasakronan, the data gathering method does not have to be broad.

An essential aspect of preparing for the semi-structured interview is to make an interview guide. It includes a list of questions that are related to the objectives and ensures that the interview structure is somewhat followed (Eriksson & Wiedersheim-Paul, 2014). Hence, an interview guide was outlined in advance of the first interviews. It included several practices, such as an introduction to the purpose, warm-up questions, a basic script of interview questions, some wrap-up questions and finally some concluding remarks and questions regarding forthcoming communication (Wilson, 2014). The initial interview guide is found in *Appendix 4.*

Broadly speaking, there are three categories of interviews; *structured, semi structured* and *unstructured*. In this thesis, semi-structured interviews were found as the most yielding interviewing approach. This choice of method followed directly from the inductive aim of this thesis, whereby semi-structured interviews allow user needs to be discovered and not only confirmed. By offering a sufficient level of flexibility, semi-structured interviews allow users to educate the interviewer about needs and functionality. This is opposed to *structured interviews* which ought to follow a fixed predefined script in a prescribed order. Instead, semi-structured interviews allow the interviewer to ask for clarifications and follow-up questions, while still providing enough structure to keep the interview relevant for the studied research area. This is a risk associated with unstructured interviews, where the interviewee is free to take the interview in their desired direction (Lazar, Feng & Hochheiser, 2017).

The level of flexibility offered by semi-structured interviews was especially valuable in this thesis work due to that the industry and system architecture were unfamiliar to the authors. The aforementioned interview guide was constructed prior the interviews and allowed for flexibility during the interview session (Portigal, 2013). In this fashion, the set of questions were generally followed, but aberrations occurred when the interviewers noticed and captured interesting information in real time. So, if components or the user's usage of the system were unclear to the authors, these could be further specified. However, as more knowledge about the intended user was gained, the interviews got more unstructured and looked further into some aspects to gain deeper insights. In the course of time, it appeared that some tools and systems were more frequently mentioned among users than others and this entailed that more focus was put on these systems as they indicated they were used in a generic work structure. These are found in figure 4 in '*2.3 Description of Common Existing Tools at Vasakronan*'.

Eriksson and Wiedersheim-Paul (2014) have outlined some bad manners and destructive approaches when conducting interviews. Those involve posing questions with a yes/no answer, since the respondent should be encouraged to speak. The interviewer should avoid asking several questions at once, since it makes it more difficult to understand what question the interviewee answered as well as for the interviewee to know which question to answer. Furthermore, the interviewer should try not to place values in questions since it might make the respondent more defensive. Overall, the interviewer should avoid posing questions that are overcomplicated, guided or exaggerated.

As for the interview sessions, the first 6 were arranged at Vasakronan's headquarters and regional offices in Stockholm. A conference room was booked for each interview. The original idea was to conduct all interviews face-to-face, but plans had to be rearranged due to the outbreak of the Corona virus. A total of 6 interviews were conducted before strict guidelines strongly dissuaded from physical meetings in the Stockholm area (Krisinformation, 2020). The remaining 5 scheduled interviews were therefore conducted as audio interviews. Prior all interviews, the prompted users were sent an email that introduced the authors, explained the purpose of the interview and proposed a time spot for the interview. The users were also provided with a form that asked for their permission to record it. In the beginning of the interview, the users were asked verbally for an allowance to record. So, the authors emphasized the user's confidentiality and pointed out that they acted as an external party. During the interview, one of the authors asked questions while the other one took notes. The one taking notes occasionally added questions for clarification. Towards the end of the in-person interviews, the user was asked about conducting a technology tour as well as participating in a field study. Audio interviewed users were asked to participate in a remote technology tour. In all, 1 technology tour was conducted in person, while the remaining 3 were arranged remotely. The ways in which these observational studies took place are presented in the *'5.1.6 Observations'* section.

Much work in conducting interviews regards building rapport and a comfortable interview environment. Video conference interviews share many characteristics with interviews conducted in-person, and most importantly they both manage to uncover both verbal and nonverbal cues (Hooley, Marriott & Wellens, 2012). In this sense, video conferences are preferable to phone interviews which only cover the verbal cues. As of the virtual interviews, video conferences turned out to be too heavy for the server and caused frequent interruptions. Audio interviews were therefore chosen to ensure audio quality, not causing irritation and reduce the risk of participants dropping out of the session (O'Connor & Madge, 2017). Though, in some interviews the user was asked to illustrate parts of their systems by sharing their screen. The software used for interviews was Microsoft Teams which allowed the video to be switched on and off. This was convenient due to that it was used internally within Vasakronan for video and audio conferences, and used daily due to the circumstances with the Corona virus. Thus, this implied that the proposed users were familiar with the context and would possess the technical skills required to participate. This is otherwise a common issue when selecting a proper tool for online interviews (Hooley, Marriott & Wellens, 2012).

Generally, the 5 audio interviews were conducted by following the same procedure as with the 6 interviews held in-person. However, there are some significant benefits and difficulties associated with the audio interview format that needed to be considered. On the one hand, it enables data gathering over longer distances, thus widening the possible range of data gathering (O'Connor & Madge, 2017). In this study, this actually facilitated the involvement of technical facility managers from other regional offices outside the Stockholm and Uppsala region. Some of the interviewed users were localized in Gothenburg and Malmö, thus a digital contact was less time-consuming. Also, the users were comfortable in their setting and could make time in between work-related tasks. On the other hand, conducting interviews on distance could make it more difficult to build rapport, especially with reserved users. To deal with this potential issue, an extra effort was put on the warm-up questions posed at the beginning of the interview. Audio interviews are also associated with some anonymity, due to the lack of facial contact. Again, this may enhance the need for building rapport but it may also benefit the interview by reducing the interviewer’s bias (O’Connor & Madge, 2017). It was difficult to compensate for the lack of nonverbal cues associated with other interviewing methods, but conducting audio interviews was considered as a necessary trade-off to gather sufficient data material for the remaining parts of the thesis.

However, conducting semi-structured interviews suffers from both being time-consuming (Lazar, Feng & Hochheiser, 2017) and generating unique sample points (Portigal, 2013). Further challenges lie in analysing compelled data because it consists of all pieces of information that have been captured from the interview (Lazar, Feng & Hochheiser, 2017), including the user artifacts. To decide on what is useful information coupled to these artifacts, several authors (Lazar, Feng & Hochheiser, 2017; Portigal, 2013; Hartson & Pyla, 2012) propose using a combination of interviews and observations. Thus, both of these methods were used in this thesis in combination with storing all data so that it could be accessed and analysed invariably.

5.1.6 Observations

When assimilating the data, several researchers (Lazar, Feng & Hochheiser, 2017; Hartson & Pyla, 2012) point out that simply *asking* users about their needs will not cover all aspects of their interaction with the system. In their practice, users are biased about their own assumptions about the system and hence provide inadequate verbal descriptions of their interactions. Descriptive investigations, such as observations, aim at constructing an accurate description of what is happening and yields richer insights since the participants should *show* how they use the technology (Lazar, Feng & Hochheiser, 2017). Connections among situations, information and events are more easily understood through observations (Eriksson & Wiedersheim-Paul, 2014). This aspect was found crucial in this thesis in order to fully realize the functioning and malfunctioning aspects of using the system. Therefore, observational data gathering in this thesis relies on field observations, as well as in-person and remote technology tours of current system use.

Nevertheless, Lazar, Feng and Hochheiser (2017) stress that field observations are an important part of user understanding. Alas, only 1 out of the 3 scheduled field observations and 1 of the 3 in-person technology tours could be carried out as planned. This was due to the outbreak of the Corona virus, hence preventing the user from being studied in their natural settings at their workplace. During the observation, the user was encouraged to "think-aloud" and verbalize thoughts (Rubin & Chisnell, 2008; Lazar, Feng & Hochheiser, 2017; Hartson & Pyla, 2012). However, the emphasis of contextual inquiry and the means of artifacts were challenged by that Vasakronan implemented a "clean desk"-policy, meaning that workers should clear their desks at the end of the day. This entailed that some physical artifacts that ought to reveal usage information were reduced. However, their virtual and computer desktops could still be accessed.

This being said, the study called for some flexibility and a more digital data gathering approach. Therefore, remote technology tours were used instead of field observations. All in all, 3 remote technology tours were conducted where the users shared their screens and were asked to show their frequently used tools and facility systems. This included illustrating activities such as logging in to their computers, access automatic control systems and navigate among common digital work practice tools meanwhile stating their thoughts or answering questions. They were also asked to show how they organize documents, work tasks and keep track on their processes.

5.2 Specification of the User Requirements

The second activity that is proposed by ISO 9241-210:2019 is to specify the user requirements. The specification is a process in which the user needs are identified, followed by that the user requirements are assembled and specified. Furthermore, it entails an explicit statement of user requirements which takes stand in the intended context of use as well as the business objectives of the system. The ways in which this was accomplished are described below.

As previously mentioned, the thesis work focuses on user values, and not the business values or objectives. Hence, all work was centred at the user. Due to the complexity and difficulty in describing people's work, contextual design relies on capturing the work of individuals and organizations in *work models* (Beyer & Holtzblatt, 2020). In order to get a holistic image of the user and their requirements, Beyer and Holtzblatt (1998) present five disparate work models that portray user work practice in contextual design. Bringing these five work models together makes up for a *consolidated work model*, which allows for a revelation of common strategies as well as individual differences among the various models (Beyer & Holtzblatt, 2020). Work models can also be consolidated within the same model category to reveal individual differences within the specific work model of concern. By using work models as well as consolidated work models, the whole system of work is analysed and synthesized holistically into a single coherent interpretation (Beyer & Holtzblatt, 1998).

The five models cover all the important design aspects. The first one, the *flow model*, illustrates the systematization and communication that has to be done in order to conduct the work. Secondly, the *sequence model* portrays the specific steps which have to be accomplished to conduct the work intent. Thirdly, the *artifact model* presents the physical entities produced to facilitate the work. Fourthly, the *cultural model* reveals the constraints placed on work by values, policy and/or culture. Lastly, the *physical model* considers the work environment that influences the work (Beyer & Holtzblatt, 1998).

5.3 The Use of Consolidated Work Models

Work models create a coherent concretization of the collected qualitative data about the user which can be discussed, manipulated and used to establish insights (Beyer & Holtzblatt, 1998). The work models were constructed for each and one of the interviewed users as a way of categorizing data yielded from the interviews and observations. The yielded data was first categorized according to user and type of work model. The work models for each of the users were then consolidated to one major model - the *consolidated work model* - which was used when designing. Nevertheless, with regards to the ethical considerations of privacy, the authors decided to only include the consolidated work model and not the individual models in the *'6. Results for User Requirements'* section. This was because some data in the work models were personal. Not only that, to keep the users anonymous, the physical work models were excluded from this report. This was due to the fact that the physical work environment was associated to the individual users respectively, hence the facility names would reveal the users' identities.

During the interviews, not all users mentioned the complete set of communication flows, artifact usage, sequences or cultural influences. This was partly due to individual differences and partly due to memory retrieval and availability bias. Also, since the interviews lasted for about an hour each and were semi-structural, it was difficult to gather equally much information about all aspects from all users. The accumulated data gathered from the interviews entailed that some information that was brought up by one user could be further examined in a later interview with another user. Furthermore, the users sometimes denoted systems incorrectly. Being aware of that a design cannot satisfy all users' needs and that users may have opposing views and experiences, the authors wanted to cover the most crucial aspects of common work practice among users. To design the prototype based on the consolidated work models enabled the prototype to be designed for a *representative user*. At the same time, the consolidated work model helped to uncover how to interpret the information from individual users. The constructed consolidated work model is found in the *'6.1 User Data Categorized into Consolidated Work Models*' section. Since it was constructed from interview data, the adherent descriptions are found in *Appendix* 1. This was to avoid repetition, while still providing thick descriptions of gathered data (Bryman & Bell, 2017).

5.3.1 Artifact Model

In order to pursue their work, users build, apply and modify tangible things that grow into artifacts. These artifacts constitute the *artifact model*. In alliance with previous statements of Lazar, Feng and Hochheiser (2017), artifacts are understood as pieces of information that reveal information about the user's work and the ways in which the work is achieved. Artifacts can provide information regarding the user's thoughts, strategies, assumptions, theories and frameworks. Examples of artifacts are tangible objects under construction such as circuit boards but also forms, to-do lists, notes, spreadsheets and documents (Beyer & Holtzblatt,1998).

The *consolidated artifact model* discloses the collective approach individuals take in structuring work and establishing conceptual patterns. Since the tasks performed by individuals have a common structure, the appliance and intent of artifacts show a resemblance. The consolidated artifact model provides designers with insights to the user's thought process.

The first step in creating the consolidated artifact model is to cluster the artifacts according to the work they support and in what way. When the clustering is done, a primary distinction is created by identifying the parts where artifacts share similarities and the connection among them. Once common parts have been classified, their usage, intent and structure can be outlined. Lastly, the holistic structure is viewed in the search for further intents. The artifacts are studied in a diagram to create a coherent design for similar intents, the various strategies for achieving these, facilitating structures and systematizing concepts (Beyer & Holtzblatt, 1998).

5.3.2 Flow Model

The *flow model* is an overarching view of the organization. The model provides designers with insights about the functional work practice, problematic areas that needs to be addressed, and the holistic system of communication. According to Beyer and Holtzblatt (1998), the flow model should reveal how individuals continuously design their work and create solutions to obstacles that arise. It includes the communicational connection between individuals as well as what is being communicated, and the individual's areas of responsibility. Databases and automated systems are not included in the flow model unless they are a critical part of communication between individuals, and act like a physical area or automated person (Beyer & Holtzblatt, 1998).

The *consolidated flow model* reveals the patterns of communication and identifies how roles correspond to individuals. By applying these roles, it reveals the organization's structure as well as categorizes responsibilities among work roles (Beyer & Holtzblatt, 1998).

Creating the consolidated flow model starts with composing a complete list of roles and their associated responsibilities. In order to uncover overlooked aspects of responsibilities, the interactions among individuals are studied. The coherency of a role is established by stating the vital responsibilities for pursuing its primary intent. The list of responsibilities is then revised based on its primary contribution to the work. Consolidated flow models identify areas where several individuals share a role and show the essentials to the role of concern. For system design, this implies that the design should support the variation which exists in the role. Finally, the communication between individuals and artifacts used for communicative purposes are consolidated (Beyer & Holtzblatt, 1998).

5.3.3 Sequence Model

The *sequence model* reveals the structures of the ways in which work is conducted and presumes that the various procedures that individuals perform follow a sequential order for a reason. Beyer and Holtzblatt (1998) state that "all work, when it unfolds in time, becomes a sequence of actions - steps to achieve an intent" (ibid, p. 97). These strategic intents are revealed by putting together the actions that individuals make with knowledge of what matters to these individuals. Areas of improvement are thus revealed as the strategic intents are uncovered. Consequently, the steps leading up to the intent can be modified, redesigned, improved and discarded (Beyer & Holtzblatt, 1998).

The repeating tasks or patterns are shown in the *consolidated sequence model*. It brings together several instances and thus reveals similar strategies and networks of tasks. The first step is to identify the trigger. Then, the abstract steps across sequences are found and labelled. Consecutive steps are dedicated to analysing and aggregating the issues, and then defining abstract steps for the ones that achieve the same thing. The consolidated sequence model focuses on identifying the important steps in pursuing the work, understanding the given order and the underlying motivating factors (Beyer & Holtzblatt, 1998).

5.3.4 Cultural Model

The *cultural model* shows the aspirations, expectations, values, policies and paths that individuals pursue in their work (Beyer & Holtzblatt, 1998). According to Beyer and Holtzblatt (1998) the *constants* that were brought up by Schön (1995), and who proposes that individuals practice their work according to a fixed set of ideas and perception about their work, are affected by work culture. Work practice is thus to be understood as part of a cultural context. The cultural context is constituted by policies, business landscape, requirements, settings, self-image of users and emotions as well as worries. Notably, culture can inflict the work, create constraints and change the decisions that individuals make (Beyer & Holtzblatt, 1998).

Wide-ranging cultural aspects are illustrated in the *consolidated cultural model*. Repetitive cultural patterns and network of influences can be seen in organizations, among individuals and in work groups. The problems that arise for the individuals conducting the work are grouped. These provide designers with information on potential paths and obstacles (Beyer & Holtzblatt, 1998).

To establish a consolidated cultural model, the individual cultural models are viewed respectively. The individual models are placed in the consolidated model by modifying and applying the connections and influential directions. This is followed by that the influences among the pairs are assembled and the duplicates or too similar ones are removed. This is done iteratively until the emotional tone of the influence is illustrated and communication flow, which was the starting point, is removed (Beyer & Holtzblatt, 1998).

6. Results for User Requirement

In the following section the results from the interviews are presented. The section starts with presenting the consolidated work models, as they provided with background information about the user and their context of work. This is followed by interview data on the work practice and associated needs among users, outlined according to recognized user requirements. A summary of the user requirements, which were used as the main outset for the design solution, ends the section.

6.1 User Data Categorized into Consolidated Work Models

This part places the user data gathered from the interviews and observations into four consolidated work models. The method for composing them is found in the *'5. Data Gathering*' section of this thesis. As of descriptions to the illustrations, the reader is referred to *Appendix 1*.

6.1.1 The Consolidated Artifacts Model

In the consolidated artifact model, presented in '*2.3 Description of Common Existing Tools at Vasakronan*' and seen in figure 8, the tools used by the representative primary user are found. This model was used to recognize what tools to integrate in the proposed design solution in order to facilitate the user's everyday work. As illustrated by lightning bolts in the figure, there were artifacts that required further attention in the new design proposition since their current function was faulty. The lightning bolts pose areas of opportunities for improvements.

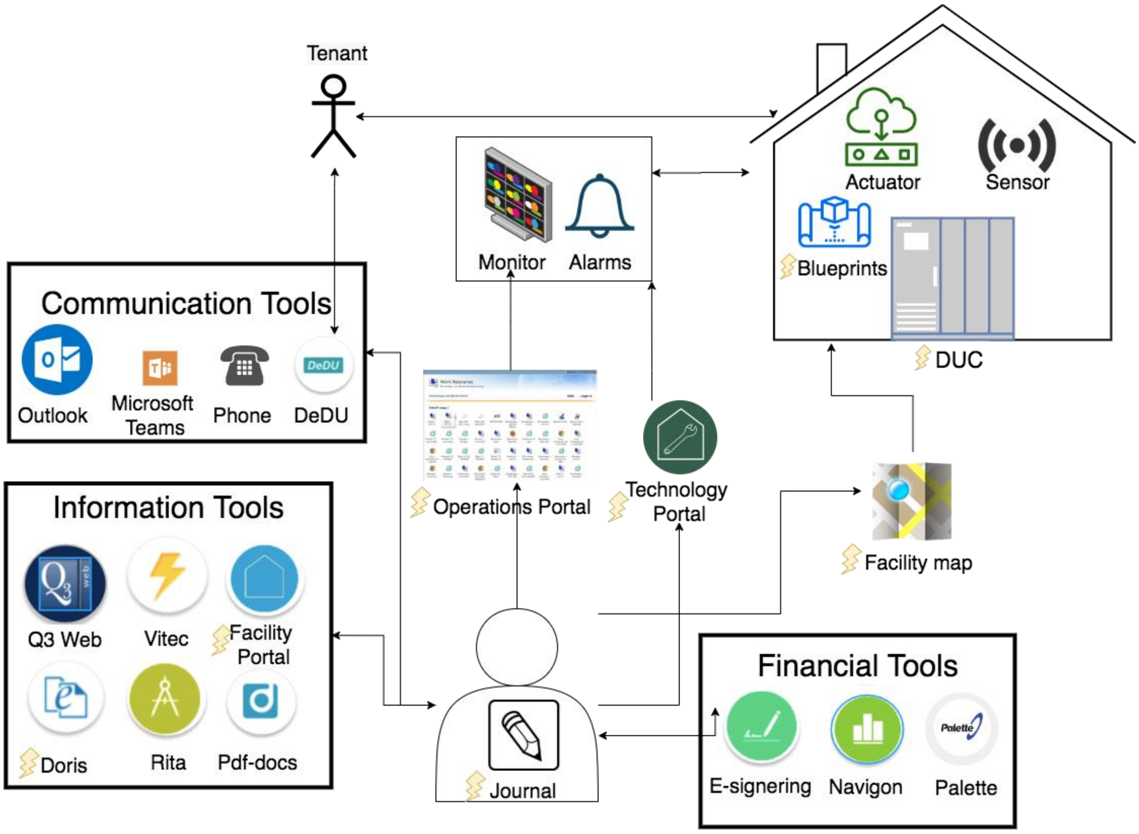

Figure 8: The consolidated artifacts model for the representative primary user, constructed according to instructions by Beyer and Holtzblatt (1998). An artifact is modelled by an illustration of the artifact, combined with information regarding intent, structure as well as strategy. Various parts of the artifact can be accentuated with notes. Similar to the flow and sequence model, a lightning bolt represents problematic aspects where information is lost, or structure does not support the work.

Illustrated in the figure are artifacts were improvements can be made. These artifacts are *Doris*, *Facility Portal*, Facility Maps, *Technology Portal*, *Operations Portal* and blueprints, who all have a lightning bolt in connection to their visual representation.

6.1.2 The Consolidated Flow Model

Illustrated in figure 9 are the ten entities, represented by 'bubbles', who communicate with the representative primary user. The most influential entities are highlighted. This model functioned to outline how work is communicated among users and related parties. In the design, these facilitate the understanding of the underlying points of relationships that needs to be regarded in order to support and enhance the users' communicational pattern. Some entities had a more representative part in the daily work, these are highlighted in figure 9. Areas of improvement are division of labour, reconciliation on service work, sharing knowledge and experience and accessing facility information.

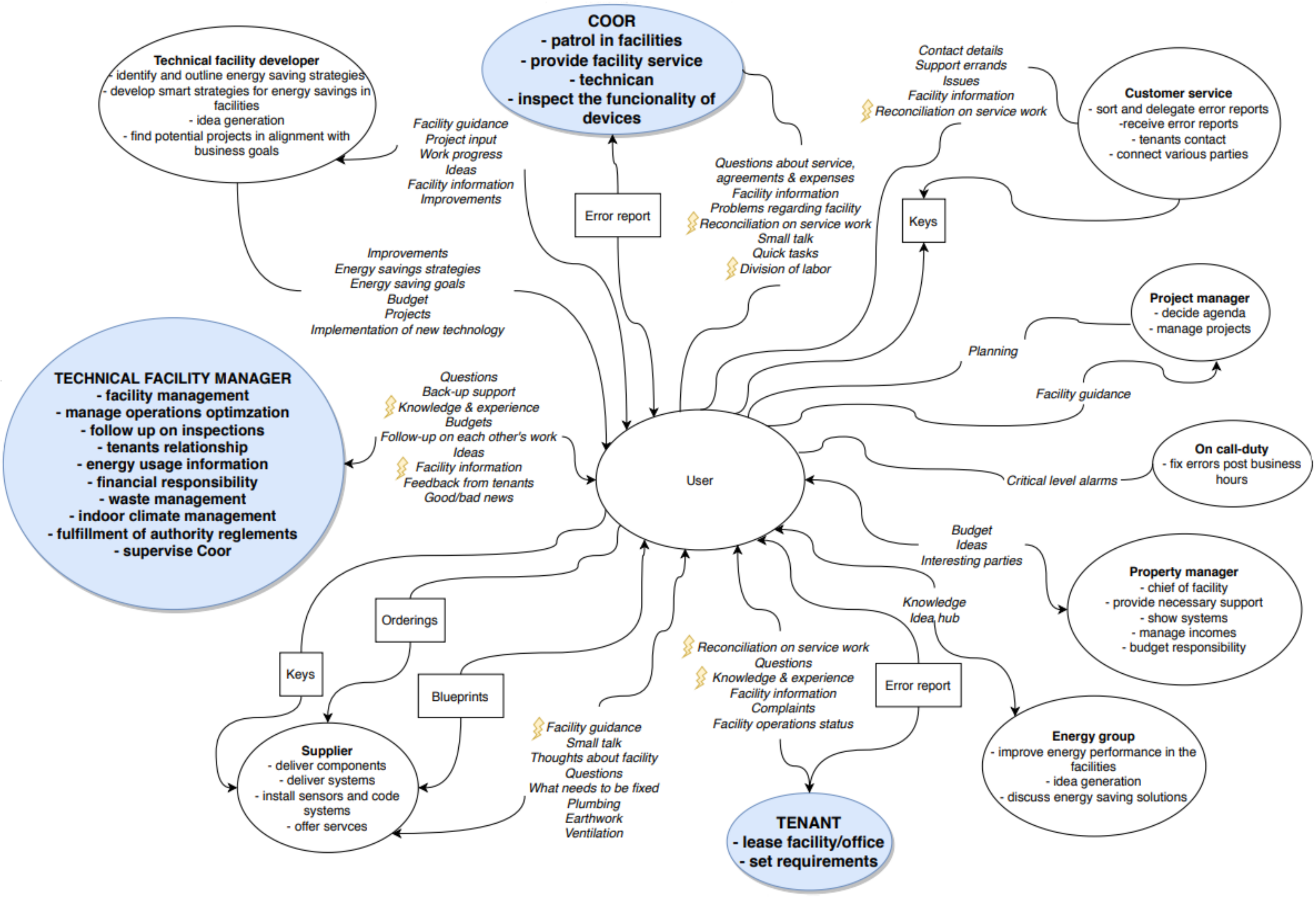

Figure 9: The consolidated flow model of the representative primary user, outlined according to instructions by Beyer and Holtzblatt (1998). Both individuals and organizations are represented by bubbles. The information flows are shown by arrows labelled with what kind of communication is occurring. Communicated entities that are artifacts or responses from automated systems are illustrated by boxes on top of the line, while non-tangible actions and informal communication are presented without the box. Faulty or obstacles in communication is presented by a lightning bolt.

6.1.3 The Consolidated Sequence Models

This model addresses *how* tasks are conducted by outlining their sequences. Five main tasks were recognized, found as *Patrolling* (figure 10), Record keeping (figure 10), *Order Placement* (figure 11), *Error Handling* (figure 11) and *Arrival at work (*figure 10). The sequences were used to recognize what work tasks the design had to support, as well as highlighting what supplementary features that should be included in the design. The areas where the workflow broke down concerned handling meetings, documentation, optimization of facility work and the record keeping.

ARRIVAL AT WORK SEQUENCE

Activity	Intent	Abstract steps
Set up agenda for the day	Efficient time management Cover responsibilities	
Check error reports in inbox from DeDU	Ensure tenants are happy Ensure optimal operation in facility	- Enter Outlook - Open email from automation control system - Screen email - If urgent 'Manage error'
Check error reports in inbox from automation control system	Ensure tenants are happy Ensure optimal operation in facility	- Enter Outlook - Open email from automation control system - Screen email - If urgent 'Manage error'
Manage email	Follow up on processes	- If user decide there are no urgent error messages - View inbox - Decide to handle errands - Reply to errand
Meetings	Customer relationship management Information sharing	- Enter calendar in Outlook - Participate in meeting
Field work Optimization of operations	Ensure optimal operations Fulfill business goals concerning energy saving	- If user is done with meetings and email - Make time in calender - Go to automation control system during that time
Documentation	Keep track of processes Information sharing	- If user is done with field work - Journaling

RECORD KEEPING SEQUENCE

Activity	Intent	Abstract steps
	Reduce memory workload Ensure all work gets done	- Daily planning - Updates to add
Make updates to note	Improve system Ensure good functioning	- Place order

PATROLLING SEQUENCE

Activity	Intent	Abstract steps
Visit the facility	Check physical status Compare system with real values	- Go to DUC - Check alarm list - Observe values - Use senses, sound and sight to inspect system sensors and components
Replace components	Improve system Ensure good functioning	- Place order

Figure 10: The consolidated sequence model, constructed according to work by Beyer and Holtzblatt (1998), for arriving at work, record keeping and patrolling. The sequential model illustrates these steps, what initiates them and the intent that is achieved through them. While stating the steps leading up to the intent, the ones which induce problems are underpinned by a lightning bolt.

Place order on component/service Sequence

Activity	Intent	Abstract steps
		- Someone reports problem - Malfuctioning component
Fill in larger order	Place larger order (> 25 000 SEK)	- Enter Facility portal - Choose supplier - Select ordering form - Fill in information - Fill in complementary information - Save as a PDF - Go to Sofia - Select e-sign software - Fill in form - Attach PDF - Send order to supplier - See invoice in Palette
Fill in smaller order	Place smaller order (< 25 000 SEK)	- Enter DeDU - Select errand - Decide on warranty errand - Select 'place order' - Fill in form - Select supplier - Save and send to supplier - See invoice in Palette
Contact supplier	Less administrational tasks	- Call supplier - Email supplier - Place order - Monitor order

ERROR SEQUENCE

Activity	Intent	Abstract steps
Error diagnosis	Fix problem Ensure proper functioning	- Open error message - Analyze information and error code - Decide error is urgent - User decides they they can fix the problem remotely - Patrolling
Reach out to supplier	Fix problem Ensure proper functioning	- User decides they need external help - Place order on component/service
Head back to office	Pursue with work Optimization of work day Manage meetings and emails	- Mark error as done/seen - Journaling
Meetings	Customer relationship management Information sharing	- Enter calendar in Outlook - Participate in meeting

Figure 11: The consolidated sequence model, also outlined according to instructions by Beyer and Holtzblatt (1998), for placing an order on a component or a service and for managing errors. The sequential model illustrates these steps, what initiates them and the intent that is achieved through them. While stating the steps leading up to the intent, the ones which induce problems are underpinned by a lightning bolt.

6.1.4 The Consolidated Cultural Models

This model demonstrates the cultural context in which work is conducted by the user. The model functioned to outline some of the underlying structures that shape how the user conduct their work and hence the use of tools that are found in the proposed design. Especially, it raised organizational issues that influence the user in their work as well as how the user thinks about their own work. The model can be seen in figure 12.

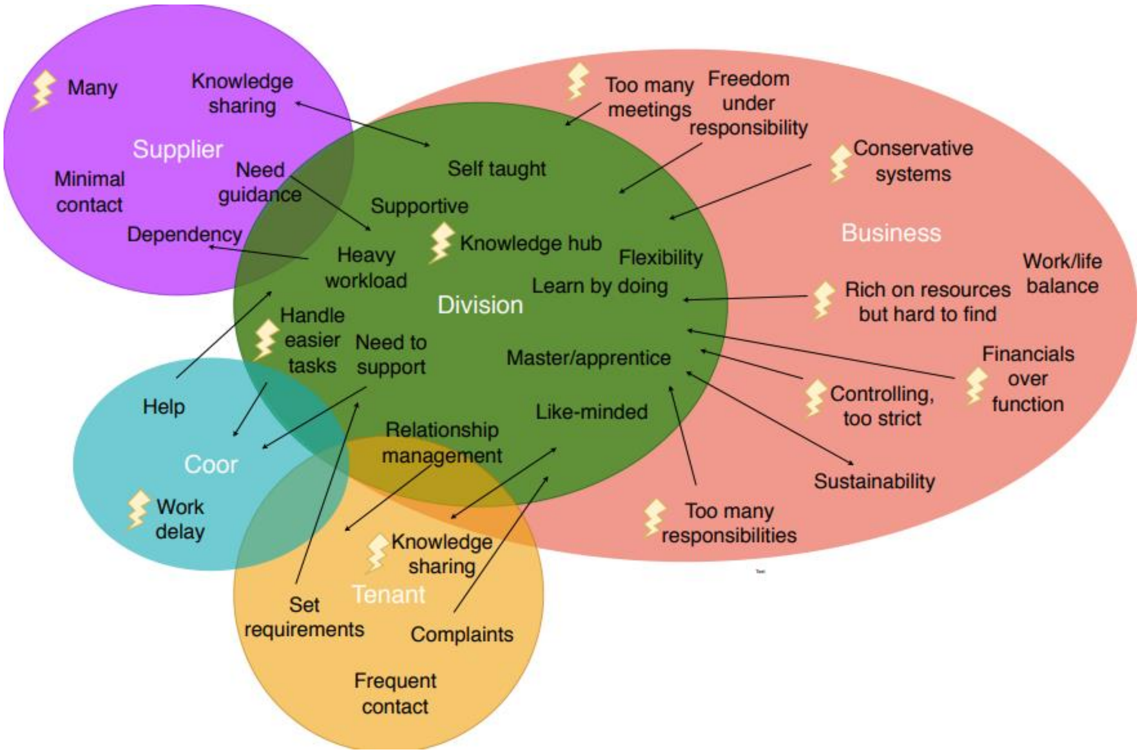

Figure 12: The consolidated cultural model of a representative primary user, designed according to instructions by Beyer and Holtzblatt (1998). Influences which change work are illustrated with bubbles. Influences can either be individuals or groups that are internal or external. The degree of overlapping between the bubbles illustrates how much the work is affected and arrows, which represent influences, show the direction. The arrows can wear a label. Yet again, problems are shown by lightning bolts. The influences are congregated based on their type of cultural influence and the projects focus.

As the consolidated cultural model reveals there were some problematic areas. These included the knowledge sharing and creation, work delays, the number of suppliers, the structure of daily work related to meetings and responsibilities, as well as the focus areas in business culture and accessibility to resources.

6.2 The User Requirements

Altogether, a total of seven requirements were acquired from the interviews. The requirements that were found were *the requirement of a holistic view, the requirement of easy access to automatic control system, the requirement of customization, the requirement of information creation, the requirement of information retrieval, the requirement of statistics and analytics* and *the requirement of structure.* The compiled data is presented according to the identified requirements.

6.2.1 The Requirement of a Holistic View

All of the users accessed most of the technical tools through Vasakronan's intranet Sofia. In *Sofia* there were links to all applications. Through *Sofia, DeDU, Rita, PDF-*

docs, Facility Portal, Teams Portal, Navigon as well as *Palette* could be reached. As concerns *Vitec, Operations Portal* and *Doris,* the Sofia-page only held information about the applications or how to access them. The automatic control systems could be accessed through the *Operations Portal* and *Technology Portal*. These were portal tools which the user accessed daily or weekly. The consolidated model covering the user's artifacts can be seen in figure 8.

There were a set of technical tools, sometimes denoted as *applications*, which were commonly used by the technical facility managers. The IT department had installed some tools on the user’s desktop, while some were placed there by the user. Some tools were used often and some more seldomly. Nevertheless, there was an inflation of tools at Vasakronan. Statements such as “there are several minor tools”, “we have a lot of applications, which are used a lot”, “the risk with new tools is that there can be too many of them” and “we have a great deal of applications” illustrated this. Notably, one user replied that there “can be too much information, too many tools”. The same user then added that many technical resources are good, but sometimes, especially as a newly employed, it was difficult to identify the one that fit one’s intentions. On that note, the user mentioned problems such as that “there are many ways to get the same information/.../ in the beginning this can be confusing”. A similar view was shared by another user, but in more general terms, “you do not know where to find what you are looking for” and thus asked for “efficiency and easier to navigate among the tools”. Contrarily, one of all the users stated that there were tools for all purposes and that “you would not want any less”. However, when faced with the question if there was any tool that was missing, another user specified that they “wanted it more collected, the things regarding automatic control system”. Withal, the automatic control system was considered to be the most vital tool. Yet, one user stressed “there are very few providers of automatic systems who *actually* knows what you do”. They wished for a quick holistic overview of the facility.

However, among all of the various automatic control systems, the users mentioned that” you want *one*” and not several systems. As one user stated, they had the “luxury” of only operating in one system. Today, the systems among facilities had various interfaces and manufacturers. A user could manage about three separate systems and act as back-up support to more. Though, understanding various automatic control systems was not a problem according to most users. Albeit, a few mentioned that they had to build up knowledge regarding the system. When asked whether the displayed system reflected the reality, a user answered that values usually align with some distortions among the sensors. The user recognized and compensated for these deviations. However, the same user drew a parallel between the automatic control systems and cars, and argued that if you can drive one, you can drive most of them.

In terms of communication tools, one of the users stated that they used the *Outlook, DeDU, Microsoft Teams, Team Portal* and that it could become “messy” due to the excessive amount of communication tools and channels. Since various channels were used, the user found it problematic that people work in different ones as not knowing where or how to connect. Hence, they would prefer if they all worked within the same. Today, *Outlook* was the closest to a common communication channel and *Teams* was one of the newest tools for group conversations. In the opinion of one user, the *Team Portal* was used once a week for their team but also added that for others, that frequency could probably vary.

6.2.2 The Requirement of Access to the Automatic Control System

As specified by one user, the *Technology Portal* was "customized for us". When demonstrating the portal, the user claimed that in their morning routine, they opened the *Technology Portal* after having checked email and *DeDU*. In addition to this, several users stated that there existed numerous ways to reach the facility's automatic control system. Be that as it may, one user claimed that the *Technology Portal* was the "correct one", it was what "you *should* use". Yet, the same user stated that "I have some shortcuts on my desktop, so I do not have to...". Additionally, when that user was asked explicitly if they usually used the link, they had placed on the instead of the *Technology Portal*, they replied that they sometimes used the portal since it had a lot of other valuable information, such as the 'good-to-have links'. These links were further mentioned by another user who started off by stating that the *Technology Portal* was "used frequently by all of us", that "we go there if we for instance need to check a supplier agreement or if an inspection is done" and that links to supplier contracts, various documents and inspections as well as the remote access to facilities were found there. Furthermore, it was explained that one of the links directed to an "error reporting pulse" that showed how the tenants had graded Vasakronan. The tenant was able to rate how a determined error report errand was treated by using three smileys. Using the *Technology Portal* in order to reach other tools, especially *Q3Web*, was something which several users described. One user entered the *Technology Portal* about 2 or 3 times each month in order to use *Q3Web*. Other tools used via the *Technology Portal* were the ordering of remote access accounts. As follows, the user stated that "I do not use the *Technology Portal* that often". Widely, users had links to their automatic control system on their desktops.

Notwithstanding, when one user illustrated how the *Technology Portal* was used, they clicked on one of the links in the lists in order to access a certain facility, then they came to the folder with the facility name and *yet* a link to that facility. This could be seen in figure 13. Having clicked on the remote access link in the map folder, they had to login with password and username to their automatic control system. When the facility had been checked and tasks were done, the user minimized the tab so it could be reopened without logging in again.

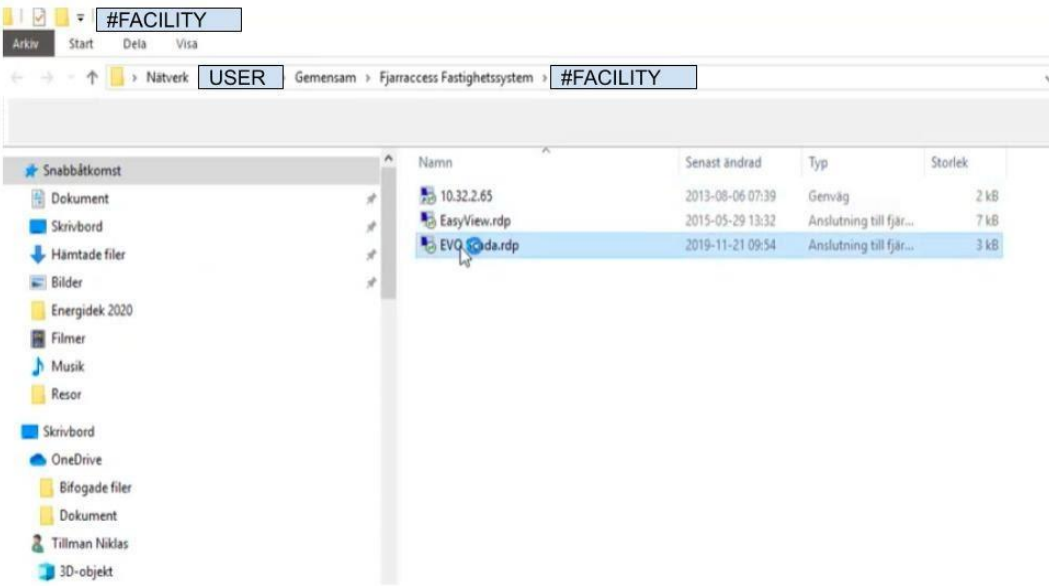

Figure 13: An image showing the view over the folder which is linked to from the technology portal.

When asked how they usually reached their automatic control system, one user referred to the *Operations Portal* that could be accessed through any web browser. Accessing an automatic control system through *Operations Portal* required remote desktop connection. As one user stated, “hopefully, all the automatic control systems are connected, that is not always the case”. Still and all, another user explained that most of the systems had a remote desktop connection, called RDP connection. To access the various automatic control systems, several users mentioned that they had a link on their computer desktop to the *Operations Portal* and to the RDP. This was something that one user said to be “the easiest way” of accessing the automatic control systems. Though, if the user was not at their work computer but had a virtual desktop infrastructure, they used the web browser and the domain name *driftportal.vasakronan.se*. This was also considered to be a “simple way to reach the various automatic control systems”.

The greater part of the users viewed their automatic control systems through remote access to check for urgent alarms, air temperature, radiators and fans. “Above all” they studied various temperatures, one user claimed. The output and set-point values related to climate regulation were registered in the automatic control system. These values were used to analyse what was malfunctioning in the building automation system. All of the users browsed their automatic control system at least once a day. A lot of the work was conducted in a proactive manner. Commonly, users monitored their automatic control systems in the morning. Chiefly, in order to detect any alarm. If there was an alarm, they went to the building and controlled it on the DUC monitor. According to one user, they could also receive error notifications via email.

Two of the users did not possess the possibility to work remotely, as their facilities were not connected. This was due to that the tenants requested a higher level of security and confidentiality, therefore prohibiting remote access to the systems. Thus, all monitoring and controlling work needed to be conducted on site. So, one of the users who managed such a facility stated that "unfortunately" the DUC's needed to be controlled in person and that their alarms could only be turned off manually.

Notably, all users primarily worked with troubleshooting and optimization of the automatic control system from an energy performance standpoint. Whether the system could be studied remotely or not, some aspects connected to the troubleshooting could only be seen on site. If things were not working properly it could be seen remotely, a note was made about the issue and the underlying cause got investigated on site. For instance, the on/off mode of a device could be seen in the system but not the ulterior reason. Thus, a lot of the work and analysing the automatic control system took place from within the facility.

Having entered the web browser for the remote access to the automatic control system, the user typed in their login and were able to reach all the automatic control systems in the facilities they had access to. According to the user, the technical facility managers "should have access to all their facilities and systems". Having logged in to the *Operations Portal,* they could enter colleagues' facilities when acting as back-up support. As further reported by users, if you got assigned a couple of houses "you enter the *Operations Portal*, there are the shortcuts to the facilities" which one user explained as the facility's SCADA systems. In the *Operations Portal*, the icon representation of the SCADA systems varied based on their connectivity. Systems that were connected to a physical computer in the building were presented with a computer icon, while systems placed on a server were presented as web browser icons (see figure 2).

Being forced to login a second time to enter the SCADA system was something which several users addressed. Disclosed by one user was that they wanted a unified way to log in to all automatic control systems, that "everyone had their own login then it all looked the same" regardless which system they wished to enter. A comparable statement was made by a secondary user, who requested a "concerted system". Furthermore, a user stressed that having a single-sign in "would facilitate for all of us technical facility managers in case if someone would be sick". On this topic, a user mentioned that there were several logins and a lot of waiting on pages to load. Hence, accessing the systems required one or multiple log ins. However, a secondary user stated that there was an inconsistency when entering the *Operations Portal*, since sometimes there was a second login and sometimes there was not.

Furthermore, one user claimed that they clicked on the link and logged in with either their private password or the ones that were shared among the technical facility managers. According to another user, a collection of documents where passwords were shared among colleagues which made it easy to access all systems. As follows, the user who managed the facility had an admin log in, meaning they could monitor, change and control all values. If it was a shared login, the user had restricted access to operate in the system. For instance, *Coor* could only inspect but not modify or control. Additionally, before the summer vacancies the user mentioned that they sent out log in's so they could provide with back-up support. Concerning the logging in, a user expressed that it was not "that safe" since most of the users had the same passwords. Sharing login also happened on field. When studying a user that logged in to the system on field, they used the account of a colleague and mentioned that they all did that.

Even so, users considered it as more important to be able to act as back-up support for each other than being restricted by a log in. Though, the users pointed out that the most important aspect of having a personal login was to know who changed what values in the automatic control system. One user mentioned that everyone should use their own username in order to have better control, because in "hindsight it is hard to know what has happened". Albeit, while some user addressed the security aspect of shared user accounts, yet one user commented that there was not that much secret information to get from the automatic control system from a security standpoint.

Moreover, accessing some of the facilities' SCADA systems through the *Operations Portal* prohibited more than one user being logged in at the same time. For instance, one user mentioned that *TAC Vista* was an example of such a system. This was what the user claimed to be "the largest problem". If someone else entered the system, the person who was already in the system got thrown out. As a solution one user voiced *TeamViewer,* since it allowed several users to access the automatic control system at the same time. This suggestion was not accepted by the IT division since it required several expensive licenses. Nevertheless, the user pointed out the advantage of several users being connected at the same time. They could share screens and illustrate the system for each other at a distance. This opened up for possibilities of having a conference, where the automatic control systems could be showed and it could be easier to support each other. Ultimately, the users asked for a system where several people could work simultaneously.

6.2.3 The Requirement of Customization

The users operated in buildings that had automatic control systems installed from several different manufacturers. All of the users were currently working with, or had experienced, at least two separate manufacturers. Some of the systems were considered to be better than others. When the users were asked to compare the systems, the systems that were considered the best were those that could easily be customized. The users wanted to be able to add own features to the interface, that could for instance promote the troubleshooting or facilitate proactive work. One user stated they had added timers to their system and had a weather forecasts integrated, so that the indoor climate could be optimized accordingly. Correspondingly, another user had customized their system by monitoring the airflow based on the time of the day. Since the activity from the tenants in the building varied during the day, the airflow ought to vary as well.

Inter alia, a further feature that had been self-developed by users was a conflict alarm, also denoted “flatline alarm”. The user was notified if the value had remained the same for 24 hours, since this indicated that the connection was faulting. Not only that, other functions had been added to the user’s automatic control systems to simplify the system usage for the on duty-call. Their automatic control system had been complemented with shortcuts to provide a holistic view of information. In that way, the user claimed that they “do not have to click to find information” and hence that “time is earned” when working. Before the implementation there were physical charts with information that the user knew how to make sense of but which would be more difficult for the on duty-call to analyse.

Another user had two distinct systems, where one was older than the other. Yet, the older system was the preferred one since it had “no limitations” as of the possibility to customize once the software was bought. The highly modern automatic control system was considered to be better looking though. Yet, it was not the favoured one since “not much” could be modified unless several expensive licenses were bought and the coding was mostly conducted by the manufacturer. As the user claimed, they “like to develop the automatic control system of the facility” or ask someone to implement the features, which could be done swiftly. Thus, they preferred the more dated system.

6.2.4 The Requirement of Information Creation and Knowledge Sharing

Remarkably, a user mentioned that “as a technical facility manager you know the building better than any other technical facility manager” and concluded that the work relied on the one person who possessed that knowledge. The same user also stated that “all houses possess their challenges”. Several of users referred to a process where knowledge concerning their facility was accumulated over time. This accumulation process entailed meetings, problem sharing and communication with colleagues regarding the various facilities. Notwithstanding, when the person responsible for a facility was unavailable, it could be difficult for other technical facility managers to answer questions about the associated facility. On this wise, one user pointed out that “it would be easier if everyone had the information concerning the facility” and that “it is better for you if as many as possible know what you know, then they are not dependent on you”.

When asked if they kept a record, one user replied that *DeDU* was the closest resemblance of one. In *DeDU*, orders could be placed, tenants could be reconnected to and prior events could be seen. Hence, they implied that nothing else was needed. Another user stated they kept their record in *Doris*. Earlier, it was kept at the computer desktop but as they were more familiar with the system nowadays, they had started to use it more frequently. Yet, when it came to record keeping, one user articulated that everyone has their own logging system and that Vasakronan lacks a unified system for logs. If such as a valve was changed, this information was stored at their private computer desktop, as their opinion was that not everything should be documented, since documentation was not always used.

Among the users, one considered their automatic control system as more digitized. This system included a system log function that could be used to gather information and act before an alarm. So, when a complaint came in from a tenant, the user might already had possessed knowledge of its underlying cause. Due to the log function they could conduct work in a proactive manner and thus, they considered that automatic control system manufacturer as the best one. As the user claimed, the system “logs everything, everything, every second, it is all there”. Contrariwise, with other manufacturers, “you have to initiate a log and add what you want to know”, and only from that juncture the system could be analysed. Thereupon, the preferred system made it easier to track what had happened historically, analyse based on a performance chart and allow for better understanding of past events. Thus, this system was seen as the best. Overall, several users spoke of the log function. One of the users who had a system which lacked remote access, also had a log in their system where they could type in what set-points that have been changed and when events such as complaints occurred. Since the system lacked remote access, the log had to be studied on site. However, not all users had a log function in their automatic control system. One of the users kept their personal log. As they adjusted values, they wrote notes in the log and later analysed how the facility reacted to the value adjustments. Their system can be seen in figure 14.

Ute	Fram			Ute	Fram			Ute	Fram
−20	70			−20	59			−20	70
−15	59			−15	59			−15	59
−10	59			−10	54	24-feb.	−1	−10	59
−5	55			−5	51	24-feb.	−1	−5	54
0	52			0	46	14-feb.	−1	0	51
5	44			10	43			5	46
10	40			15	25			10	42
15	25			20	19			15	27
20	19							20	19
B-VS3				C3-SHG4 Syd				D4-VS2 Syd	
Ute	Fram			Ute	Fram			Ute	Fram
−20	60			−20	59			−20	70
−15	55			−15	59			−15	59
−10	52			−10	54	24-feb.	−1	−10	59
−5	50			−5	51	24-feb.	−1	−5	54
0	50	24-feb.	2	0	45	14/2+17/2	−2	0	51
5	43	24-feb.	2	10	42	14-feb.	−1	5	45
10	38			15	25			10	41
15	25			20	19			15	25

Figure 14: An excel spreadsheet for tracking the changes in values in operation optimizations purpose. It shows the dates when the changes were made and the number of degrees Celsius that were adjusted.

Moreover, the lack of log function in one of the user’s system was considered a “huge scarcity” since it could, according to the user, help with the daily analysis. More than that, the user ascribed the aspect as an impaired “security function”.

In some cases, there were no digital copy of the operation charts, they only existed as physical artifacts in the building. The operation charts that showed the set-point values were attached to the installed DUCs. One of those cases could be seen in figure 15.

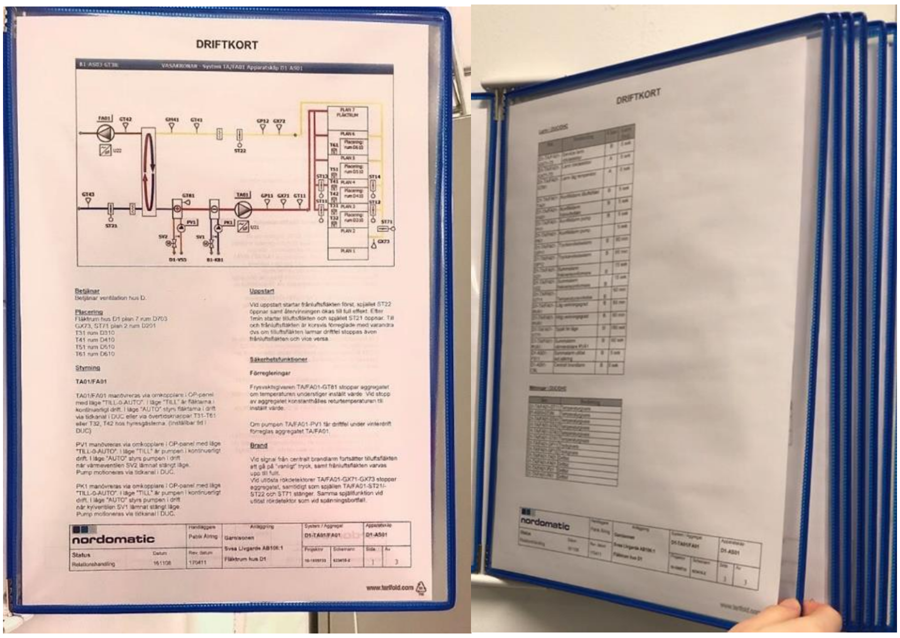

Figure 15: Images of operation charts.

Several of the users mentioned *Doris* as a system they used frequently. *Doris* is placed on the computer's desktop but also exists as an application in *Sofia*. As one user remarked "we are actually forced to use *Doris*, whether we like it or not, everything is stored in *Doris*". Initially, in order to learn the system, several users applied a "trial and error"-technique. Subsequently, the same user added that "if you know the facility, it is simple". However, they also kept some folders and documents on their desktop and stated that they were "for my own sake". A secondary user of the system though *Doris* was better than a regular folder structure but stated that they were quite new to the system. Hence, they had experienced difficulties when for instance doing a second search for a document they wanted to access again. Even though, they wanted to learn the system better by keep trying it on their own.

Among the users, some used *Doris* more frequently than others. Yet a user stated that they placed "everything I do" in *Doris*, ranging from Excel documents, to meeting notes and protocols. So, when the user needed information, they made a search in *Doris* and downloaded the information that was needed to their desktop. Further mentioned by users were that "all files are there" and that *Doris* was used to search for or store files. On the contrary, another user stated that *Doris* was seldomly used and claimed that "it is only a digital shelf where folders are kept". Related statements were articulated by others, who for instance declared that "I am really bad at using *Doris*". The utterance was followed by the explanation that documents were not continuously stored in *Doris*, even though they knew they ought to be. Although, the user also uttered that every now and then documents were uploaded.

As one user explained it, the point of using *Doris* was that documents would be accessible for everyone, and information would not be tied to one individual. Hence, if someone was sick or any other reason for the need of back-up support, the person taking their place would have the information. But the user added, this presupposed that everyone would use *Doris* continuously and upload their documents. What one user requested was “a better structure on how to find documents and things needed”. Furthermore, they stated that *Doris* runs slowly and “this can be a bit messy, but maybe it is because so many people are in the system at the same time”. Otherwise, they stated that “it is a good system”.

A tool that was used frequently was the *Facility Portal.* Users stated that they used it “very often”, almost daily and “several times each day”. If they received an email with a question related to the tenant’s facility, contact information or contracts, they often visited the *Facility Portal* to retrieve that piece of information. For instance, if the tenant requested a blueprint and more detailed data about the space of the facility, the user entered the *Facility Portal* to collect this information. In terms of information retrieval, the user stated that “there is a lot of useful information about facilities” in the portal. As further explained by one user, everything from basic data, rental agreements, blueprints from *Rita*, suppliers and supplier agreements can be accessed from the *Facility Portal*. Also, the facility numbers were considered to be one important piece of information. These were numbers that the users memorized since they were unique numbers for each facility. Thus, they came in handy when accessing facility information through other applications such as *DeDU, Doris, Q3Web,* and were needed when invoicing in *Palette*. However, one user especially expressed a wish to tie the *Facility Portal* to all work tools that were coupled to managing automatic control systems, so one holistic tool for their work was created. They claimed that “I want to find everything in the *Facility Portal* with a more distinct interface”. Even so, the secondary user claimed that the *Facility Portal* was “very good” and “perspicuous” in comparison to their previous experiences of similar tools. Thus, they regarded the information in the *Facility Portal* as “extremely good” since it was “collected at one place”.

Blueprints could be found in both *Rita* and the *Facility Portal*. Optimally, prior a renovation, blueprints were accessed from the contractors. Vasakronan then lent suppliers and tenants their blueprints and wanted them updated when the projects were done. Despite having an established process for the handling of blueprints, it was not always followed by the users. This was one of the ulterior reasons why the information about operating space was tied to individuals. This meant that if the technical facility manager who was responsible for the facility was absent it became problematic to navigate in that facility. Furthermore, a user clarified that blueprints from *Rita* were used to navigate in facilities, but that these blueprints were not always updated. Recurrent renovations were one of the underlying problems of inconsistent blueprints. As one user stated there were “inadequacies” in keeping the blueprints updated since “we can renovate, the tenant can renovate”. Several users agreed to that incorrect blueprints were a problem. Similar allusions towards the tenants were made by several users, one pointed out the issue as “you do not always find your way around”. Besides that, one user stated that their blueprints were considered to be quite good, unlike the ones in some of the older facilities. One of the users who had higher security in their facility could not distribute blueprints in *Rita*. Thereby, suppliers and external parties could not find their way around in the facility and needed the user’s guidance. Nevertheless, users expressed that they wanted the blueprints to mirror the reality better and also provide information about the floor levels of the facilities. As a solution to that the blueprints did not represent the reality or were outdated, one of the users had created their own blueprints by using the tool *pdfDocs*. Thus, the user had taken snapshots and manually marked in the PDF-documents where important system components were located. Today, the blueprints were only two-dimensional, meaning that information regarding the location of objects was not accessible. According to some users, the blueprints were considered necessary when analysing the cause behind problems. What is more, blueprints were considered to be important, especially in order for a newly employed to find their way around in the facilities. Though a user accentuated that personal meetings were important and added that “in order to learn you probably need to be on site”. This view of learning their new facility was shared among several of the technical facility managers. Accumulating knowledge about their work within the facilities was something which one user spoke more of. According to this user, it was almost irresponsible to hire people as technical facility managers if they had not built up a prior practical experience as an operating technician.

6.2.5 The Requirement of Statistics and Analytics

All users said that they utilized *Vitec* for tracking energy consumption and users claimed that this tool was used regularly for accessing and reporting values coupled to their own facility. Some users stated that they browsed the tool weekly. As one user claimed, the most frequently viewed figures were heating, water, cooling and electricity. Not only that, the user clarified that they used *Vitec* if “there are problems with the technology”, and in those cases they compared the numbers to the ones in prior months. All of the users did a monthly run through *Vitec* to report and complement system outputs. In the future, one user reasoned that this kind of tool would become more important. According to another user, the technical facility developers were looking to build a *Vitec*-tool that updated figures by the hour, not monthly. This was something which was seen as “a lot better”. Enhancements of *Vitec* were also requested by yet a user, who stated they wanted figures in a more proactive manner and for prognosic purposes. The user requested a view that showed “If I make these modifications, how does the prognosis look”. By all means, the user reasoned that this could be done with Excel calculations but that this required time and experience. All in all, the user wished for more proactiveness and visualisation of information which in turn could inspire their work practice. *Vitec* was placed on everyone's desktop. Even so, a feature that one user thought would come in handy was to be able to see key performance indicators (KPI’s) from *Vitec* in the *Facility Portal*. According to the user, “It is time to make it more fun, efficient and easier to control”.

Other than using *Vitec* for monitoring statistics, two users mentioned that they used *DeDU*. It illustrated how many error reports that came in, statistics for how often a lightbulb got broken in a certain stairwell and so forth. Thus, the user checked whether *Coor* did this by generating reports.

6.2.6 The Requirement of Structure

Microsoft's calendar and email tool, *Outlook*, was frequently used among all of the users. They received error reports from *DeDU* and managed their communication with suppliers, tenants and colleagues via email. Several of the users managed their calendar and email the first thing they did each workday. As one user stated, they first checked their email in the morning and then *DeDU*. Several users described that most time was spent on responding to and checking emails. One stated that there was "a lot of emailing" and when checking the inbox, they took action according to what was the most urgent. The heavy email correspondence, which was centred at answering questions from tenants and colleagues, was seen as stressful or time consuming among several of the users. Two users specified that there was a delay in their work since all orders through email required a follow-up process. Thus, their to-do lists could include tasks that spanned over several months. To structure their daily work by time scheduling, several users used their mailbox, *Outlook*. In order to ensure that other work tasks got done besides meetings, a user mentioned that there was "a lot of planning". According to one user they added a block in their calendar for time to check their inbox, reconnecting with tenants, run through current projects and ensure there is an energy focus. However, *Outlook* was used, not only to plan their day according to the most urgent task that came in, but also utilized for the folder structure as email and document storage. One user applied colour scheming to categorize emails, documents and files.

Another user had a system where they went through their inbox in the morning and if there were errands that were important but not urgent, they could add those as activities to their calendar. Also, the user stated that they used the "calendar for writing things down, in order to not forget". Yet a common tool for planning and record keeping was Microsoft's tool *OneNote*. However, users also kept personal to-do lists in Word documents placed on their computer desktop. For instance, one user demonstrated that they had a folder which entailed to-do lists for their properties, some documents related to values or information concerning their automatic control system and and more specific numbers connected to various parts of their facilities. A simplified and fabricated image based on the original lists and document can be seen in figure 16.

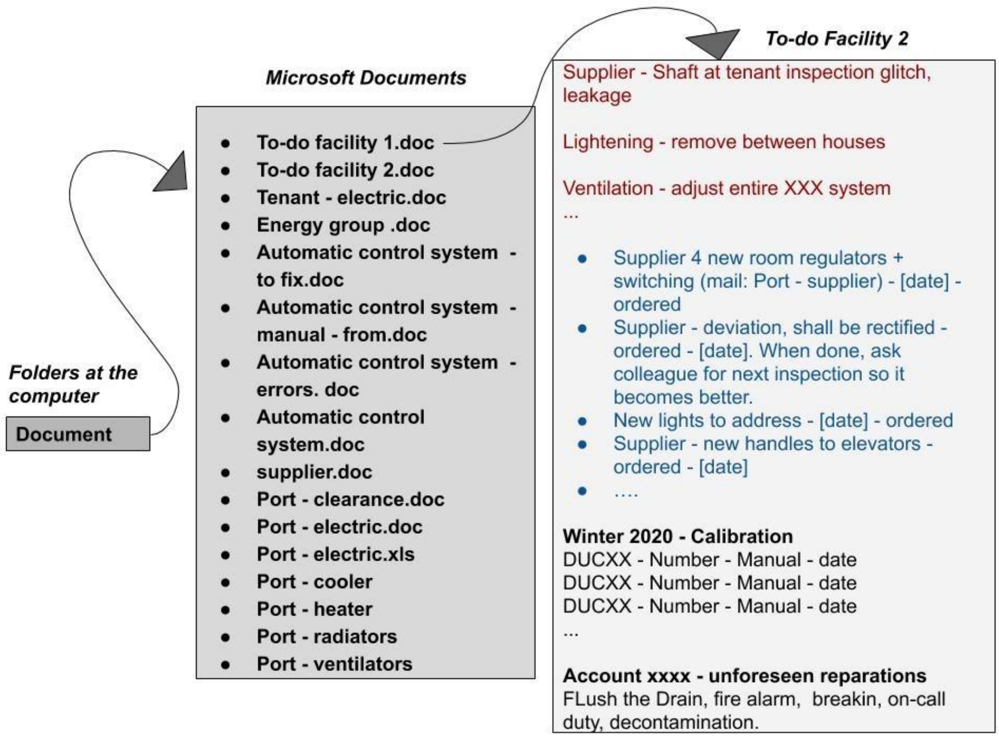

Figure 16: An image of how one user structured their to-do list by colour scheming and how it was stored. The red markings were things that needed to be fixed, followed by a textual description marked in blue. The blue text often entailed orders, date, names, some additional information and the problem that was addressed. The document contained lists of values and numbers that had been changed or needed to be remembered.

6.3 Summary of Requirements

The results reveal that the users relied on a lot of different systems, tools and applications in their work practice, but the various automatic control systems were at the very heart. Thus, it was revealed that the user had a need for a portal that connected commonly used tools as well as the various principal control systems.

Thereby, ***the design must incorporate the automatic control systems.*** To start with, the users confirmed the fundamental need of an assembly point, that is a *portal*, of automatic control systems to all of the facilities that Vasakronan managed. Furthermore, it was revealed that the portal should include tools and applications coupled to operating and managing their facilities and conducting their everyday work practice. As of today, the *Operations Portal* and *Technology Portal* did not cover their work scope, nor did they facilitate easy access to automatic control systems. Some systems, such as the automatic control systems, were purely related to facility operations. Other tools, such as *Navigon* and *Vitec*, were related to data reporting of their facilities' status. Nevertheless, there were also tools that related to information sharing and communication among colleagues, such as the *Teams Portal* and *Doris*. The mixed use of these tools and subsystems were crucial to users in their everyday work but the user expressed a wish for having the tools assembled at one access point. Thus, ***the design***

contains the most commonly used tools and applications among users. These involve *Navigon, DeDU, Vitec, pdfDocs, Rita, the Facility Portal, Teams Portal, Outlook, Q3 Web, E-sign, Doris,* and the *Technology Portal.* Since information and system use vary with facility, ***the design must support easy access to the user's own facilities as well as the ones that the user supports***.

Also found was that users had to search for information from diverse sources to access sufficient information about their facilities in order to conduct their work tasks, such as corresponding with tenants and reporting data. They had to enter each system separately at disparate locations and with multiple logins. Therefore, ***the design must assemble the facility information that the user relies on in their common practice at one place***. Noteworthy, some of the information was not documented in current systems but acquired verbally among technical facility managers. This was when users acted as back-up support for their colleagues' facilities. In addition to it being crucial in work practice, this knowledge sharing was also found positive among users who enjoyed this aspect of work. Thus, ***the design must promote knowledge sharing among technical facility managers and associated external parties***.

The results also revealed that users experienced high workload and that some work tasks were more prioritized than others. To structure their work and track ongoing projects and processes, the users created their own documentation and task lists. Thereby, ***the design must support the structure and planning of everyday work as well as follow-up on processes***. Users wanted to be able to conduct more proactive work to decrease their workload, but seldom had time to do so. The correspondence with tenants and colleagues as well as managing various projects were prioritized to actually managing the operations of facilities. Users found joy in problem-solving and optimizing the energy performance in their facilities. Therefore, ***the design must provide the data and tool prerequisites for managing energy optimization and proactive work in facilities***.

7. Framework for the Designing Phase

This section addresses the two last activities which *ISO 9241-210:2019* raises connected to prototyping, testing and creating a design. It discusses the three of the four phases in the method of *test-driven design*. Hence, it brings up how the prototype was designed and evaluated iteratively.

The third activity addresses the production of a design solution, which is crucial in the field of HCD combined with establishing a good user experience. Potential design solutions should be produced in alignment with the intended context of use, design and usability guidelines, and the results of any baseline evaluations. To produce the design, various user tasks, interactions and interfaces should correspond to the aforementioned derived user requirements and incorporate the whole user experience. From this, the design solution should become more concrete and even more so when being altered in response to user feedback, which is the fourth activity that is proposed by ISO 9241-210:2019. The fourth activity seeks to evaluate the proposed design solution. Nevertheless, user-centred evaluation is essential and should be integrated in all parts of designing. User-centred evaluation also involves sufficient testing to provide meaningful results for the system as a whole. From these results, issues should be prioritized to help improve the design solution. Lastly, the design solution should be communicated to relevant stakeholders and users so that it can be used in an efficient way. The ways in which this was accomplished are further described below.

An important point is that in this thesis work, evaluation through usability testing was an integrated part of producing the suggested design. Despite it being described as a fourth activity, it should rather be considered as a prolongment of the third activity mentioned in *ISO 9241-210:2019.* Thus, the phase in the method thatconcerns testing will be integrated with the phase concerning design as they take place iteratively.

7.1 Further Application of Test-Driven Design

As aforementioned, the iterative *test-driven design (TDD)* method is a common method for producing a design solution through a prototype. By gradually testing, the design is continuously verified with the user and hence enables a quicker detection of any deficiencies (Gothelf & Seiden, 2016). The three steps that address the design phase in the TDD will be further discussed accordingly.

Throughout the process of developing prototypes, evaluative interviews with users can be a way to obtain feedback regarding information flow, language or control functions and validate design choices or identify areas of improvements. Usability testing is used for evaluation of systems or products. It can take part at every stage of the software development, but is preferably integrated in all stages of the design process. Usability tests in combination with interviews can be used for assessing an existing interface, a proposed interface design on either paper or a somewhat functional prototype. It is used in order to eliminate design problems and to establish a valuable relationship with the intended user (Lazar, Feng & Hochheiser, 2017; Rubin & Chisnell, 2008).

7.1.1 The Outset when Designing the Prototype

This work was first initiated through a designated workshop day where the thesis reviewer assisted with design advice. The workshop took place as all interviews had been conducted and the user requirements had been outlined. The identified user needs and requirements originated from the data gathering, presented in the foregoing section. These were prioritized according to their relative importance, which aimed at filtering the vital system functions that the proposed design solution ought to cover. This ended in a decision of creating four main displays that constituted a *prototype* that corresponded to what *TDD*. This prototype consisted of the *portal view*, the *find facility view*, the *log view* and the *alarm list view*. The interactions among these views as well as the various functions were based on the previous results.

The layout was scaled to fit a computer screen. For idea generation, the researchers designed and sketched alternately in pairs and by their own, iteratively and divided in short sprints. By the end of the day, a first set of sketches was finished. It was then presented to the thesis reviewer, who gave verbal feedback on further design improvements.

7.1.2 Stages of Usability Testing

The various stages of the general usability testing process include (1) selection of representative users, (2) selection of setting, (3) conclusion of what tasks the users shall perform, (4) determination of what type of data to amass, (5) preparations before test session (e.g. informed consent), (6) during the test session, (7) debriefing after the test session and (8) compile the test results and recommend areas of revision (Lazar, Feng & Hochheiser, 2017). These steps are further described below.

Firstly, the representative users have to be chosen and recruited. The difficulty of selecting how many to interview is something that Bryman and Bell (2017) agree on as one problem that qualitative researchers are faced with in the beginning of their research. At Vasakronan there are approximately 50 managers. Some of the users that were interviewed to compile the user requirements also participated as test users. However, some of the test users were completely new to the thesis work. The new users provided with their view on the system design, hence giving valuable feedback with no prior knowledge about the thesis work. This served to further validate that the design indeed was intuitive to users. Importantly, all test users qualified as intended users. All in all, *seven* usability tests were conducted.

Secondly, the test setting must be set. As regards to the selection of test setting, Lazar et. al. (2017) propose that “the user may feel most comfortable in their normal environment, using their own technology, which again, may enhance their performance” (ibid, p. 279). The choice of test setting in this thesis was rather given due to the Corona situation. This being said, the remote usability testing poses challenges for contextual inquiry. However, the advantage of conducting such usability testing remotely is that the users are fully familiar with the equipment, since they use their own devices to complete tasks. The test environment is less artificial compared to a lab environment (De Bleecker & Okoroji, 2018) or if the authors supervised the test in person. Noteworthy, this remote work environment was their new “normal environment” due to the virus-related restrictions. Hence, all usability tests were conducted remotely through *Microsoft Teams*. When testing the paper prototypes, the researchers shared their computer screens to show the user the PDFs.

Thirdly, a task list with the purpose of directing the users towards the goal is constructed. Each task should be articulated well and explicit enough so no further explanation is needed. In all tests, the user was first asked to describe what they thought was the purpose and meaning of the sketch or displayed view. This was to reveal *if* and *in what ways* the proposed design solution corresponded to their conceptual model of the system. Furthermore, the researcher can provide the participant with a context by stating the background information in the outset of the list (Lazar, Feng & Hochheiser, 2017).

The tasks that are placed on the task list should be critical ones that are performed frequently and connected to the user’s goal. In the task list creation, the participants’ navigation among the tasks must be structured. It has to be stated whether any order or time-aspects are important and if interventions by the moderators are allowed or what should be done if the task is not accomplished (Lazar, Feng & Hochheiser, 2017).

As the user had guessed on the purpose of the view, the researchers gave a short note on the purposed intention of it. Then, in the first tests with a non-interactive prototype, the user was asked to verbally describe how they would navigate in the display if they were to perform the given task. It is proclaimed that the user should interact with the prototype rather than just seeing it (ISO 9241-210:2019). In the later stages of testing, the users were able to interact and conduct tasks. As proposed by Lazar, Feng and Hochheiser (2017), the task list was created based on the most crucial work tasks of the primary users and the most vital functions of the system. These tasks were identified by the consolidated work models and the test user was instructed to illustrate how to conduct the tasks.

Fourthly, a decision about measurements must be made. Generally, task and time performance along with user satisfaction are common quantitative assessments. There are also qualitative metrics, when participants are asked to speak their mind, share emotions and thoughts (Lazar, Feng & Hochheiser, 2017). In this thesis, the usability tests were valuable for qualitative reasons and thus served to reveal the test user’s thoughts about the proposed layout. Even though that quantitative measures were not applied, they could serve as cues on areas of improvements. Such as if a test user took long to identify the intended symbol, function or alike, this was recognized by the authors as that associated cue not being intuitive. Hence, that design component was redesigned and tested in the next user test.

During the usability test, the participant might show signs of nervousness or frustration. Despite emotional distress, Rubin and Chisnell (2008) proclaim that the user shall not be assisted as soon as distress occurs. A recommendation is to stay more passive since the behavior at this critical point might give crucial information. With that said, staying entirely passive is also not advocated. The moderator should emphasize and encourage the participant by stating that there is an end goal and establish a collaborative atmosphere. Suggestively, the moderator should "play dumb" in order to not receive too many questions and intervene too much. If a deviation from the test plan takes place, the moderator should take notes but not jump to conclusions. Therefore, the authors tried to have a rather laid-back approach throughout the usability tests and not provide the users with too much instructions. Instead, the test users were encouraged to reason out loud. If the test users made suggestions that did not correspond to the intended purpose of the design, this feedback was noted by the authors without the test user being interrupted or corrected. Also, the authors reminded the test user that there were no "right" and "wrong" navigations, or "good" and "bad" users.

7.1.3 Creating the Prototype

The third step of test-driven design is to create a prototype. Prototyping techniques should be decided in respect of the intended audience, desired learning outcomes, current knowledge and timeframe. *Paper prototypes* can be built by materials that are easy to obtain and approximate the experience in a quick, simple, cheap and enjoyable way (Rubin & Chisnell, 2008; Gothelf & Seiden, 2016). As Shneiderman and Plaisant (2004) point out, creating a product with excessive functionality could make the design too complex and as a consequence the learning and usage can become more difficult. Stated by Lazar, Feng and Hochheiser (2017) the advantage of using paper prototypes at an early stage is that the designers are not too attached to a certain design and it can easily be modified. When testing, the interface can be altered with after each interview which opens up for direct feedback on the evolving system. Furthermore, the user might be more comfortable with critical feedback on a paper product with insignificant refinements. Though, Gothelf and Seiden (2016) clarify that the simulation is fabricated and needs to be re-created. Furthermore, it conceives limited feedback and is only useful when the magnitude of test users is restricted.

After the design workshop, the received feedback was taken into consideration and the sketches were refined into the first version of a paper prototype, which later was to be evaluated by the first set of test users. The paper prototypes portrayed the four vital views and 1-2 design suggestions per view, whereas the test user was asked to compare and discuss pros/cons with the various designs and share their own thoughts on improvements. However, due to the circumstances with the outbreak of the Corona virus, paper prototypes were created, scanned as PDF: s and then shown to two randomly selected users. During the tests the users were asked to give their feedback on both the requirements as well as the suggested solution in the paper prototype. This was done in a video interview that was held in *Microsoft Teams* and where further questions concerning the design and layout could be asked.

A more advanced prototype is the *Low-Fidelity On-Screen Mockups*. These are clickable wireframes that offer richer feedback and insights due to the interface interaction. Simultaneously, the test users are experienced enough to recall that this is an unfinished product that they can review (Gothelf & Seiden, 2016). The Low-Fidelity On-Screen Mock-ups were created in a prototype software tool called Figma. The Low-Fidelity On-Screen Mock-up commenced from the paper prototype and was modified according to the user feedback. During the usability tests, colours, features, actions, icons, and labels combined with their logical connection were tested. The user was given tasks and instructed to 'think out loud' meanwhile pursuing them. They were reminded that they could not do anything 'wrong' and if they found that anything appeared illogical, it was valued feedback. For each view they were given instructions followed by a set of questions. As the mock-up was modified, the adjustments were evaluated by the ensuing usability test. This evaluation and modification loop were done iteratively according to the test-driven development model.

7.1.4 Research and Learnings

The fourth and last step is research and learning. At the core of UX design is the user. Thus, it is suggested that the user is continually included in the stages, from hypothesis creation, design to feedback. When the feedback is received the aim should be to synthesize it. Occasionally, data might have contradictions. In order to safeguard learnings Gothelf and Seiden (2016) offer some guidelines. These includes looking for patterns and outliers and if outliers are found do not discard them, but place them in a backlog where they can be stored for future use. Further, when faced with uncertainty, verify the feedback with other sources. Usability testing will be further specified in the following section *'8. Design Result'*.

7.1.5 Communicating the Solution to Relevant Stakeholders

As mentioned, a dialogue was initiated at the beginning of the thesis work with a project manager and the chief of the information technology division. This initial meeting revealed an emerging resistance for implementing new projects, since these were commonly not communicated with the IT division that later were faced with maintaining them. Therefore, in this thesis emphasis was placed on communicating the proposed design solution efficiently. In order for the findings, the requirements and design proposal to become useful they were presented to a project manager at Vasakronan. As the design of the prototype was finished, it was presented within the company along with the entire study.

8. Design Result

The design result consists of a digital prototype covering the aforementioned defined functionality in four views. The overarching design of the portal's interface is first brought up and how it was designed. This is followed by its structure predicated on theories concerning portals and design, as well as their connection to derived user requirements.

8.1 The Portal's Interface

As Sullivan (2003) suggests, a portal's interface should be divided into a three-panel structure consisting of a *global area*, a *navigation area* and a *main content area.* This design architecture was followed in order to create a visible structure that would serve the user with cues of possible actions, something which Norman (2013) denotes as *signifiers*. Each part of the three-panel design will be discussed respectively in the following sections. Having these panels, supports task performance by what Shneiderman and Plaisant (2004) refers to as *grouping*.

Having said that, the prototype held views such as the *log view*, the *find facility view* and the *alarm view,* that the user could navigate to. When accessing these affiliated views, they were placed as an overlay on top of the portal's interface, functioning as *modal dialogs* (Shneiderman & Plaisant, 2004) that would support the initiated user task. By having them placed as overlays with a blurry layer distinguishing the top view from the underlying view, the users ought to be aware of their position within the system. To persevere the system's consistency, this overlay design was implemented on all views that were opened. Ergo, by having this holistic view mixed with the specific, the comparison could be conducted on a higher level which is more suitable for the human information-processing capacity (Tufte, 1990). Hence, when the user wanted to escape the view, they could either click on the close button, illustrated with a cross, or press on the blurred area that surrounded the view and showed the main view underneath it. The usability test revealed that both paths were used by the test users as some test users realized that they could leave the view by clicking on the side.

8.1.1 The Requirement of a Portal that Would Support the User's Daily Work

The aim with the design of the portal was to cover the user's general work practice, facilitate knowledge sharing and thus, to create an artifact that is useful in the user's daily activities. In this manner, this requirement supported Ehn's (1988) theories of how to design computer systems and artifacts. Also, the primary focus of the design was to capture what the users considered important about their work domain, not to design according to external parties. Hence, the main objective of the conceptualizations was to *map* (Sullivan, 2003) the user's *conceptual model* (Norman, 2013). As the usability test revealed, this was accomplished by the proposed design. When asked to think out loud and inspect the portals interface, seen in figure 17, the test users stated that the portal "covers everything we work with", "you get a lot of information on a single page", "It is clean yet holds a lot of information, as I see it, less is more", "clear overview", "this is really good as the initial view with access to *DeDu*, *Vitec*… And my facilities… If my colleagues are sick, I can add their facilities", "I want to start using this tomorrow", "you have capture what I considered as the most important" and "It looks much better than our current *Operations Portal*". Furthermore, the test users seemed pleased with the design as their direct replies when inspecting the interface were that it looked "swell", "nifty", "slick", "highly logic" and "neat". Altogether, the interface can be seen as *effective* (Shneiderman & Plaisant, 2004) since it created the aforementioned positive response.

The theme colour for the portal was a single green colour due to several reasons. Among them was Tufte (1990) who declares that "a palette of nature's colours helps suppress production of garish and content-empty colourjunk" (ibid, p. 89), that Vasakronan's *Technology Portal* was green and that Shneiderman and Plaisant (2004) suggest using monochromatic colours to avoid negative effects from designing with many colours. Besides the green, colours were applied judiciously and the most common ones were grey and white.

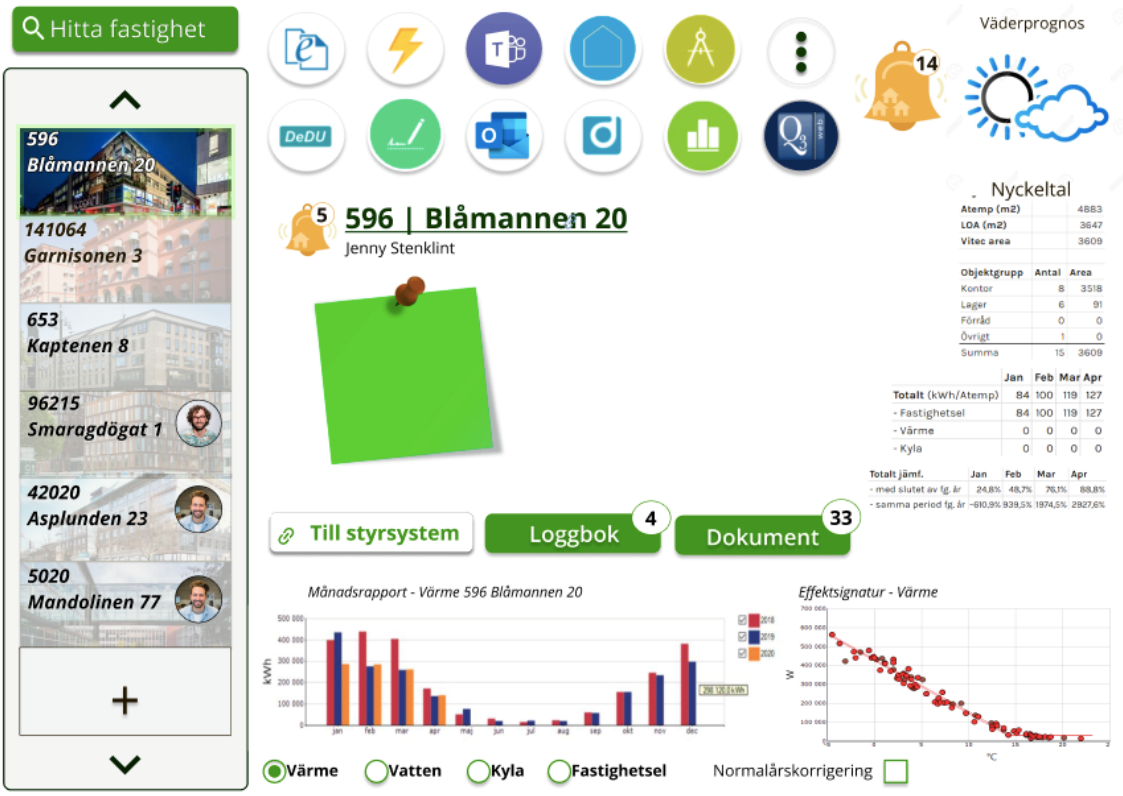

Figure 17: An image displaying the portals interface which is structured according to Sullivan's three-panel design covering a global area, navigation area and a main content area.

8.2 The Global Area

In the global area the requirement of accessing to the most commonly used tools was brought up. Among these were the were tools from the intranet Sofia, frequently accessed links as well as the weather and alarms.

8.2.1 The Requirement of Access to the Most Commonly Used Tools Among the Users

The top panel, which Sullivan (2003) also refers to as the *Global Area*, ought to be consistent throughout the portal. Thus, the *portal's global area* was designed to access the tools that were frequently used by the contextualized user in their daily work practice, but that were not coupled to one facility. As revealed in the result session, these were: *Vitec, Facility Portal, Navigon, Q3Web, Doris, Rita, pdfDocs, Microsoft's Teams, DeDU, Outlook* and *E-sign*. These tools all had established logotypes, presented in the consolidated artifact model in the section '*6.1 User Data Categorized into Consolidated Work Models*', that the users were familiar with. To adopt these logotypes and structure from Vasakronan's intranet Sofia, followed what Ehn (1998) discusses as an established work practice and *tradition* of the system's design. Furthermore, these logotypes were also used based on Sullivan's (2003) recommendation to apply labeling standards to facilitate the users mapping of what they represented. Hence, these were used in the portal view to make it more familiar to the user.

Figure 18: The portal's global panel with the most vital tools.

During the usability tests, a test user who had not been interviewed prior the testing, was asked to share their thoughts on the global area seen in figure 18. Their response was that "it is the tools I am using" and further explained that "it is how it looks on my desktop where I have chosen my favourites, those are the ones". Thus, their response indicated that the user's *conceptual model* had been adequately captured (Norman, 2013) as this confirmed a successful apprehension of the frequently used tools. All of the test users recognized the tools and commented that these were the ones that they were using. Anyhow, there were some test users who stated that one or two tools among the presented ones were used rather seldom and therefore wanted them excluded. As aforementioned, the global panel was created according to the representative user's consolidated work model. That is why it is reasonable that the individual test user would ask for smaller modifications of this panel. The user could make these individual modifications by clicking on the *vertical ellipsis*, the button with three dots. This button supports an *enabling form of flexibility* (Adler & Borys, 1996) since it should allow the users to adjust the list of tools in the interface according to individual work practice. Hence, this aligned with the the *requirement of customization*. As the usability tests revealed, some users suggested that tools should be added to the global area. Thus, to change the displayed set of tools or to view a hidden additional set of tools, the user could click on the vertical ellipsis. Through this, the users work would not be constrained (Norman, 2013) by the tools or links that the system afforded. What is more, the user would not have to go to the *Facility Portal* to access its links, which was mainly why it was used as a tool today.

Moreover, the results disclosed that the weather was something that was important in the user’s daily work. The weather affected how they operated the facilities’ indoor climate, whereby a weather forecast was added to the portal’s interface. As the usability test showed, this feature was coveted. One test user stated that this was good since they otherwise had to “google it separately” and it was helpful to have on the first page.

Side by side with the area of tools and the weather forecast, a large bell was positioned. The large bell represented *all* of the alarms extracted from the automatic control systems. Due to this, it was seen as relevant among the global tools. What is more, the results showed that it was a tool which the users would check on a daily basis as the first thing they looked at on a workday. This can be seen in the ‘arrival at work sequence’ within the *consolidated sequence model* in the section *‘6.1 User Data Categorized into Consolidated Work Models*’. By displaying the alarm bell larger than the icons, a test user reflected that “the alarm is the largest, that is good”. Moreover, the number of active alarms were presented in connection to the bell to provide the user with holistic information of the systems status. Initiatory, the usability test reported that the test user found it difficult to distinguish between the two bells, the large bell in the global area contra the smaller one in the main area. For that reason, they were repositioned and marked with the number of active alarms that the list entailed and dissimilar facility icons. In order to assist its *mapping* (Norman, 2013), referring to addressing the relationship between a set of things, there were multiple facility icons attached to the large bell which signified that it represented several facilities. On the contrary, the small bell had one facility attached to it. Besides making a distinction between the bells, as a result from the usability test, the initial green coloured bells were replaced with yellow ones, as presented in figure 18. This resulted from one test user’s remark on the main view being “too green” and suggestion to revise the bells. Their objective supported Tufte’s (1990) discussion concerning colour providing information, and that overusing pure and intense strong colours can have a negative effect. In the ensuing tests, none of the test users addressed the application of colour.

8.3 Navigation Panel

To begin with, the requirement concerning the navigation panel is brought up together with the design theories that contributed to the design. Thereafter, the view that enables the users to modify their navigation list is brought up.

8.3.1 The Requirement of Easy Access to the User's Own Facilities as well as other Users'

The side panel should, according to Sullivan (2003), consist of a *navigation area*. As the portal's main purpose was to access the various automatic control systems installed in facilities, it appeared natural to structure the navigation area according to the user's managed and back-up supported facilities. In the navigation panel, the facilities were presented with an image of the facility, the facility name and the facility number. Also, if it was not the user's own facility, the object in the list entailed an image of the technical facility manager who was in charge of the facility. This enabled quick access to the most commonly wanted information as well as promote the user's understanding of what the navigation list encompassed. Also, an image of the technical facility manager was presented next to a facility since adding more text to the small area could make it difficult for the user to comprehend the information. The information connected to the objects in the list facilitated what Norman (2013) expresses as *knowledge in the world*. This, since the user did not have to strictly remember facility number, facility names or the person connected to them, rather the information was displayed in the system. Moreover, this could be seen as *natural mapping* (Norman, 2013), since the relationship between on facility and the control of it appeared evident to the user.

Figure 18: The list of facilities in the navigation panel.

The navigation panel was encircled with a thin frame, that visually structured the content through ***grouping*** (Shneiderman & Plaisanted". Using colour in this way can distinguish between information and is the point that Tufte (1990) makes. What is more, the user was eligible to add and remove facilities from their personal list. This was important since they could alternate facilities that they managed as well as to whom they acted as back-up support to. Facilities could be added to the list in two ways: by pressing a plus sign at the lower bottom of the list, or by pressing the button above the list with the label 'find facility'. Both ways led to an overlay display for adding and removing facilities from/to the user's personal list. The list of facilities could be populated with several objects, which consequently meant that the button where facilities could be added was the last element and could become hidden in the list. This potential issue was addressed by adding the second button, *find facility*, above the list. Yet, it could be the case that the user browsed the list of facilities and realized that the one they were looking for was not there, hence, the last element was a button where this facility could be added. Importantly, the usability test showed that test users selected both ways when they wanted to make a permutation to the list and thus, they were equally important to retain. Thereon, this supported the *affordance* of *customization* as the user preferences varied, with that the user could select according to their preference.

An important problem that Sullivan (2003) reports is that the user can get overwhelmed by the full scope of a portal. For that reason, the design ought to “provide an immediately visible and easily accessible path to related components in the portal” (ibid). Thus, only one facility could be selected at the time. This decision was made despite that one test user suggested that the system should possess the ability to select several objects in the list and in such way have them all presented in the main area. What the test user requested is what Norman (2013) would call an *affordance*, the actions that were possible. Be that as it may, the design decision took stands in Sullivan’s (2003) work and prevented the user from an overwhelming sensation and this function was kept as an *anti-affordance*. Ergo, this possibility of actions was communicated, or as Norman (2013) refers to as *signified*, by applying the focus-context technique (Sullivan, 2003).

Nevertheless, the usability tests revealed that the test users understood the navigation panel. Several test users stated that the navigation panel appeared familiar, and some took this notion further as they drew a parallel to the *Facility Portal*. For instance, one test user stated that “I think it is good, somewhat like the one in the *Facility Portal*” and further explained that they assumed that the functionality would be the same with the affordance to select one facility among the ones within the list. The list which the test user referred to, back in the *Facility Portal*, was a source of inspiration for two reasons. Firstly, it provided the user with quick navigation between an assortment of facilities. Secondly, the user would recognize it if it was replicated and put in a new context because they could rely on their *repertoire* of work practice (Schön, 1995). Hence, their mapping to its functionality would already be present regardless if it was a new tool since it aligned with an existing *conceptual model* (Norman, 2013). This was also seen in the aforementioned case regarding the navigation panel, which had a resemblance of the intranet *Sofia*. Additionally, when establishing a new work practice, it could face objections. As a solution to potential protests, Norman (2013) suggests to maintain a consistency. Therefore, the logotypes and general structure in the interface were consistent to the user's current artifacts so that they would adopt the new portal instead of using the existing ones, supporting both *transcendence* and *tradition* (Ehn, 1988). However, the navigation section was placed vertically, instead of horizontally which it was designed in the *Facility Portal*. The underlying thought of the vertical position relied on Sullivan’s (2003) theory concerning a portal’s interface with the navigation panel, as well as the knowledge of that at the scroll functionality on computers would work better if it was placed vertically.

8.3.2 Modifying the Navigation Panel

As one requirement was to enable easy access to the user’s personal facilities as well as the ones that the user back-up supported, an imperative was that the portal ought to entail a way for the user to find other facilities managed by other users. On that ground, a view where the user could add a facility to their list in the portals interface was designed. Equivalent to the other pages, the page with the list of facilities was presented as an overlay on top of the portal's interface, thus functioning as a modal dialogue that streamlined the current task by attracting the user's awareness (Fessenden, 2017). By studying the *Facility Portal* along with the *Technology Portal* and asking what the test users considered was the vital information, the columns in the list ended up covering the facility information; *facility number, facility name, address, region, responsible technical facility manager* and *actions*. Also, to reduce the need of storing information in the memory system (Norman, 2013), the design had two separate lists. This also opened up for users being able to apply *direct manipulation* (Shneiderman & Plaisant, 2004) on the facilities in their list. So, one of the lists contained the user's selected facilities which corresponded to the one in the portal's navigation panel. The other list was generated by the search result. Hence, when the user wanted to add a facility to their list they got instant feedback (Norman, 2013), displaying that their action had been successful as their personal list got updated. Moreover, the possible actions were clear along with its constraints and natural mapping among the separate tables, labels and logotypes. According to Norman (2013), all of these are" perceivable cues that act as knowledge in the world" (ibid, p.79). The icons used to represent actions were the *plus* symbol for adding a facility to their personal list, a *minus* for removing a facility from their personal list and an *eye* for only browsing a facility without the user making changes to their personal list. The test users quickly fathomed what they could do in this view. So, the interaction design was considered to be a success since it aligned with what Norman (2013) explains to be the goal, namely "to enhance people's understanding of what can be done, what is happening, and what has just occurred" (ibid, p.4) and included the importance of *feedforward*. The test users considered it useful to be able to modify their list according to whom they act as back-up support to. One test user commented that "this is smooth". However, some feedback that was voiced by the test users was that they would like to see a description while hovering over objects, they wanted to click on the entire row or the eye to only enter a facility and that they wished for the two lists to be more distinguishable. Resolvedly, by for instance applying another colour to their own list. Affording the user to click on the entire row and dividing the list through a green line were implemented as possible solutions.

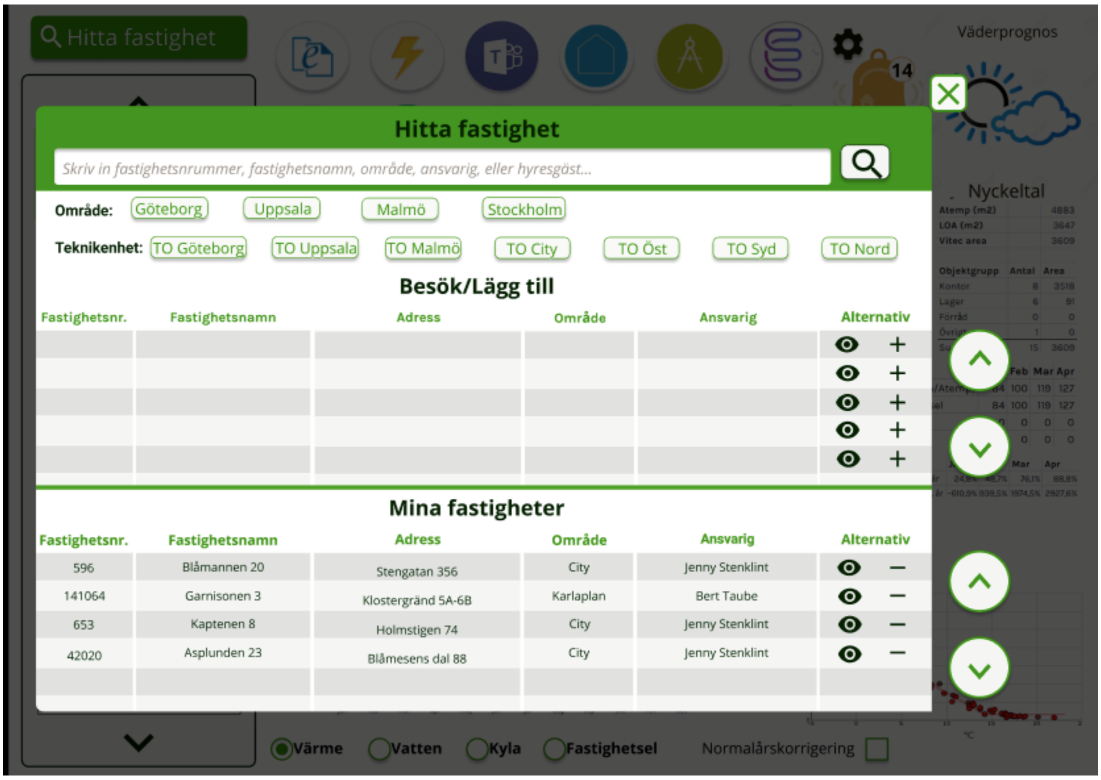

Figure 20: The find a facility view, showing the search field, the filter options and lists.

Notwithstanding, the *affordance* (Norman 2013) of the search function was an important design aspect. The result seen in figure 20, was a fusion of what started out as two separate designs. This was due to the fact that the test users stated that they liked both of the designs and considered them to be equally relevant. This was also a case where the customization requirement was put into effect as multiple preferences were met.

So, the search field had a placeholder text stating what terms the user could enter as a *signifier* of the search's *affordance*. The possible search terms were: *facility number, facility name, area, responsible technical facility manager or the tenant.* When the test users were asked to analyse the search field and share their opinion, they reported that "it is a good complement, I think my colleagues will appreciate this", "good search and filter", "you do not always know the colleagues facilities and their names" then added it that was good, "I would primarily make a search on the facility name, perhaps also the technical facility manager", "really good possibilities to sort in order to find what you search for", "I usually search by facility name. Unless it is my facilities, then I know the facility numbers". All in all, the test users claimed that they liked the design of the *find a facility* view. Their immediate responses were "Oh, smart", "it feels very detailed" and "this is awesome". Numerous test users had a positive approach to the ability to search based on the tenant and commented that "it could be reasonable", "that is good" and "super good" then added especially in the cases that were related to backup support. They based their statements on past experiences where they would have considered this search option useful. One stated that a tenant in one of the facilities that they back-up supported, called and they did not know which facility the case related to. Another test user recalled that they had not been able to provide a supplier with information as they did not remember who was responsible for the facility that the supplier was working in. Hence, they considered the tenant as well as the technical facility manager search terms highly relevant.

Besides the search, the users could select a *region* or a *technical unit*. These were buttons and not checkboxes as it was considered unlikely that a user would be interested in an area that was not in close proximity to their current facilities. Thus, they would only be interested in one choice, and only afforded one choice. Against this background, one test user stated that they only needed one filter option as their geographical region only held one technical unit. They regarded having both the options of selecting region and technical unit as excessive and when reflecting further they remarked that "I do not know if the buttons are needed at all, you free search". At the same time, they added that "it is a matter of taste" and that the buttons could be reasonable if you were located in Stockholm. Broadly speaking, the test users were pleased with the search view likewise the buttons and commented on them as "that is good", "well, that is perfect" and "very legible".

8.4 The Main Panel

In this section, which is the largest one, the requirements of providing facility information, knowledge sharing, facilitating structure and planning as well as providing the user with data for a proactive work connected to a facility are discussed. This area consists of design discussions and proposals regarding documents, links to automatic control system, the view with a list of alarms, the notebook view, the view of the log function and how statistics could be presented, all seen in figure 21.

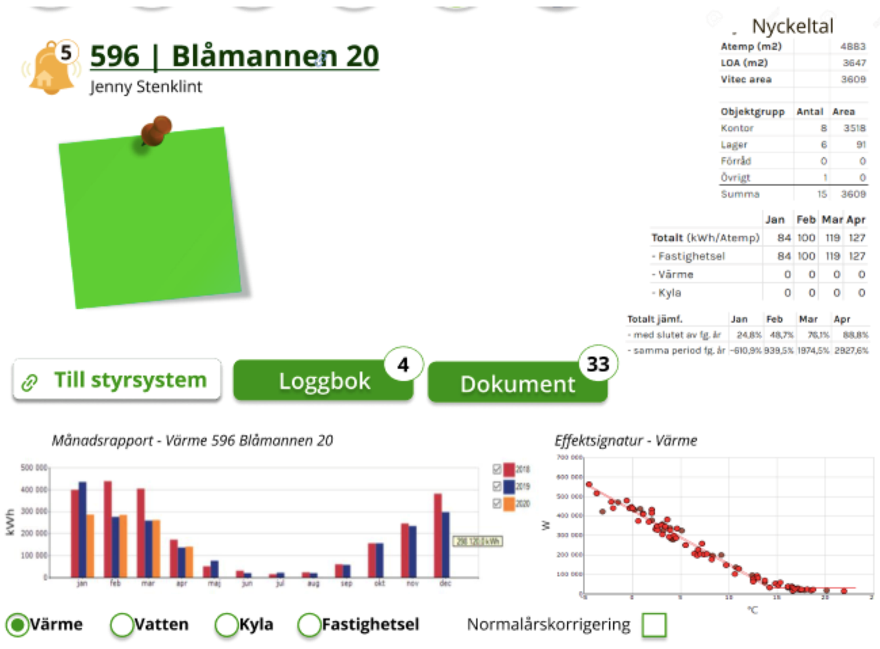

Figure 21: The portals interface over the main panel with facility information.

8.4.1 The Requirement to Assemble the Facility Information that the User Relies on in Their Common Practice at One Place

The last section which Sullivan (2003) brings up, is the larger area with the main information and operations that the user seeks. In this regard, the main content area comprised the information coupled to the selected facility in the navigation panel. Hence, the information and features presented in the area were the *facility name, facility number, responsible technical facility manager, alarms, statistics, notebook, documents* and a *facility log*. Vicente and Rasmussen (1992) claim that the user interfaces should support associated perceptual processing as work activities are linked to competence and knowledge. Therefore, the design aims to facilitate the user's competence and knowledge creation.

The user could access *documents* with information coupled to the facility, a feature that they stated was good. By placing documents in the portal, the user could conduct a larger part of their work within the portal and thus, their work structured could be supported (Ehn, 1988; Norman, 2013). When discussing the need of connecting documents to a facility, blueprints, agreements and templates were brought up. What one test user stated during the usability tests was that they had created their own ordering template with the facilities *Global Location Number,* the *facility number,* the *facility company* and *address* which they could copy and paste on to orders. They stated that the information for compiling the template had to be sought on various places and in different portals. Thus, this information could be collected as templates in *documents*. As a reminder (Norman, 2013), information concerning the number of documents that existed in connection to the facility was displayed with a number, seen in figure 21. The same signifier was used for the log function, on the left side of the document button, which will be further discussed in the section '*8.4.3 The Requirement to Support the Structure and Planning of Everyday Work as well as Follow-up on Processes'*. It should be noted that by implementing the documents which the user otherwise searches for through the *Facility Portal* or *Doris*, the user could stay in this proposed portal as facility information was better assembled, which supports the user's requirement.

Furthermore, the main point with the portal was to access the various automatic control systems of the user's own facilities as well as the ones that the user back-up supported. Hence, a vital function was the button that stated that it led *to the automatic control system* and the icon that signified that the button was a link path. Additionally, the usability test uncovered that test users also wanted to be able to click on the facility name in order to gain access to the same automatic control systems that the main content area referred to. So, this link path was added to the portal. Connected to this, when the test user hovered over the button and link an information text would be displayed.

All of the test users found these alternatives to be intuitive. When entering the automatic control system, the portal ought to remember the level of access and login. This is supported by the discussion that Norman (2013) makes concerning security. The human ability to memorize security passwords is restricted, hence it should be connected to the profile in the portal so they would not have to login to each automatic control system respectively. Regardless of this is an important function, how this ought to be designed was not addressed in the usability test. Hence, this will be further discussed in the section '*9. Reflection on the Proposed Design*'.

When clicking on the alarm bell, whether it was the small one that was connected to one facility or the larger bell which was connected to all of the facilities in the navigation list, an overlay was presented on top of the portal's interface, seen in figure 22a. The table that covered the portal's interface contained the information associated to the alarms and held seven columns. These were the *date*, *status*, *notation*, *common name*, *facility number*, *alarm code* and *actions* to change or move the alarms all of which the users considered necessary. Displaying this information of function and status supports what Adler and Borys (2004) denote as *enabling* in their discussion regarding *internal transparency* since the user could access desired information concerning the status of the system. According to one test user, the alarm code could entail widespread and diffuse text, since it was retrieved from the automatic control system. However, the test user further explained that "this is actually something which the one responsible for the house has to learn. You have to modify the alarm text to understand" and that this was something that had to be learned. Besides this, several users were unanimous and commented such as it "looks good", "can contain several alarms" and "you get an overview".

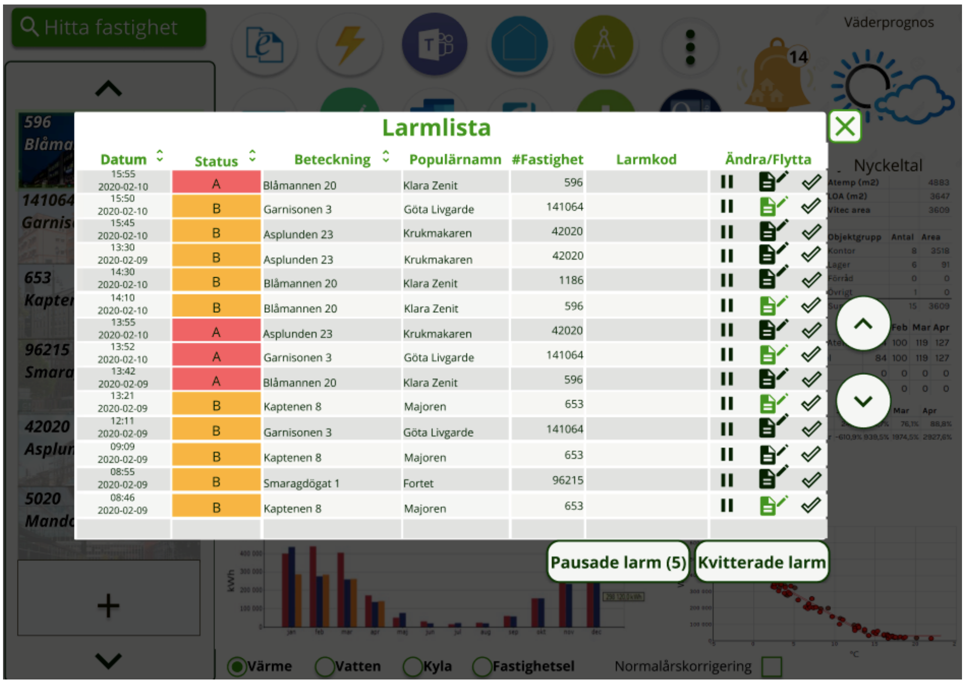

Figure 22a: What a populated table of alarms looked like.

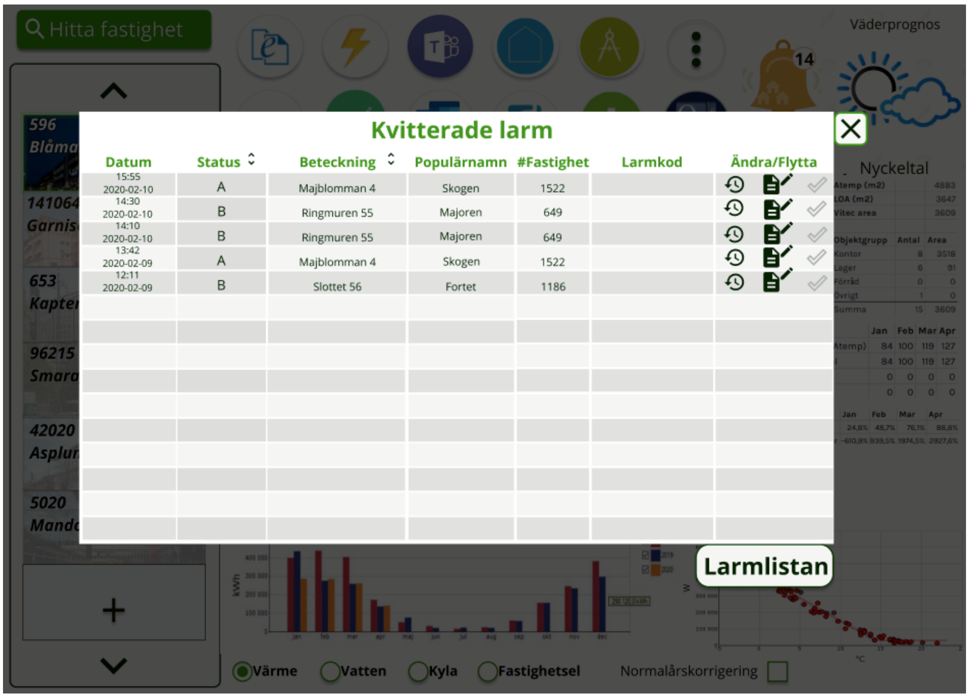

Figure 22b: What the receipted list of alarms looked like

During the usability tests, the test users stated that they would like to sort the lists according to the date and time as well as the status or the common name. What they considered to be the choice of preference varied. Therefore, arrow icons that indicated that the user could sort the list was added to all of the aforementioned columns. When testing this iteratively, the new set of test users considered the feature to be good. On top of that, one of the test users voiced criticism to the global list of alarms. This test user reported that “it sounds reasonable” but then added that they had experience from a common list of alarms and that “the list can become very long”. Consequently, the test user stated that they did not check the list due to the length.

In order to prevent the list from becoming too extensive and unstructured, the user could as previously mentioned sort according to the status of the alarms. Despite that, one test user specified that they wished for the possibility to filter the list based on alarm status. This is not something which this design addresses and the feature will be a subject of discussion in the section ‘*9. Reflections on the Proposed Design*’. What is more, besides having the possibility to sort, a pause action was implemented in the proposed design. The interviews revealed that users sometimes had alarms which they could not or chose not to deal with instantly. Hence, there were several alarms that they were aware of but did not act on. These alarms could stay active in the system for months or even years and thus, the pause feature would place them on a separate list. On this note, test users stated that they appreciated the pause action. So, in the course of the usability tests, test users stated that” this was new to me but it sounds reasonable”, and “it is a really good thing” and mentioned that they saw a resemblance to their “hide” action which they had in their current system. Nevertheless, the test users pointed out that there was a danger related to the option of pausing an alarm. For instance, the users concluded that “it is easy for me to forget them... if I see the alarm, I know it is there" and "it is somewhat dangerous to pause, there is a tendency that everything ends up there". What the user sought was some sort of *reminders* (Ehn, 1988).

Initially, the signifier to receipt an alarm was an 'archive' symbol. Also, the very first button label to the alarms which had been receipted was 'alarm history'. Notably, the usability tests revealed that the test users were more familiar with a 'check' icon as a representation to receipt an alarm and that the button should be relabelled to receipted *alarms*. Furthermore, all of the chosen logotypes and labels which were iteratively modified according to feedback from the usability tests, were applied in a *consistent* (Shneiderman & Plaisant, 2004) manner across the entire portal. This design decision corresponds to what Sullivan's (2003) points out to be the main aspects when creating a satisfactory labelling: to *label according to use*, *industry standards* and *in a consistent manner*. So, the receipt function entailed that as the alarms had been receipted, they ended up on a separate list, seen in figure 22b. To distinguish between the analogous views, one held a grey tone as an indication of age (Shneiderman & Plaisant, 2004). Considering that the portal's design also aimed to address errors, as errors can only be diminished if their existence is admitted (Norman, 2013), the user could restore a receipted alarm from the list over alarm historic by either pressing the check icon again or a bell. This was properly understood by the test users where one stated that "I would press the check again… Or the undo symbol, it looks like an undo symbol". However, one test user declared that "technically, I have neither been able, nor wanted, to retrieve an alarm which I have receipted". Though, there were a discordance over the restore action as another test user stated, "I think this is good".

Besides being able to pause and receipt an alarm, the user could add a comment to it. When the user had posted a comment, the icon of a paper and pen was highlighted green as a signifier which would notify the user with the information of an existing comment. Thus, it became distinguishable from the uncommented ones (Shneiderman & Plaisant, 2004) and was a way to provide the user with instant feedback (Norman, 2013) on that they had been successful in creating a comment. To make certain signifiers and smaller areas stand out by applying colours is something that Tufte (1990) advocates. Colours can serve as an intermediary of communication between the user and the interface. In the course of the usability testing, the test users demonstrated that they understood this information concerning the available comment. By the same token, colours were also inserted in the status list. As promoted by Tufte (1990), colours can serve as a *quantifier*, which is why the various status codes were coloured in a red gradient. The colours would be applied instantly when the list was rendered, as it was based on the information provided from the automatic control systems. Here, the most intense red colour depicted a more urgent alarm than the ones that were coloured orange. Wherefore, this could be a way to provide the user with quick information for comparison between the alarms and thus, help with the prioritization. Thus, this followed what Shneiderman and Plaisant (2004) emphasize regarding colours, to apply it in such way that it supports the users work along with an automation appearance. The test users liked this colour scale representing a quantifier. As one test user mentioned "many systems only have red" and further stated that they though a gradient was superior.

8.4.2 The Requirement to Promote Knowledge Sharing Among Technical Facility Managers and Associated External Parties

The *notebook* should entail updated and relevant information that the technical facility manager considered important for other users who visited the facility. This could for instance be information concerning an ongoing renovation. Thereby, the feature promoted knowledge sharing of *tacit knowledge* depended on its *context* (Schön, 1995; Polanyi, 2009). One test user told that they had implemented a similar feature to their own system as well as added a "to do"-list. They used it as a reminder to self of errors that could not be managed instantly. Hence, the test user found it a relevant and helpful feature. Complementary to this information sharing, a *facility log function* was displayed so all users could follow-up on the facilities' operation status and the processes. Additionally, placing documents in the portal also covered the requirement of sharing information and knowledge as the user could upload guides and manuals. Yet, the log function will be further discussed in the following section. The notebook was added as a way to handle the *semantic constraints* (Norman, 2013) which are established when the facility knowledge is bounded to one user. Hence, the knowledge that each user brought as *constants* into their work (Schön, 1995) could thereby be shared in an artifact disclosing "the values that will shape their practice" (ibid, p. 309).

8.4.3 The Requirement to Support the Structure and Planning of Everyday Work as well as Follow-up on Processes

Apart from that, Norman (2013) emphasizes to place the knowledge concerning notes, checklists and reminders in the world and reduce the burden placed on the memory. Additionally, it could serve as reminders for reflection on the current and future operations (Ehn, 1988). Hence, there is both a signifier in the portal's main view concerning the reminders' existences, how many logs that exists, in addition to the information that the log contains when browsing it. On top of that, prior interviews showed that the users *accumulated knowledge* connected to their facility over time and some can operate it in an automated fashion by relying on their *procedural memory* (Norman, 2013). As the users have claimed, they primarily enjoyed the problem-solving aspects of their work. Even though that the level of experience varied among technical facility managers, by having faced different cases they established a *repertoire* of experiences which they could apply in new situations (Schön, 1995). These experiences and generated expertise ought to be shared in the log function. The ultimate goal would be if the user's *tacit knowledge* (Polyani, 2009) could be traced in the daily notes as "we know more than we can tell" (ibid, p.4). Hence the tool is constructed for both personal and mutual interests.

As aforementioned, an appreciated feature in the proposed design was the log function. Having clicked on the log button, a list covering the logs of facilities appeared as an overlay. The view can be seen in figure 23. Each log had a timestamp and date attached to it in order to trace its history and when modifications had been made. The timestamp and data were generated automatically as each log ought to have that information affiliated. Not only that, each log held information regarding who created it which was something the users requested. Generally, the log supported the design goal that Shneiderman and Plaisant (2004) explain as to provide the operators with adequate information concerning status such that the user would understand what to be done when a necessary action was needed. Also, this *enabling procedure* gave the users insights to the work methods which they managed and codified "best-practice routines" (Adler & Borys, 1996, p.72). As reported by the test users, "it is good to have the time if you for instance have more information added later during that day", "I am pleased with the comment, user and date", "It is good. It does not have to contain that much more. The most important information is who has done what" then the same test user added that "I think you have captured the essentials". Also, the usability tests disclosed that the test users wanted to be able to attach documents or images to the log posts. Hence, an attachment logo was added to one log post. Even more, the test users remarked that they wanted the information about which facility's log they currently were browsing, as each facility had its own log. Implementing this feedback and adding this to the display was further supported by Norman's (2013) discussion concerning placing knowledge in the world as well as Vicente and Rasmussen (1992) proclaim that the design ought to provide the adequate support. Not providing the facility name in the log view forced the user to remember which facility they had just entered, which burdened the memory system and would be unsupportive.

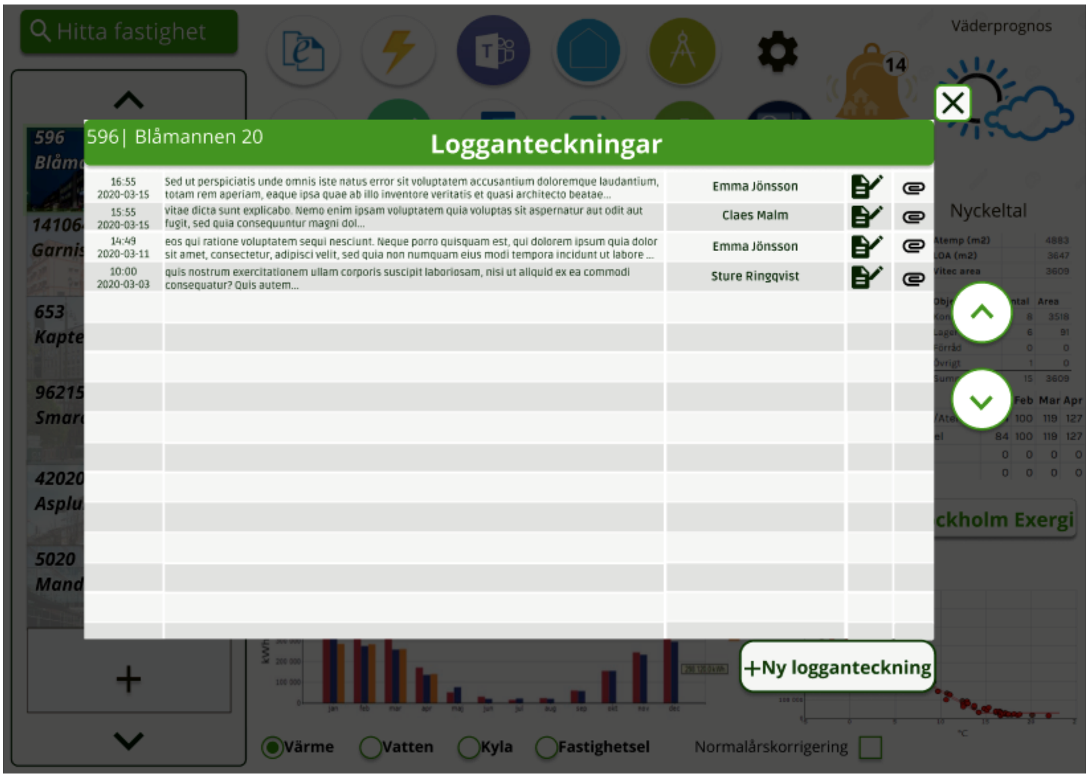

Figure 23: The design of the table with log notes.

In order to create a log, the user had to press the button with the label *'+ new log note'*. In the initial design, the button was located in the header. However, the usability tests confirmed the important aspects of consistent design and mapping among objects which Norman (2013), Vicente & Rasmussen (1992) and Sullivan (2013) raise. That is why it was placed in the bottom right corner, alike the other buttons in the portal. This uniform design was further employed in the icons that represented the actions of reading a log post as it was the same that was used in the list of alarms which support a *consistent design* principle that Shneiderman and Plaisant (2004) suggest. For browsing a log post, the user could click on the icon with the pen and paper, or on the entire row. Opening a log post by clicking on the row was something which the test user proposed during the usability tests. Also, given that log posts could be quite long, they would be cut in the column. However, when hovering with the mouse over the log post, it could be displayed in a temporary text field.

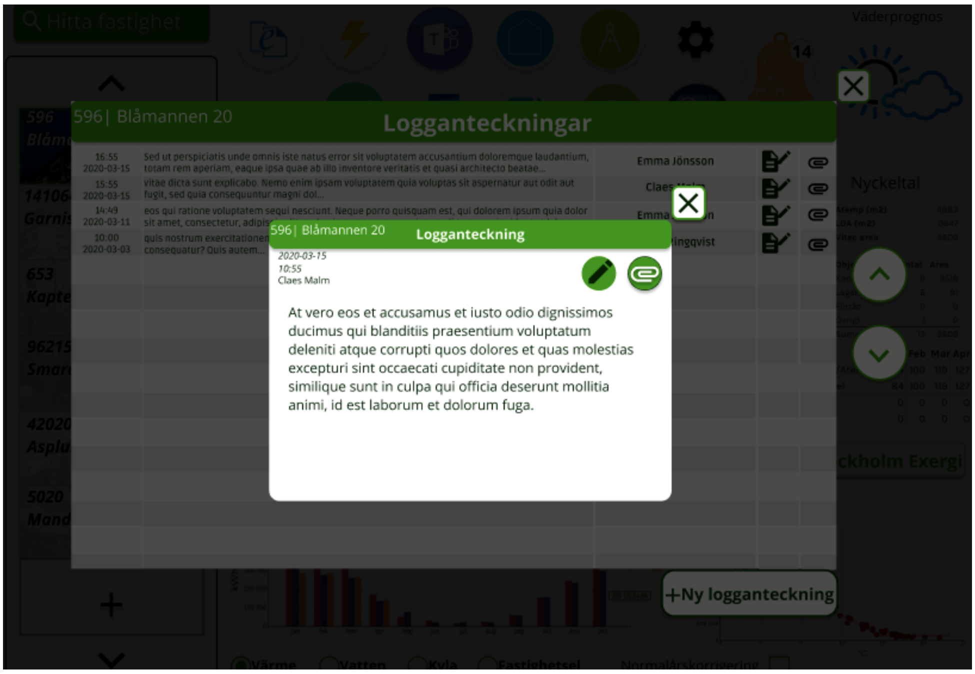

Figure 24a: How one log note is presented when it has been opened with the choice to edit or add an attachment.

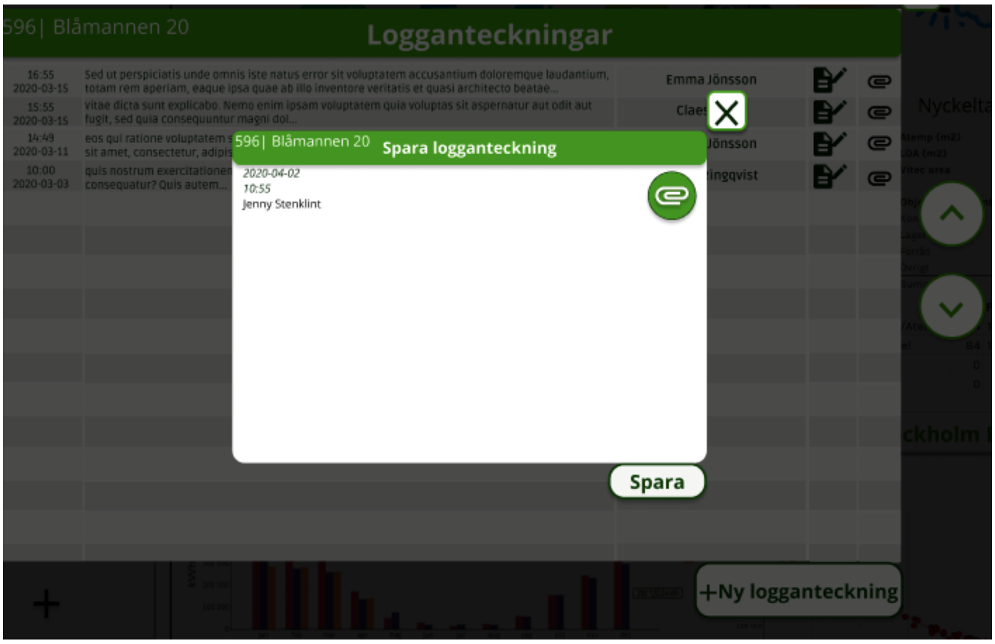

Figure 24b: How to create a new log note and being able to add an attachment.

When accessing a log post, figure 24a, or creating a new one, figure 24b, a window appeared as an overlay. If the user wanted to create a new log post, it was an empty text field with a timestamp, the user's name and the facility name as well as its facility number. The user could write a log post and add an 'attachment' by clicking on a button. If the user wanted to change an existing logpost they had to click on the button with the pen icon that signified the action to *edit*.

As revealed through the interviews, the users kept private logs of the output and set-point values coupled to the automatic control systems, as seen in figure 14. Therefore, a shared log would aid the users to structure their work, reduce their memory load and enhance their optimization of operations work. When the log function was discussed in the usability tests, the test users stated that "it is really good if you act as back-up support and have changed or receipted something and are unsure ", "good if I have done something in the systems which others want to take part of /.../ good with it all collected" and "highly sensible… Not actually a strange function but the alternative to place that information in the automatic control systems is seldom given".

8.4.4 The Requirement of Accessing Data Prerequisites for Managing Energy optimization and Proactive Work in Facilities

In order to address this requirement, statistics and key performance indicators were displayed at the bottom of the main content area. They were produced iteratively by implementing the feedback from the usability tests where the test user was asked to discuss the figures presented combined with questions if they wished for other numbers. The test users claimed that they considered it "enjoyable to see energy consumption" and further specified that they liked seeing the statistics concerning the indoor climate which they were optimizing. According to the test user it would make it "easier" and be useful to have it presented directly instead of having to enter *Vitec*. This would "reduce the number of clicks". The iteratively disclosed figures were the use of heating, cooling, facility electricity and water. Furthermore, the key performance indicator was coupled to energy performance and showed the total energy use divided to the aforementioned usage posts. The test users stated that "this is really good. It is the plots we look at" and "it is really good. I think you have captured everything" then they explained that today these figures were not found in one place as in the prototype. Instead, they had to make several clicks and go through multiple steps in various systems for the sake of finding the displayed information. Against this background, one test user recommended to add a button and linking to *Stockholm Exergi* as they stated "there you can get reports that are updated daily, before we get them in our systems". Against this background, displaying these figures was a way for the user to get *feedback* on their operations and evaluate their work performance (Adler & Borys, 1996).

9. Reflections on the Proposed Design

Evidently, the users were pleased with the initial prototype design of the system as their responses were positive. However, the first critical design aspect of the proposed prototype is that it ought to be understood as a starting point of a more extensive and advanced design solution. Since the design process is iterative, more testing would be preferable to refine current features and test additional ones. Also, the test user population could be widened and include more primary as well as secondary users.

Secondly, while some measures for error prevention were integrated to the design, more emphasis should be made concerning this area. An idea would be to notify the users when there is a possible risk of future errors or alarms in the automatic control system. Withal, such a solution would require a certain degree of connectivity of the automatic control systems. As of today, this is not the case. Error preventing alerts could for instance be connected to deviations on field level measurements, when certain values or information could erroneously be modified or deleted. Feedback and feedforward are thus crucial as error prevention measures. How to present the feedback should be further studied. A possible way would be through modal dialogs (Fessenden, 2017). To implement error preventing constraints is also a field which could be further analysed.

Thirdly, even though that the thesis work held the user value at centre, the design ought to be technically feasible. The integration of systems could become a complex process. Moreover, it could be expensive and the business aspects have to be considered as well. However, as this is an initial exploration concerning the needs of a tool such as the presented one. The results have illustrated that this is something that could become valuable for the users in managing their daily work.

9.1 Information from the Automatic Control System

The most crucial aspect of the portal was to reach various automatic control systems. However, what kind of information that could be retrieved from the systems installed in buildings varied. Importantly, the portal design supported the *access* to information on the automation level, as mentioned in *'2. Background - A Description of Systems*' and figure 1, through intuitive representation. As of the automatic control systems, the *structure* on the information level is set and follows the manufacturer. Due to the large number of manufacturers and age of systems, there is a great variation in terms of features, functions and connectivity. This poses challenges when implementing a portal, since information retrieval on a large scale depends on the standard of the automatic control system. The constraints built into the system restrict not only the way in which work is conducted, as proposed by Ehn (1988) and strengthened by Norman (2013), but also restrict the possible design solutions. Some information from set-point and output values might be difficult to transfer from the field level to the information level of the building automation system. As revealed, the users built up knowledge about deviations between the information and the field level. This implied the need of comparing values on various levels of the building automation system. Furthermore, and despite that the portal may present e.g. the number of revolutions, it will not reveal the sensoria information such as the sound of a fan. Instead, a better representation should be seen as a complementary source of information that serves as an indicator of when further investigations are needed.

Apart from this, values perceived at the field and information level ought to be better integrated to the main content area of the interface. This could support what users desired, namely, to have one holistic system and not several separate ones from various suppliers. In the proposed portal design the automatic control system was incorporated by links. In practice, this implies that the user accesses their automatic control system through a RDP-connection much alike today. An improvement would be to fully integrate the automatic control systems in the portal, thereby allowing the operation chart for each facility to be shown directly in the portal's *main area*. By presenting output and set-point values from components directly, users would be able to conduct more proactive work with less effort. By having these figures more at hand, the users would be provided with better prerequisites to react on deviations prior an alarm or error errand. This would promote error prevention among users and foster a better error handling culture (Norman, 2013). Figures of interest are valve, pump and media values. However, it should be noted that displaying these values will not *replace* the need of gaining the knowledge from field work and modifying the system by hand. Thus, the portal should also support the field work and therefore, promote usage on mobile devices.

9.2 Access to the Automatic Control System

As of the current connection to various SCADA-systems by links, the user had to log in respectively. In such instance, the users should not have to enter their username and password for every system they wished to enter. Having to do so was a source of irritation and confusion, according to the users. Passwords can be understood as *constraints* (Norman, 2013; Sullivan, 2003) because they constraint the access to the systems and could also prevent the user from making errors. Their aim is to provide the right access to the right people, so they pose an important security function. Realizing that not all users are authorized to the complete set of systems, they should nevertheless not cause such resistance that the users create their own, easier ways of accessing common systems. It becomes impossible to know who did what in what system when all users use the same login account, as they do in some of the studied systems today.

A *logical constraint* (Norman, 2013) held by some of the studied automatic control systems was that they only allowed for one remote user at the time. This deficiency might not be *removed* from the system, but improvements should be discussed. To mention one possible solution, the system should provide the entering user with information that the current user will be thrown out. This would provide the users with *feedforward* (Norman, 2013) as they are acknowledged prior an action that might hinder someone else in their work by getting them thrown out of the system.

9.3 Implementing Tools in the Portal

Ideally, users should be able to *use* the tools directly in the portal. In further developments of the prototype, more of the associated tools would be integrated to reduce the number of new pop-up windows and the need to shift from the portal. This would reduce the *divided attention* forced among users and reduce the risk of possible errors (Norman, 2013). *DeDU*, which was used for error reports and communication with tenants, is an example of a tool that could be integrated. This since *DeDU* is one of the primary tools which the user relies on. By extending the current error reporting poll with a reply function, it could promote knowledge sharing between the user and the tenant. As the user makes adjustments to the automatic control system, they could more easily inform the tenant and educate them about climate regulation if the feedback tool is accessible within the portal. Furthermore, they could share progress and goals, thus improve collaboration. Also, the user could access statistics from *DeDU* that would tell how often certain complaints were sent, what usually malfunctioned as well if the tenant got a response within 24 hours, according to Vasakronan's goals. This statistic might also facilitate the user's analysis on their work (Adler & Borys, 1996).

On top of that, the function that enabled the users to edit in their selection of tools in the portal, seen in the global panel in figure 18, should be designed and tested. Implementing *flexibility* that would support the users specific work demands (Adler & Borys, 1996) is seen as an important aspect as customization was one of the user requirements.

Another implementation regards one of the raised issues in *'The Requirement of a Holistic View '*, namely the vast amount of communication tools. Yet, since the technical facility manager could be considered as an expert on their facility and a large part of their work consisted of problem solving, facilitating the communication among the technical facility managers could be seen as important. Communication happens partly through the proposed log function, but being able to ask questions related to operation management in a forum implemented in the portal could be a future implementation. A forum for sharing insights, knowledge, problems, solutions and experiences. Notwithstanding, this has to be tested and further studied since it should not increase the current experience of "messiness" among the various channels. A probable solution would be to analyse how *Microsoft Teams* could become integrated.

9.4 List of Alarms

Importantly, the user should not be forced to receipt alarms twice, in the portal *and* in the automatic control system. As of the current system structure, there is a one-way traffic of information between the list of alarms and the automatic control system. This opens up for a mismatch, or *inconsistent mapping* as Vicente and Rasmussen (1992) put it, of information between the systems. This since the user may clear an alarm in the alarm list while it remains in the automatic control system. Moreover, this also opens up the discussion regarding the possibility to restore an alarm as it should also be restored in the automatic control system. However, the users should be able to make these likely errors and be able to correct them (Norman, 2013; Adler & Borys, 1996)

Furthermore, the proposed design includes a pause function of alarms. As revealed by the usability tests, this was not an entirely unproblematic function. There is an associated risk in hiding information about the system status since it impairs the mapping (Norman, 2013; Shneiderman & Plaisant, 2004). Just as with receipts, the pausing of alarms is exclusively related to the *representation* of information in the portal and logically connected to the system within the facility. Nevertheless, the experience of such a function is to be understood in relation to the user's intended use of the alarm list. In their everyday work, the representative user used the alarm list for error handling. Not all errors could be fixed at once, but entail lead times due to the delivery of components or service work from external parties. Therefore, a system design idea would be to include a calendar or a timer. Anyhow, any possible design solutions were not tested with the user. When pausing an alarm, the user could be faced with a *modal dialogue* (Fessenden, 2017) which would force the user to decide a date of when the alarm should be brought back to the alarm list. In testing this feature, one could elaborate with various time settings and intervals. Pre-set intervals would come in handy because they save time and require less effort from the user. The user can easily decrease mental workload by removing pieces of information that are not relevant at the time being, relating to what Norman (2013) denotes as putting *knowledge in the world*. *Too short* pre-set intervals might cause irritation among users if they have long lead times, since they would have to prolong the pausing as time passes. Alas, shorter time intervals would function as an important reminder (Ehn, 1988) of the underlying alarm. *Too long* pre-set intervals might come out risky since the user might forget to follow up on the associated process, but might be preferable in cases of long lead times. In contrast, a calendar would be a customized solution to time alarms. If the user knew the expected day of arrival of a component, they could easily set the alarm accordingly. The calendar could e.g. be on a daily, weekly or monthly notice. Yet, having a calendar presented in a *modal dialogue* would force the user to make a more demanding and conscious choice and as a consequence they might become frustrated. Testing is crucial to nuance what level of preciseness that is preferable to the users when it comes to pausing alarms.

As of now, the list of alarms possesses a sorting function coupled to date, status and notation. Despite adding the aforementioned pause function, the list of alarms may still be long and difficult for the user to grasp. As one test user told during a usability tests, a filter function based on the alarm status could be a possible solution. Such a filtration would enable the users to access the alarms information of importance while temporarily exclude the uncalled-for information (Vicente & Rasmussen, 1992). To achieve natural mapping (Norman, 2013), the filter function would be designed by using an icon that illustrates a filter. Furthermore, the filter icon would be placed in close proximity (Shneiderman & Plaisant, 2004; Norman, 2013) to the column that it ought to filter, which is the status column. Despite this function being seemingly relevant to integrate in the design, it was not incorporated in the usability tests and thus, not a part of the prototype. Hence, this calls for further testing and exploration.

A further development of the proposed design concerns the alarm code. As of now, the alarm lists display the alarm code in the same format as it is received and generated by the automatic control systems. As revealed by users, the understanding of the alarm code relies on the user's knowledge of the automatic control system and how the manufacturer of the system chose to generate it. Thus, the alarm code format may be understood as a *semantic constraint* (Norman, 2013) hold by the automatic control systems. Further supported by Norman (2013), a design should support good performance even in absence of previous knowledge. Hence, further developments of the system should investigate possible solutions of reformatting the alarm code in the alarm list so that more knowledge is put in the world.

9.5 Documentation View

Today the users access various documents from disparate sources. Facility information that ought to be found in the documentation view regards blueprints, suppliers, supplier agreements, rental agreements and operation charts. The attached documentation should be related to the facility since it is mapped to one in the portals view. As suggested by one test user, the document view could e.g. display the 10 last updated or accessed documents found in *Doris*. However, it should be further investigated what documents that ought to be included in the documentation view in addition to how they should be presented. As a test user implied, some documents might be of higher importance than others. Also, the interviews in the section '*6. Results for User Requirement*' disclosed that there is a great variety in the needs and errands among facilities and tenants, which arguments that there are variances in what documents that are found crucial to the user. To pursue the design requirement of customization, the documentation view should afford adaptability by e.g. permitting the user to choose their most commonly used documents. This should be placed within eye span, as supported by Tufte (1990), at e.g. the top of a list of documents.

Anyhow, at the one hand, one may argue that the current documentation policies should be followed and the proposed design should support those policies by following established traditions. This means, as an example, that the documentation should be integrated with *Doris* and *Rita*. At the other hand, most users pointed out several underlying problems with these systems and this implied that there is a need of a more *transcending* (Ehn, 1988) approach when designing the documentation view. A preferable set-up would be if the user could upload documents directly in the portal without having to enter *Doris*. *Doris* could then function as an underlying system, and the system's *traditions* (Ehn, 1988) could be maintained, while the user interface would be improved. Also, this would enable the users to access information at more ease since they are less likely to be overwhelmed by the passive amount of information (Sullivan, 2003) that is the case in *Doris*.

As the documentation view also would entail blueprints, it should provide yet a feature. As the interviews revealed there is an inconsistency between the blueprints and the facility’s outline. In this view, the users should be able to edit and update blueprints with information regarding the location of physical components, such as the DUCs, on the information and the field level. As of now, this *tacit knowledge* (Polyani, 2009) is coded to an insufficient degree and exclusively tied to the technical facility manager and partially to their back-up support. The main content area should provide a common platform where this knowledge is tied to the facility rather than to the individual. These extended blueprints ought to be in at least two dimensions, since they should provide the users with spatial information concerning both floor level and location. Thus, current blueprints would first have to be transformed to multi-dimensional blueprints. Thereafter, they would be complemented with an edit mode where the technical facility manager can choose from a certain set of icons (Shneiderman & Plaisant, 2004) which they can add to the physical components on the information as well as the field level of the building automation system.

9.6 Main Content Area Displaying Facility Information

Nevertheless, open-access to facility information poses some noteworthy thoughts on information security. Not coding this knowledge could be seen as one way of controlling who knows what, since information sharing then relies on knowledge transfer from one person to another. One could argue that the number of people who must have access to this knowledge is rather limited and that providing the information sharing infrastructure opens up for external threats. That might be the case, but the fact that users created their own information sharing infrastructure suggests that this is a deficiency of the current system and security culture. Passwords may serve as possible constraints in other proposed features, such as the log function and the notebook. As of the log function, it is equipped with an edit and a reading mode. Depending on the authority of the login account, the user could have varying degree of access to the edit function in the log. It seems reasonable that the technical facility manager and the back-up support possess both edit and reading access, while other colleagues only have reading access. Using authorization in this way is supported by Sullivan (2003) and Norman (2013) as means to prevent errors. However, such a solution relies on that the users use their own login accounts.

Notwithstanding, some users that had higher level of security due to requirements from the tenants. Therefore, they could not store things digitally. This had negative implications on their work as they could not conduct it remotely and had to maintain as well as hand over artifacts personally. It could be valuable to investigate whether their work structure and artifacts could become digitally connected in a system that met their need for a higher level of security.

9.6.1 The Alarm Bell

Accessing the right facility information at the right time is crucial for managing work tasks. As shown in the consolidated work model in section '*6.1 User Data Categorized into Consolidated Work Models*', information about the status of the system through alarms was crucial information to the users since they ought to act on urgent alarms instantly. To increase the salience and highlight the alarm bell, one solution would be to animate them. By adding an animated bell that is activated by certain levels on the alarms, the urgent alarms are *differentiated* from the non-urgent alarms (Tufte, 1990) and the animation acts as a *signifier* (Norman, 2013) of when actions are required. Other possible solutions that would provide the user with more information connected to the alarm lists could be by applying colours, shadows, different thicknesses, icons or numbers as quantifiers or illustration of status (Shneiderman & Plaisant, 2004). As of now, the prototype includes one number connected to the bell icon, seen in figure 17, which presents the total amount of alarms in its list. However, this could be further studied, modified and customized to utilize the human capacity by providing the user with more information connected to the alarm list in the main view (Tufte, 1990).

9.6.2 Key Performance Indicators

The design of the key performance indicators as well as the statistics from *Vitec* are a first attempt of promoting proactive work and spur the joy found among users in energy optimization. With that said, there are more things to be done in this area. Some users wished for a prognosis tool and chart. A prognosis feature could thus be added to the portal, where the user types in various set-point values and study the output values and the associated performance chart. Such a function would both work to encourage the users to lower the energy performance in their facilities through its proactivity, but also prevent errors from occurring. The user would not have to wait to find out the future results when they adjust some values in the automatic control system, but be assisted by these energy performance forecasts. Such a function would provide the user with useful feedback (Norman, 2013) on what consequences their adjustments would entail. Moreover, to provide the user with their progress in relation to Vasakronan's goals and comparison to other metrics could be investigated. This would support what Adler and Borys (1996) claim about an *enabling* design towards *global transparency* where the user gets holistic contextual information on processes. Consequently, they can recognize wider improvements.

10. Final Thoughts on Legacy

Some concluding remarks regarding what Norman (2013) denotes as *legacy problems*, which refers to the obstacles of implementing new systems in relation to current ones. Integrating existing systems to a new portal requires that the current ones and their attached data are updated. As pointed out by users, many of the existing tools that they were using today worked slowly. If these are not updated and renewed, the new system or portal will carry the deficiencies of the old ones, only with a nicer interface. This could cause frustration which would cause a perception of low quality of service (Shneiderman & Plaisant, 2004).

However, legacy problems might also be understood in terms of the users' inhabited work practice. As pointed out by Schön (1995), users are framed in their practice and will most likely protest as these frames are challenged. Introducing a portal may be perceived as such as challenge. To manage these legacy problems, the compliance relies on getting the users to use the system in their everyday practice. For this to take place, the user must understand the intended use as well as the benefits of using the system, as opposed to the old one. They should feel comfortable with using the system.

What is more, the tool has to acknowledge future development and be revised periodically. New important tools can emerge as well as the employees can change the way they conduct their work. As their language can change, so ought the communication in the portal (Sullivan, 2003). Thus, the tool must evolve with its users.

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Appendix 1

Description of the Consolidated Flow Model

Technicians employed at the company *Coor* had as their main duty to provide facility services and handle error messages. They patrolled the facilities to inspect the functionality of the devices. *Coor* communicated with the user about questions coupled to service, agreements, facility information and expenses. Primarily, the communication concerned error reports, who should run what errands, and quicker and simpler tasks were forwarded to *Coor*.

Project managers managed projects coupled to facilities. The user and project managers conducted the planning of projects together. On site, the user helped projects managers with guidance.

The *energy group* purposed as a forum for generating and discussing ideas coupled to energy saving solutions. Users gathered to share knowledge and brief ideas on how to improve energy performance in the facilities.

The various *suppliers* had multiple functions. Generally, the user talked to suppliers about what needed to be fixed in the facility, hence, their contact regarded orders and service work. In this respect, the supplier functioned to deliver components and/or whole systems, and provide the user with services coupled to these. The user provided the suppliers with keys as well as blueprints, which they wanted adjusted according to any renovations that had been done. Additionally, the user provided guidance in the facility, coupled to deliveries and answered questions regarding operations.

Tenants leased areas in the facility from the user. If the indoor climate operations did not live up to expectations, the tenants would send an error report concerning the problems and malfunctioning components in the facility. Error reports and complaints were often followed by reconciliation on associated service work between the tenant and the user. Thereby, the user had continuous contact with the tenant about the operation status of the facility. Furthermore, the user tried to share knowledge and experience with the tenant about indoor climate for proactive purposes.

Customer service functioned as a mediator, primarily among the tenant, Coor and the user. Customer service had the first and foremost contact with the tenant as they received the error report, which were sorted and delegated to Coor and the user. Sometimes they could be passed between Coor and the user post the initial delegation. They also connected various parties across the organization and provided contact details. The user and customer service briefed each other on issues and information regarding the facility. They also had reconciliation on service work and supported errands. As suppliers were to perform work in the facility, the user handed over keys to customer service so that they could pass them over to the supplier.

Property managers were the chiefs of the facilities and functioned as necessary support. During the period when the user was newly employed, the property manager functioned to show what systems and tools to use for managing the facility. Since the property manager had budget responsibility coupled to incomes, the user and the property manager discussed budget and interesting parties.

The *on call-duty* worked with fixing errors post business hours. Thus, the user and the on call-duty communicated about urgent alarms on the most critical level.

As a t*echnical facility manager*, the user worked with facility management. This included to manage the optimization of building operations, relationship with tenants, energy usage information and indoor climate. The user also had to ensure that the facility fulfilled authority reglement and follow up on inspections. The user also supervised *Coor*.

The user talked to other *technical facility managers* about questions, ideas and budget coupled to managing the facilities. In this way, they shared information, knowledge and experience. Furthermore, they provided each other with back-up support and thus briefed each other on good and bad news coupled to their facilities as well as feedback from tenants. Coupled to this was also to brief each other on facility operation status.

Technical facility developers worked with identifying and outlining energy saving strategies for facilities in general that would align with the business goals on sustainability. Ideas were shared with the user, who was supposed to implement this new technology in their facility. Thus, the technical facility manager and the user worked together through discussing ideas, budgets, facility information and projects to improve energy performance.

Description of the Consolidated Artifacts Model

Several existing applications and tools were used by the user. To communicate internally, the user relied on *Microsoft Teams,* the *Teams Portal* and *Outlook*. For individual errands and questions, the user sent emails through *Outlook*. For less formal talks, the user took calls, either by phone or through *Microsoft Teams*.

To access information regarding facilities, the user had various portals to choose from. The automatic control systems were accessed through the *Operations Portal* and the *Technology Portal*. The *Operations Portal* assembled the complete set of SCADA systems among all facilities across Vasakronan. If the user knew the facility name, they could visit the *Technology Portal* and access the associated automatic control systems from there. If the user was interested in documents coupled to the facility, they would visit the *Facility Portal*. The user got access to protocols concerning authority inspections through *Q3Web*.

For self-produced documentation, the user wrote notes in some kind of record. The journal was either digitized and found in *Doris* or *OneNote*, or as a physical copy. It served to keep track on various processes. If the user made adjustments or replaced components in the building automation system, these were noted in the journal. The user also kept journal to keep track on their own work and to make sure that all work got done and that no responsibilities were forgotten. If the user needed to handle PDF-documents, the user utilized *pdfDocs*.

The user used several of the applications found on the intranet *Sofia*. In everyday practice, the user worked frequently with *Vitec, Doris, DeDU, Rita, Navigon* and *Palette*. *Vitec* was used by the user to follow up on energy performance in the facility. The numbers that the user typed in to *Vitec* were further transmitted to *Navigon*. In *Navigon*, the user worked with financial prognoses coupled to the facility. *Doris* was used to manage documents and share information and knowledge across the organization. *DeDU* was used to manage error errands from tenants and communicate with *Coor*. The user also used *DeDU* to place orders on broken and malfunctioning components in the facility. All invoices from placed orders were found available to the user in *Palette*. To sign invoices, the user used *E-sign*.

To find existing blueprints, the user relied on *Rita* since all digitized blueprints coupled to a facility were found there. Furthermore, the user complemented existing blueprints with self-made facility maps. The facility maps showed where to find the DUCs and the service and operation rooms in a facility. The user created these maps for own purposes when recently been assigned with a new facility. Further on, the user provided the maps to colleagues and suppliers to help them with guidance in the facility.

Descriptions of the Consolidated Sequence Model

Patrolling took place due to an error, proactive work or simply as a part of a routine. The sequence can be seen in figure 10. The purpose of patrolling was to check the physical status of the facility and compare the system values with values displayed on site. First of all, the user went to the DUC where the user checked the alarm list and observed the values that were displayed on the monitor. Then, the user used their senses, such as their hearing and sight, to inspect system sensors and components. Deviations between system values and physical system were adjusted to optimize operations in the facility. Afterwards, the user made documentation on what changes that had been made. Further comprising, the patrolling could uncover components that needed to be replaced. In that case, the user placed an order on the component or system, seen in figure 11.

Record keeping functioned to reduce memory workload and ensure that all work got done. The user kept journal when the system had been updated. It included daily planning and new updates. To document the journal about updates, the user first opened the record keeping tool. Then, the user scanned the latest updates and edited the journal to the current status. This was done for maintenance of information. The journaling sequence can be seen in figure 10.

Some problems had to be rectified by *placing an order* on new components or services, either because someone reported a problem or because a component malfunctioned. To fill in a smaller order, which were order amounts below 25 000 SEK, the first thing was to enter *DeDU*. The user selected an errand, decided that if it was a warranty errand and selected to place order. Then, the user filled out a form and selected the supplier of concern. The form was saved and sent to the supplier, who in turn sent an invoice to the user. The user could see the invoice in *Palette*. If the order amount was more than 25 000 SEK, the user placed orders by first entering the *Facility Portal*. The user chose a relevant supplier and clicked on 'ordering form'. The user filled in complementary information and saved the form as a PDF. Then, the user opened the web browser to visit *Sofia*. In *Sofia*, the user selected the *E-sign*. In the *E-sign*, the user filled in the form, attached the created PDF and sent the order to the supplier. The supplier sent the user an invoice, which was found in *Palette*. When the user wanted less administration than what was followed by placing an order in *DeDU* or the *Facility Portal*, they contacted the supplier directly. Then, the user called or emailed the supplier, placed an order and then monitored the order by regularly checking the status through email or telephone. The sequence for ordering can be seen in figure 11.

Errors were reported by either the tenant or the automatic control system. The user was notified about errors by notifications and alerts through email and/or text messages. In view of diagnosing the error, the user started by opening the error message and analyse the received information and alarm code. If the error was found urgent, the user decided whether they could fix the problem through remote access. Otherwise, the user went patrolling. The patrolling sequence is seen in figure 10. In some cases, the user had to reach out to the supplier to be able to fix the notified problem and ensure proper functioning of the facility. In this instance, they placed an order on component or service. The ordering sequence can be seen in figure 11. Then, the user headed back to the office to pursue with other aspects of work. Thus, the user marked the error as done and documented what had been adjusted. The record keeping process could be seen in figure 10.

The daily *arrival at work* was initiated by that the user set up the agenda for the day. The intent of doing this was efficient time management and to make sure that all responsibilities would be covered. To ensure that the facility operated optimally and that the tenants were satisfied, the user checked the inbox for error reports forwarded from *DeDU*. Thus, the user entered *Outlook*, opened email from *DeDU*, screened email and checked whether the error was urgent. In that case, the user acted on the error immediately according to the error handling sequence, seen in figure 11. Not all defects were reported by the tenants, so to really ensure that the facility was working properly and optimally, the user checked for error reports generated by the automatic control system. Hence, they checked email, *Outlook* or the alarms in the automatic control system. If the error was urgent, the user acted on the error immediately. If not, they managed their email to follow up on processes. The user viewed their email, decided to handle a specific errand and replied to it. The user took part of meetings to manage their customer relationship and share information with colleagues. To know what meeting to attend, the user entered their calendar in *Outlook* and then participated in meetings in *Microsoft Teams*. To ensure optimal operations and fulfil business goals concerning energy saving in facilities, the user controlled and monitored the automatic control system and conducted field work. If the user decided that they were done with meetings and managing their emails, the user scheduled time in their calendar to visit the automatic control system on site during that time. The sequence concerning patrolling can be seen in figure 10. The user documented their work to keep track of processes and share information with colleagues. Documenting was conducted as the user decided that they were done with field work and optimization of facility operations. This entailed record keeping.

Description of Consolidated Cultural Model

Relationship with Overarching Business

Vasakronan focused on sustainability and was prone to find new smart energy saving solutions for their facilities. The user was therefore expected to certify their facilities to show excellent energy and indoor climate operation. As of the automatic control systems, the user sometimes experienced that the company prioritized the financial aspect to the functionality. Systems were often outdated and rather not replaced by new ones. As for other kinds of systems and applications, the user was provided with a great variety of resources. The difficulty was rather to find the one needed.

The organization allowed for the user to operate independently and practiced “freedom with responsibility”. There were no expectations on working post regular business hours, so the user felt that there was a sound balance between work and family life. But while working, the workload was heavy and full of responsibilities. Occasionally, the user felt that less emphasis was put on practical skills coupled to work practice. Instead, work had become more centred at the computer.

Relationship with Coor

The user had regular contact with *Coor*. Sometimes the user experienced that *Coor* did insufficient analyses of errands. Therefore, the user supervised that *Coor* did their assigned duties and helped them with errands if that was not the case. According to the user, *Coor* solved easier and more practical issues in the facility. Their work was often delayed and since the user possessed almost equal levels of practical skills, it occurred that they did *Coor’s* work if the errand was considered urgent. The user found it more convenient to fix problems immediately as they were discovered in the facility than calling *Coor*.

Relationship with Tenants

The user prioritized a frequent and easy-going dialogue with the tenants, and hence spent much time on communicating with the tenant. Regardless of leasing period, the user strived to establish a trustful tenant relationship. If trust was hurt, it had to be re-established. The tenant governed the user's daily agenda in several ways, since their needs ought to be fulfilled. Some tenants needed special treatments due to the nature of their business or organization, but fulfilling these was considered a part of the user's work role.

However, the user also had to make some trade-offs between the wishes from the tenant and the overall business goals concerning sustainability. In many cases the tenants had no interest in understanding how indoor climate related to outdoor climate, even though the user tried to share this knowledge. Some complaints expressed by the tenants were reoccurring, hence inducing monotone conversations and caused the user a lot of frustration.

The user enjoyed their work because it offered a great variety of work tasks and flexibility. However, the range of work tasks was sometimes too wide and caused the user to be burdened with high workload. In particular, the user suffered from having too many time demanding meetings and scheduled appointments.

Relationship within the Division

Among colleagues and team members, the user found themselves among equals and could tease colleagues in a friendly matter. There was a strong team spirit where the user offered support as well as was supported by colleagues in their everyday work. The general approach was to get work done so the user often stepped in to help the team out. Ideas and knowledge were constantly exchanged within the team.

As a new employee at the work division, the user often found themselves in a master-apprentice relationship to be introduced to how work gets done. However, the user was convinced that learning comes by doing so one should try first and ask later.

Relationship with Suppliers

The user had contact with many various suppliers. These were contacted by the user when problems occurred or something was to be fixed, but not otherwise. At the same time, the user was prone to share knowledge about the facility with the supplier to enable a greater understanding of the system and enhance co-development. As the supplier conducted work on site, they needed guidance by the user.

Appendix 2

Audio Tape Consent Form

- I……………………………………… voluntarily agree to participate in this research study.
- I have had the purpose and nature of the study explained to me in writing and I have had the opportunity to ask questions about the study.
- I understand that participation involves being interviewed, and, if consent is given, take part of an observational study.
- I understand that I will not benefit directly from participating in this research.
- I agree to my interview being audio-recorded.
- I understand that all information I provide for this study will be treated confidentially.
- I understand that in any report on the results of this research my identity will remain anonymous. This will be done by changing my name and disguising any details of my interview which may reveal my identity or the identity of people I speak about.
- I understand that disguised extracts from my interview may be quoted in the Master thesis conducted by the researchers.
- I understand that signed consent forms and original audio recordings will be retained in the researchers' private computers until the exam board confirms the results of this dissertation.
- I understand that under freedom of information legalisation I am entitled to access the information I have provided at any time while it is in storage as specified above.
- I understand that I am free to contact any of the people involved in the research to seek further clarification and information.

Johanna Holmqvist Larsson – Master of Science in Sociotechnical Systems Engineering – Energy Systems – johanna.holmqvistlarsson@vasakronan.com

Fanny Tapper – Master of Science in Sociotechnical Systems Engineering – Information Technologies – fanny.tapper@vasakronan.com

Signature of research participant:

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Signature of participant Date

Signature of researchers:

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Signature of researcher

Date

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Signature of researcher Date

Appendix 3

KRISINFORMATION.SE
Krisinformation från svenska myndigheter

Restriktioner och förbud

Här hittar du en sammanställning av de restriktioner och förbud som införts i Sverige med anledning av coronaviruset.

Foto: Melker Dahlstrand/Sveriges riksdag

Sveriges Riksdag och Rosenbad.

Nationellt besöksförbud på äldreboenden

Regeringen har beslutat om ett besöksförbud på samtliga landets äldreboenden för att förhindra spridningen av sjukdomen covid-19. Beslutet trädde i kraft den 1 april. Beslutet är generellt.

Den verksamhetsansvarige för ett boende får i det enskilda fallet medge undantag från förbudet om det finns särskilda omständigheter som motiverar ett undantag och om risken för spridning av coronaviruset är liten. Läs mer om besöksförbudet på regeringens webbplats.

Förbud mot allmänna sammankomster med fler än 50 personer

Från och med söndag den 29 mars får allmänna sammankomster och offentliga tillställningar ha max 50 deltagare.

Polisen kan ställa in eller upplösa en allmän sammankomst eller offentlig tillställning med fler än 50 deltagare. Den som anordnar en tillställning som bryter mot förbudet kan dömas till böter eller fängelse i högst sex månader.

Med allmän sammankomst avses:

- sammankomster som utgör demonstrationer eller som annars hålls för överläggning, opinionsyttring eller upplysning i allmän eller enskild angelägenhet
- föreläsningar och föredrag som hålls för undervisning eller för att meddela allmän eller medborgerlig bildning
- sammankomster som hålls för religionsutövning
- teaterföreställningar, biografföreställningar, konserter och andra sammankomster för att framföra konstnärligt verk
- andra sammankomster vid vilka mötesfriheten utövas.

Med offentlig tillställning avses:

- tävlingar och uppvisningar i sport, idrott och flygning
- danstillställningar
- tivolinöjen och festtåg
- marknader och mässor
- andra tillställningar som inte är att anse som allmänna sammankomster eller cirkusföreställningar.
- Skolor, kollektivtrafik, privata evenemang och besök i affärer omfattas inte.

Mer information om förbudet hos polisen.
Mer information om förbudet hos regeringen.
Mer information om förbudet hos Folkhälsomyndigheten.

Tillfälligt förbud mot resor till Sverige

Den 17 mars fattade regeringen beslut om att stoppa icke nödvändiga resor till Sverige från länder utanför EU. Förbudet, som trädde i kraft den 19 mars, gäller fram till den 15 juni. Syftet är att mildra effekterna av coronavirusets utbrott och minska spridningen av covid-19. Läs mer om beslutet här.

Följande är undantagna från inreseförbudet:

- svenska medborgare

Appendix 4

Inledande:

- Presentation
- Vilka är vi

Syfte med intervjun/arbete

Vårt examensarbete går ut på att 1) undersöka om det finns ett behov av att förändra åtkomsten till fastigheternas styr- och reglersystem samt övriga system som fastighetsansvariga använder och 2) i sådant fall ge ett förslag på hur en sådan plattform kan designas på ett användarvänligt sätt för att underlätta för fastighetsansvariga.

Syftet med denna intervju är därför att få en bättre insyn i dina arbetsuppgifter som fastighetsansvarig och hur du använder befintliga plattformar för att utföra ditt dagliga arbete. Vi är främst intresserade av din väg in i systemet och dina tankar och reflektioner kring detta. Även om det skulle finnas funktioner i ett nytt eller befintligt redskap som du saknar idag. Det är alltså inte utformningen av enskilda styr- och reglersystem vi primärt är ute efter, utan snarare en mer generell diskussion kring sökvägar och hur du upplever dessa.

Innan vi börjar med intervjun så är det två saker vi vill ta upp:

- Var inte rädd för att uttrycka åsikter. Du kommer att vara anonym i rapporten och vad du säger här under intervjun är för att skapa en så bra design som möjligt.
- Du har inför denna intervju fått ett dokument för ditt medtyckande att delta i denna intervju och låta oss spela in samtalet. För att vara på den säkra sidan - Är det okej för din del att vi spelar in samtalet?
- Det finns inga rätt eller fel och dina uppgifter kommer inte delas
- Du är anonym
- Får spela in samtalet
- Berätta lite om dig själv

Frågor:

1) Beskriv en typisk arbetsdag och i vilken ordning du utför arbetsuppgifter
2) Hur strukturerar du din arbetsdag?
3) Hur vet du vad du ska göra under dagen?
4) Vilken ordning prioriterar du uppgifter?
5) Hur följer du upp ditt arbete?
6) Vad ingår i dina arbetsuppgifter?
7) Vilken information hittar du från de olika delarna, var och varför? (tänker om det är uppgifter)
8) Vilka fastigheter ansvarar du för?

9) Vad är dina ansvarsområden?
10) Gör du någonting utanför dina ansvarsområden?
11) Hur länge har du arbetat som fastighetsansvarig?
12) Vad har du för utbildning?
13) Har du jobbat på andra arbetsplatser innan?
14) Vilka system använder de?
15) Vilken skillnad är det mellan deras system och det du använder idag?
16) Är det någon funktion du saknar?
17) Vad gillar du med ditt yrke?
18) Arbetar du tillsammans med någon?
    a. Vilka?
    b. Arbetslag?
19) Vilket stöd finns?

Nu kommer några frågor kring de som du kommunicerar med på regelbunden basis.

20) Beskriv lite om de du kommer i kontakt med på regelbunden basis
21) Vad kommuniceras?
22) Hur kommunicerar ni?
    a. Vad funkar bra i kommunikationen?
    b. Vad fungerar dåligt i kommunikationen?
    c. Vad skulle du säga var deras arbetsuppgifter?
23) Hur ser din kontakt ut med Coor?
    a. Vad kommuniceras?
    b. Vad funkar bra i kommunikationen?
    c. Vad fungerar dåligt i kommunikationen?
    d. Vad skulle du säga var deras arbetsuppgifter?
24) Hur ser din kontakt ut med kundservice?
    a. Vad kommuniceras?
    b. Vad funkar bra i kommunikationen?
    c. Vad fungerar dåligt i kommunikationen?
    d. Vad skulle du säga var deras arbetsuppgifter?
25) Hur ser kontakten ut med dina kunder/hyresgäster?
    a. Vad har du för relation till den?
    b. Hur bygger du upp relation med dem?
    c. Hur ofta har ni kontakt?
    d. Vad fungerar bra i kommunikationen?
    e. Vad fungerar dåligt i kommunikationen?
26) Hur ser kontakten ut med FUT?
27) Vilka övriga delar hos Vasakronan kommunicerar du med?
28) Om du har idéer vem vänder du dig till då?
29) Om du har feedback vem talar du med då?
30) Har du hittills kommunicerat feedback?

Redskap

Vi undrar vilka tekniska redskap du använder, varför, var, när och hur du använder dem i ditt arbete. Vi vill gärna gå igenom varje tekniskt redskap för sig för att förstå detta. Så…

31) Vad har du på ditt (dator)skrivbord?
32) Vilka tekniska redskap använder du idag?
33) Hur använder du redskapet idag?
34) Vilken information brukar du hämta?
35) Vad använder du den informationen till?
36) Finns det fler tolkningar av informationen?
37) Hur vet du att du gjort rätt i redskapet? (ljud/ljus)
38) Hur många gånger kollar du om dagen?
39) Vilket syfte?
40) Vad söker du?
41) Vad fungerar bra i redskapet?
42) Vad fungerar dåligt i redskapet?
43) Har du gjort fel någon gång när du använt redskapet?
    a. Vilket?
    b. Hur visste du det?
44) På vilket sätt skulle du säga att du är insatt i redskapet idag?
45) Vad är din rutin för en:
    a. befintlig fastighet
    b. ny fastighet
46) Hur skiljer sig din systemanvändning när du är på fältet från när du är på kontoret?
47) Hur utbyter ni kunskap mellan fastighetsansvariga?
48) Hur upplever du Vasakronans tillhandahållande av redskap?
49) Hur ser du på antalet system idag?

Doris

Vi skulle nu vilja gå lite närmare in på Doris.

50) Hur lärde du dig att navigera i Doris?
51) Vad gör du typiskt i Doris?
52) Vilka funktioner använder du i Doris?
53) Vilka funktioner använder du inte i Doris?
54) I vilka situationer öppnar du upp Doris?
55) Hur ofta öppnar du upp Doris?
56) När ditt mål är att xx, kan du visa oss hur du gör
57) Vad tycker du om Doris?
58) Vilka misstag brukar du göra i Doris?

Framtida system:

59) Är det någonting du anser saknas i systemet idag?/Är det några ändringar som skulle systemet lättare att använda?
60) Skulle du vilja ändra något med hur systemet ser ut?
61) Finns all information du behöver i systemet?
62) Vilken information saknar du?
63) Vilka andra redskap använder du idag?

Wrap-up:

64) Vi skulle gärna vilja ha en kortare intervju där du går igenom vissa redskap och dina fastigheter digitalt. Är du villig att ställa upp på en sådan?

EVENTUELLT:

65) Hur fyller du i dokument?
66) Använder du folder eller workspace?
67) När använder du det ena framför det andra?
68) Hur ser din rutin ut för att skapa nya versioner på befintliga dokument?
69) Hur ofta skapar du en ny version av ett befintligt dokument?
70) När skapar du versionen - i slutet av arbetsdagen, när du står i fastigheten, i slutet av veckan?
71) När använder du Fastighetsportalen och när använder du Doris?

Styr- och reglersystem:

72) Vilka tekniska system inkluderas i styr- och reglersystemet?
73) Vilka system styrs och vilka system regleras?
74) Vilka insignaler och utsignaler är du intresserad av? Finns det till exempel vissa regulatorer som är särskilt informativa?
75) Vilken information behöver du snabbt agera på? Vilken information behöver du inte alls reagera på?