

Berg, Henrik Mathias

Exploring Expectations for a Non-Conformance Management System Using the Design Science Research Framework

Master's thesis in Computer Science

Supervisor: Parmiggiani, Elena

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Faculty of Information Technology and Electrical Engineering
Department of Computer Science



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Abstract

This paper explores expectations for Non-Conformance Management (NCM) Systems, a form of Information System (IS), using the Design Science Research Framework by performing Usability Testing on a prototype. The findings verify and improve the understanding of NCM Systems, its context of use and expected functionality, from the in-depth study "Mapping Expectations for a Non-Conformance Management System" [1]. The study also finds the construct of an NCM System to be both a Management Information System (MIS) and a Decision Support System (DSS) that support Continuous Improvement, and that businesses may increase access to information and usability of ISs by involving it in their Enterprise Resource Planning (ERP) system. The findings give a foundation for understanding system requirements for NCM Systems to assist Systems Development and allow for further research on NCM Systems.

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Acronyms

- BIM** Building Information Modelling. 1
- DSS** Decision Support System. iii, x, 5, 66, 68
- EHS** Environment, health and safety. 9, 17, 42, 49, 58, 59
- EIS** Executive Information System. 1, 5, 66
- ERP** Enterprise Resource Planning. iii, 5, 66–68
- IRD** Information Requirements Determination. 2
- IS** Information System. iii, vi, 1–5, 7, 9, 11, 12, 66–68
- ISO/IEC** International Organization for Standardization/International Electrotechnical Commission. 10, 12, 27, 44
- IT** Information Technology. 2, 3, 12
- MIS** Management Information System. iii, 5, 66, 68
- NC** Non-Conformance. 8, 9, 12, 14, 16–18, 20–22, 25, 27, 29, 31, 39, 46, 49, 62, 65–67
- NCM** Non-Conformance Management. iii, x, 2, 3, 7–14, 19, 20, 27, 43, 46, 48–51, 53, 56, 62, 64–68
- NTNU** Norwegian University of Science and Technology. 10, 13

Glossary

NCM System A type of information system that is used by employees to improve business processes by systematically register, inform, process, and follow up on non-conformance to perform corrective, preventative, and improvement measures, external standards, or established practice. iii, 2, 3, 7–14, 19, 20, 27, 43, 48–51, 53, 56, 62, 64–68

Continuous Improvement Constantly seeking improvement of business processes, products, and services. iii, 7, 9, 12, 66–68

Decision Support System An organized collection of people, procedures, software, databases, and devices that support problem-specific decision making. iii, ix

Executive Information System A specialized DSS that includes all hardware, software, data, procedures, and people used to assist senior-level executives within the organization. ix, 1

Feedback Information from the system output that is used to make changes to input or processing activities. 5, 65

Firma Model A Wireframe made using the online wireframing tool "Figma" [2]. vi, 14–20, 27, 45, 46

Information System A set of interrelated elements or components that collect (input), manipulate (process), store, and disseminate (output) data and information, and provide a corrective reaction (feedback mechanism) to meet an objective. iii, ix

Input The activity of gathering and capturing raw data. 2, 4, 7, 9, 65

Management Information System An organized collection of people, procedures, software, databases, and devices that provides routine information to managers and decision makers.. iii, ix

Non-Conformance Occurs when a process, service, product, piece of equipment, or business operation fails to meet requirements set by internal standards, external standards, or established practice. ix, 8

Output The activity of producing useful information. 2, 5, 7, 65

Processing The activity of transforming data into useful outputs. 4, 65

Sikt Norwegian Agency for Shared Services in Education and Research. 10

Systems Development The activity of creating or modifying business systems. iii, vi, 3, 5, 6, 8–11, 65–68

Usability Testing Testing the extent to which a system, product, or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use. iii, 3, 8, 9, 11–13, 19, 26, 27, 41, 64, 65, 67, 68

Wireframe A sketch of a digital interface. x, 14, 20

Chapter 1

Introduction

1.1 Review

"An IS is a set of interrelated elements or components that collect (input), manipulate (process), store, and disseminate (output) data and information, and provide a corrective reaction (feedback mechanism) to meet an objective" [3].

The development of IS to meet business needs is highly complex and difficult, as stated by the book "Principles of Information Systems: A Managerial Approach" [3], which recommends dividing the process into several steps with well-defined goals and a set of tasks to accomplish. The two first steps named are systems investigation and system analysis. These steps involve understanding the problem to be solved or opportunity to be addressed. The article "Determining Information Requirements for an EIS" [4] claims that it is challenging to develop an Executive Information System (EIS), and that a major problem is determining the information requirements for the system. It describes a multi-stage study that identified and explored 16 methods used to determine the information requirements and concludes that determining the information requirements for an EIS "is a challenging task that can seldom be successfully completed using a single method" [4].

"Eliciting requirements from users and other stakeholders is of central importance to information systems development" [5] as "Understanding user needs is an obvious prerequisite to building a functional system" [6]. The article "Method for managing requirements in healthcare projects using building information modelling" [7] "highlights the importance of managing client requirements in healthcare projects, which often face limitations due to the poor involvement of users during design". The article also "pointed out the difficulties in dealing with a large number of different clients, who may have conflicting requirements" [7]. It proposes a method for managing client requirements with the use of Building Information Modelling (BIM). The article "An Empirical Investigation of User Requirements Elicitation: Comparing the Effectiveness of Prompting Techniques" [5] presents a model of the requirements elicitation process, which is used to construct a new requirements elicitation prompting technique, and then evaluates the

new technique. The article "Improving information requirements determination: a cognitive perspective" [6] discusses psychological and social limitations due to the people involved in the requirements determination process and offers techniques to mitigate them. It states that "improving the Information Requirements Determination (IRD) process must be undertaken incrementally, by furthering our understanding of business tasks, of cognition and behavior, and of the gathering, representation, and verification of knowledge" [6].

"Non-Conformance occurs when a process, service, product, piece of equipment, or business operation fails to meet requirements set by internal standards, external standards, or established practice" [1]. "A Non-Conformance Management System is a type of information system that is used by employees to improve business processes by systematically register, inform, process, and follow up on non-conformance to perform corrective, preventative, and improvement measures" [1]. The in-depth study "Mapping Expectations for a Non-Conformance Management System" [1], by Henrik M. Berg (me), explores the expectations of NCM Systems through interviews focused on system Input, system Output, and the 11 "Characteristics of Valuable Information" from the book "Principles of Information Systems" [3].

"Two paradigms characterize much of the research in the Information Systems discipline: behavioral science and design science" [8]. The article "Design Science in Information Systems Research" [8], presents the Design Science Research Framework and divides IS research into two complementary phases; behavioral science, where the goal is truth, and design science, where the goal is utility. There are two activities in Design Science Research in IS, "Build" and "Evaluate", identified by "Design and natural science research on information technology" [9]. "Build" is the process of constructing an artifact for a specific purpose, while "Evaluate" is the process to determine the artifact's performance. The artifacts produced by design science research are representational constructs, models, methods, and instantiations.

1.2 Claim

The construct of an NCM System and user expectations for NCM Systems are not thoroughly explored. To develop an NCM System will be difficult, as mentioned by [3] and [4], with little to no literature to guide system design, requiring system developers to perform system investigation and analysis, as [5] and [6] emphasize the importance of, from scratch. Also, research on NCM Systems lack a clearly defined construct for NCM Systems.

By exploring user expectations to verify and improve the definition of an NCM System from [1] as a construct, to map the expected functionality of an NCM System, and to understand the context of use of an NCM System, I will produce new or improved analysis from the application of existing theories and methods in a new context and fill a gap in knowledge of Information Technology (IT) regarding NCM Systems. The contribution may assist IT system developers and decision-makers in

the development of NCM Systems, and open for further research regarding NCM and NCM Systems.

To explore user expectations for an NCM system I will apply the Design Science Research framework. By developing a prototype of an NCM system and performing usability testing as evaluation in iterations, I aim to answer the research questions:

- What is an NCM System?
- What expectations are there for an NCM System?
- How do users interact with an NCM System?

By using the findings from the in-depth study [1] that used interviews, and performing usability testing, I will avoid using a single method to perform system investigation and analysis as [4] warns is seldom successful. The usability testing and iterative process of "Build" and "Evaluation" in Design Science Research allow for, as recommended by [6], incremental improvement through improved understanding. By involving participants from varying industries I attempt to avoid poor involvement of users, as highlighted as a problem by [7], but might have a challenge meeting expectations of users with conflicting requirements, also mentioned by [7].

The target group for the findings are researchers with a background in IS and IS developers with an interest in the development of NCM Systems. The reader is assumed to have a basic understanding of the processes of IT Systems Development, System Investigation and Analysis, and Usability Testing.

1.3 Agenda

Chapter 2 presents principles of IS from "Principles of Information Systems" [3] and the in-depth study [1] used as a foundation for understanding the context of use of NCM Systems presented in the research context in Chapter 3.

Chapter 3 describes the research context, study participants, data management, methods, application of Design Science Research Framework and Usability Testing, and each evaluation's artifact, tasks, and follow-up questions.

Chapter 4 presents results and analysis from the artifact evaluations as well as refinement notes for future refinement of the artifacts described in Chapter 3.

Chapter 5 discuss the findings from Chapter 4 in relation to the research questions presented in Chapter 1, while referencing the related literature from Chapter 2.

Finally, Chapter 6 summarises the project's achievements.

Chapter 2

Related Literature

2.1 Principles of Information Systems: A Managerial Approach

The book "Principles of Information Systems: A Managerial Approach" [3] describes the principles of Information Systems (IS), including information technology concepts, IS classification, and concepts concerning IS development.

2.1.1 Information Systems

An IS provides feedback to meet an objective and consists of a set of connected elements or components that collect, manipulate, store, and disseminate data and information, divided into input, process, and output. "The value of information is directly linked to how it helps decision makers achieve the organization's goals" [3].

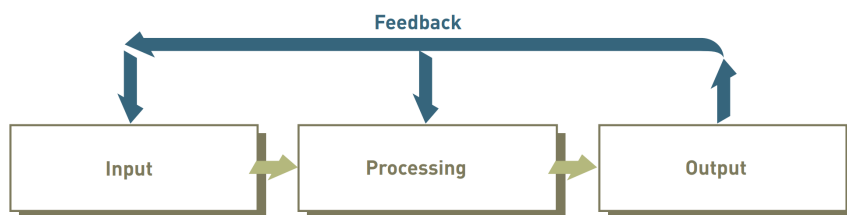


Figure 2.1: The Components of an IS, from Principles of Information Systems [3]

The relation between components of an IS, from Principles of Information Systems [3], is presented in Figure 2.1. Input is the activity of gathering and capturing raw data. Processing is the activity of transforming data into useful outputs and typically involves calculation, comparison, and storage of data. The processing

can be done manually or with computer assistance. Output is the activity of producing useful information, often in the form of documents and reports. Feedback is information from the system output that is used to make changes to input or processing activities.

Management Information Systems

An MIS "is an organized collection of people, procedures, software, databases, and devices that provides routine information to managers and decision makers. An MIS focuses on operational efficiency. Marketing, production, finance, and other functional areas are supported by MISs and linked through a common database" [3]. The book presents the principle; "The MIS must provide the right information to the right person in the right format at the right time" [3].

Decision Support Systems

A DSS "is an organized collection of people, procedures, software, databases, and devices that support problem-specific decision making. The focus of a DSS is on making effective decisions. Whereas an MIS helps an organization 'do things right,' a DSS helps a manager 'do the right thing.'" [3].

An EIS "is a specialized DSS that includes all hardware, software, data, procedures, and people used to assist senior-level executives within the organization" [3].

Enterprise Resource Planning Systems

An ERP system is implemented to enhance the internal functions of business and is connected to the principle; "An organization must have information systems that support the routine, day-to-day activities that occur in the normal course of business and help a company add value to its products and services" [3]. The primary benefits of ERP systems include improved access to data for operational decision-making and improvement of work processes. ERP system vendors have developed specialized systems that provide effective solutions for specific industries and market segments.

2.1.2 Systems Development

"Systems Development is the activity of creating or modifying business systems" [3]. The authors of "Principles of Information Systems" [3] state that the development of IS to meet business needs is highly complex and difficult, and recommends dividing the process into several steps with well-defined goals and a set of tasks to accomplish. These steps are presented in Figure 2.2. The book also presents the principle; "System users, business managers, and information systems professionals must work together to build a successful information system" [3].

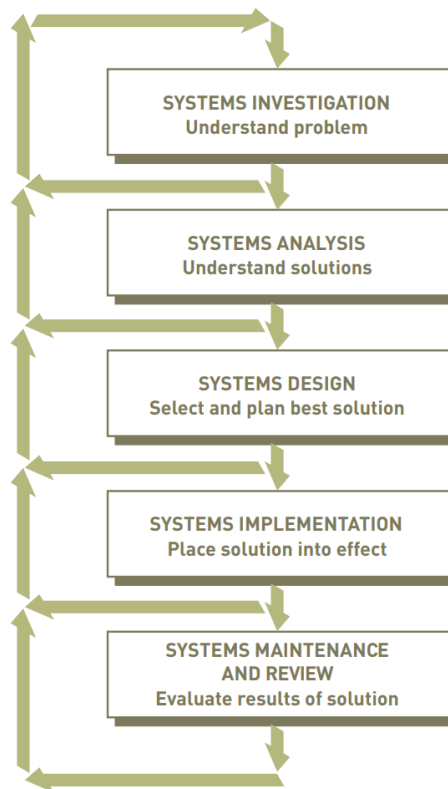


Figure 2.2: An Overview of Systems Development, from Principles of Information Systems [3]

Systems Investigation and Analysis

The goals of the first two steps in Systems Development, "Systems Investigation" and "Systems Analysis", are to gain a clear understanding of the problem to be solved or opportunity to be addressed, problems and opportunities with existing systems, whether or not it is worth solving given the organization's limited resources, and to define business needs.

Systems Design, Implementation, and Maintenance and Review

During "Systems Design" it is determined how the new system will meet the business needs defined during "Systems Analysis". "Systems Implementation" involves developing or acquiring the various system components, including hardware, software, and databases, as determined in the design step, and putting the new system into operation. The purpose of "Systems Maintenance and Review" is to evaluate and modify the system so that it continues to meet changing business needs.

2.1.3 Continuous Improvement

The book [3] also presents the idea of Continuous Improvement, which is to constantly seek improvement of business processes, products, and services. Continuous Improvement involve routine actions taken to make minor improvements. It is bottom-up change driven by workers and usually has a narrow scope. The goal of Continuous Improvement is continuous, gradual improvements, and it is normal that ISs provide data to guide these improvements.

2.2 Mapping Expectations for a Non-Conformance Management System"

The in-depth study "Mapping expectations for a non-conformance management system" [1] consists of interviews of NCM System users from varying industries, centered around system Input, system Output, and the 11 "Characteristics of valuable information" as defined in "Principles of Information Systems: A Managerial Approach" [3]. The study presents a general definition of NCM Systems presented in the Introduction (Section 1.1), as well as a longer understanding of what an NCM system is presented in the Research Context (Section 3.1).

Chapter 3

Research Design

The study's chosen research strategy "Design and creation" focuses on developing artifacts, which include constructs, models, methods, and instantiations [10]. I applied the "Design and creation" strategy through the Design Science Research framework [8], and offered a combination of an instantiation and a construct as a contribution to knowledge. The instantiation, a prototype of an NCM System, and the construct, a description of NCM Systems.

Data is generated through evaluation of the artifact, using Usability Testing [11], a combination of "Observation" and "Interviews" [10]. Based on data from evaluating the artifact there is performed qualitative data analysis [10].

I sought to answer the research questions "What is an NCM System?", "What expectations are there for an NCM System?", and to that end also answer "How do users interact with an NCM system?". I chose the Design Science Research framework [8] as the framework allowed for a user-involved research process. I knew of multiple potential study participants in my network with extensive experience with both instantiations of NCM Systems and the processes involved in their usage. To take advantage of the knowledge of these and other individuals, as well as my own competence in Systems Development, I chose to apply the processes of development, assessment, evaluation, and refinement that constitute the Design Science Research framework.

The evaluation of the artifact performed using Usability Testing, as observation of the user-system interaction and participant feedback from follow-up questions allowed me to evaluate the artifact's usability, as well as improve my understanding of the artifact's context of use, through qualitative analysis.

3.1 Research Context

The project used the definitions of Non-Conformance (NC) and NCM Systems introduced in Section 1.1 and the following descriptions of an NCM System from the in-depth study "Mapping expectations for a non-conformance management system" [1] presented in Section 2.2.

The information in an NCM System assists decision-making on preventive and corrective measures, both immediate and long-term. Measures are implemented, carried out, controlled, and evaluated to correct errors and prevent future NC, leading to improved processes. Driving factors behind improving processes include achieving a safer work environment, increasing customer satisfaction, and improving profitability. The system may also provide tools for communication, motivation, and instruction for employees.

System Input is information regarding NC, including circumstances and conditions that could affect it. Normal categories of NC include unwanted incidents, hazardous working environments, security breaches, and non-fulfillment of requirements. The system Input varies by business and NC category. It usually includes a notifier, location of discovery, timestamp, and description of NC. The description may include how, when and where it was discovered, its extent, its severity, relevant product, violated procedure/process, performed immediate corrective or preventative measures, presumed cause, proposed improvement, the deadline for correction, the person responsible for processing or follow-up, photo/video, external conditions, work conditions, and personal conditions. All registered information (system Input) should be accessible as historic data.

System output is reports, statistics, trends, and high-level analytics regarding registered NC. This information, in combination with easily accessible system Input, is used to support Continuous Improvement of business procedures, identify root causes for NC, and assist decision-making on preventive and corrective measures. The system must communicate descriptions of NC and a picture of the work situation to management and decision-makers keeping notifiers updated.

3.2 Participants

The participants for the Usability Testing are workers and managers from varying industries with experience and expectations for NCM Systems, as well as students with education in either IS Systems Development or business leadership. The project involved the participation of 8 test users with ages varying from approximately 20 to 70 years, covering multiple industries and levels of experience with NCM Systems. See Section 3.5 for details regarding participant selection.

3.2.1 Table of participants

Participant	Gender	Age	Occupation/Role	Computer Experience	Product Experience
P1	Male	~20	Factory Worker	Proficient	User
P2	Male	~25	Computer Science Student	Expert	System Development
P3	Male	~25	Computer Science Student	Expert	System Development
P4	Female	~25	Economics and Leadership Student	Proficient	Educated Understanding
P5	Male	~50	Factory Worker	Proficient	Examiner / User
P6	Female	~50	Educational Coordinator	Intermediate	User
P7	Male	~50	IT Company Manager	Expert	Manager / User
P8	Male	~70	Retired Factory Environment, health and safety (EHS)-Manager	Intermediate	Manager / User

Table 3.1: Table of participants

The table of participants (Table 3.1) is based on the example presented in International Organization for Standardization/International Electrotechnical Commission (ISO/IEC) 25062 [11]. The characteristic of "Occupation/Role" is the source of the user's "Product Experience", which is the user's relevance in participating in the study. Definitions of the "Product Experience"-levels are listed in Table 3.3. The characteristic "Computer Experience" is relevant to usability testing as unfamiliarity with computer systems may limit the testing to the intuitiveness of the specific product, while the project also aims to evaluate the product to improve understanding of the context of use. Definitions of the "Computer Experience"-levels are listed in Table 3.2.

Level	Definition
Novice	Basic understanding of computer systems, but with little to no experience of use.
Intermediate	Basic to intermediate understanding of computer systems with considerable experience of use.
Proficient	A high understanding of computer systems and comprehensive experience of use.
Expert	Extensive understanding of computer systems and comprehensive experience of use.

Table 3.2: Definitions for levels of "Computer Experience"

Level	Definition
User	The participant has experience using this type of product as a user.
Manager	The participant has experience making decisions regarding the usage of this type of product.
Examiner	The participant has experience evaluating apprentices' usage of this type of product during trade certification.
System Development	The participant has experience with Systems Development.
Educated Understanding	The participant has an understanding of the usage of this type of product obtained from studies.

Table 3.3: Definitions for levels of "Product Experience"

3.2.2 Expert

Participant P5 (See Table 3.1) has experience as a trade certification examiner, which means they have observed extensive usage of NCM systems in numerous locations, involving numerous implementations/instantiations. The participant is seen as an expert on NCM Systems.

3.3 Data Management

The project handled information including names, online identifiers, anonymous screen recordings, and sound recordings of people. Sikt was notified through a notification form and assessed the data collection. A data management plan was drafted through Sikt's website, following their standards. The data was stored on Norwegian University of Science and Technology (NTNU) OneDrive, accessible only by researcher Henrik M. Berg (Me). The usability tests were performed with the use of NTNU Microsoft Teams, and there were captured screen recordings and sound recordings used to analyze the participants' interaction with the NCM System prototype. This storage option and collection method satisfy security requirements set by Sikt. Information regarding data management was provided to the participants through an informed consent form (Appendix A) following Sikt's

guidelines for information letters. Student Henrik M. Berg (Me) was the project’s only researcher, and both prepared and performed the interviews, handled and analyzed the data, and finally presented the data and findings in this report.

3.4 Design Science Research Framework

The article "Design Science in Information Systems Research" [8], presenting the Design Science Research Framework, divides IS research into two complementary phases; behavioral science, where the goal is truth, and design science, where the goal is utility. Behavioral science research has to do with the development and justification of theories that explain or predict phenomena related to identified business needs, while design science research through the building and evaluation of artifacts designed to meet identified business needs. The article’s position is that truth and utility are inseparable; "Truth informs design and utility informs theory."

Figure 3.1 presents the article’s conceptual framework combining behavioral-science and design-science to understand, execute, and evaluate IS research.

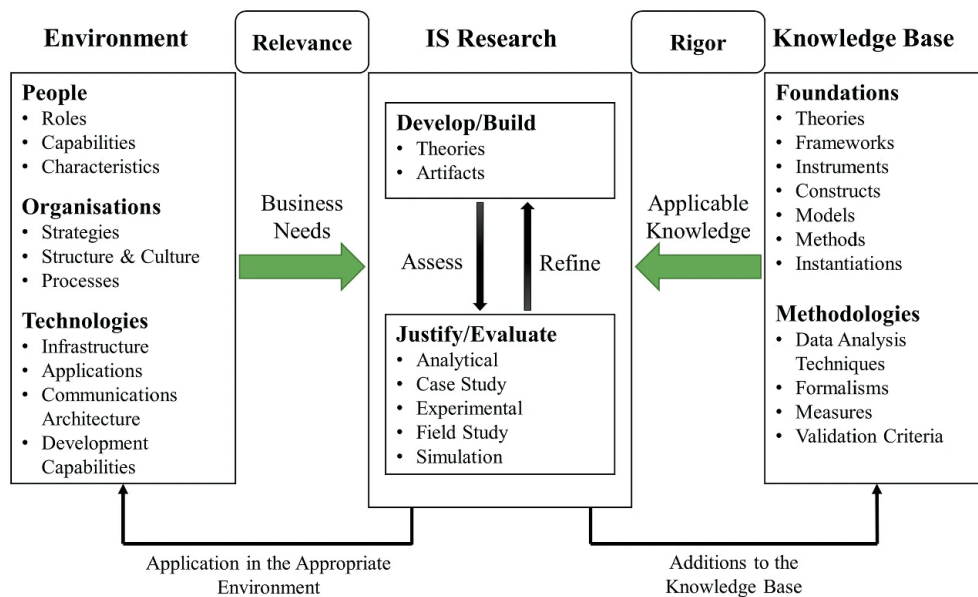


Figure 3.1: Model for Information Systems Research Framework, from Design Science in Information Systems Research [8]

The knowledge base in this study includes IS principals from "Principles of Information Systems" [3] presented in Section 2.1. It also includes an understanding of NCM Systems, described in Section 3.1, from "Mapping expectations for a non-conformance management system" [1] presented in Section 2.2. The Systems Development of the artifact used the knowledge of agile development principles [12] and Systems Development principles from "Principles of Information Systems" [3]. The artifact was evaluated using Usability Testing, described in Section 3.5, based

on the standard ISO/IEC 25062:2006 [11].

The environment in this study involved people and organizations with interest in NCM Systems, including IT companies and IS developers with an interest in developing NCM Systems, companies and managers of any industry with interest in the development or purchase of NCM Systems to assist Continuous Improvement, and IS researchers.

The innovative, purposeful artifact created through this project was a combination of an instantiation of an NCM System and a defined construct for NCM Systems.

3.5 Usability Testing

Usability Testing was performed after best practice based on the ISO/IEC 25062:2006 [11], adapted to use with the Design Science Research Framework [8].

As described in the standard, usability is "the extent to which a system, product, or service can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." [11] Usability is not a property of the product, but a relation between the product and its context of use.

To explore the expectations of an NCM System using the Design Science Research Framework, the evaluation of the product and artifact, the instantiation of an NCM System, will give insight regarding both the product's usability and context of use.

Usability in the context of evaluation in this study is the product's ability to provide expected functionality to perform tasks related to registration, informing, processing, and follow-up on NC to perform corrective-, preventative-, and improvement measures. The usability is evaluated through qualitative analysis [10] of observed user behavior and user feedback.

Reliability and validity are key research quality measures. Reliability is the overall consistency of the usability tests. It is to what extent the tests yield the same result, and in this study to what extent the test participants' feedback and system interactions correspond.

The validity of the usability testing does not only involve to what extent the test results accurately measured the usability of the product but also how well the evaluation allows for obtaining an improved understanding of the product's context of use. Three factors that affect the validity of the study's usability testing are the users, the tasks, and the environment.

3.5.1 Users

The users chosen to participate in the usability tests, described in Section 3.2, cover multiple industries, ages, and levels of experience with . The broad specter of participants was chosen to approach answering the research questions as generally as possible, without heavy influence from a single industry or age group. The

recruitment was performed through the network of the researcher, student Henrik M. Berg (Me). The participants number 8 users, which is the recommended minimal amount of participants [11].

3.5.2 Tasks

The tasks will be based on an understanding of the product's context of use. The first evaluation's tasks were based on an understanding from the in-depth study "Mapping expectations for a non-conformance management system" [1] described in Section 3.1. The understanding of the context of use was deepened by the evaluations, and tasks changed between iterations. See details regarding the usability testing tasks for each iteration of evaluation in Section 3.6.2, Section 3.7.2, and Section 3.8.2.

3.5.3 Environment

The environment in which the usability tests were performed was a digital remote setup where the communication happened over NTNU Microsoft Teams, and the interaction between the users and the system happened through a browser. This environment was close to the natural environment for the use of an NCM System for some industries, while very unnatural for others. I deem the occurrence of unnatural environments in which the system is used to be of little importance in the case of this research, as the system should also be accessible from an office setting, which resembles the test environment.

3.5.4 Test Plan

The Usability Testing plan was as follows:

Introduction of the researcher, the study, and the purpose of the observation.
The participant is informed that they can stop the test at any time
The participant is instructed to set up their end of the environment: Open an anonymous browser window and follow a link that allowed the user to interact with the product, and then screen-share said browser window.
The participant is informed of sound- and screen recording, as described in the signed informed consent form.
The participant is introduced to the product and instructed to ask any question they might have before the test starts.
The participant is asked to think out loud while solving tasks. Tasks varies and are described in each evaluation (Section 3.6.2, Section 3.7.2, and Section 3.8.2)
The participant is asked follow-up questions. Questions varies and are described in each evaluation (Section 3.6.2, Section 3.7.2, and Section 3.8.2)
Test is concluded. The participant is thanked for their participation.

Table 3.4: Usability Testing Plan

During the participants' interaction with the system, I took notes of both my observations and the participants' feedback. The follow-up questions asked after the tests were used to probe for further information regarding the system's usability and expected functionality.

3.6 Iteration 1: Figma Model

3.6.1 Artifact

A Wireframe is a sketch of a digital interface. The online wireframing tool "Figma" [2] simplifies the process of communicating ideas visually to get feedback. A Firma Model was made to present my understanding of an NCM System's features.

The Firma Model presents a system where the user may register, view, and edit reports on NC. It also presents the ability to create and change categories of NC. These categories, when selected under registration of NC, present the user with configured input fields deemed relevant to the specific category.

(a) "Login"-page

(b) "Request access"-page

(c) "Password reset"-page: Step 1

(d) "Password reset"-page: Step 2

Figure 3.2: Firma Model: Authentication-related pages

Figure 3.2 presents the system's mock authentication features. The model has a "Login"-page, presented in Figure 3.2a, with simulated login functionality by

simply pressing "Login". The "Reset password" button directs the user to a "Password reset"-page presented in Figure 3.2c. The "Send" button on said page directs the user further in the simulated process of resetting the password, to the page represented in Figure 3.2d. The "Set Password" button simply returns the user to the "Login"-page. The "Request Access" button on the login page directs the user to the "Request access"-page presented in Figure 3.2b. This page presents mock functionality for requesting access to the system. Pressing the send button simply directs the user back to the "Login"-page.

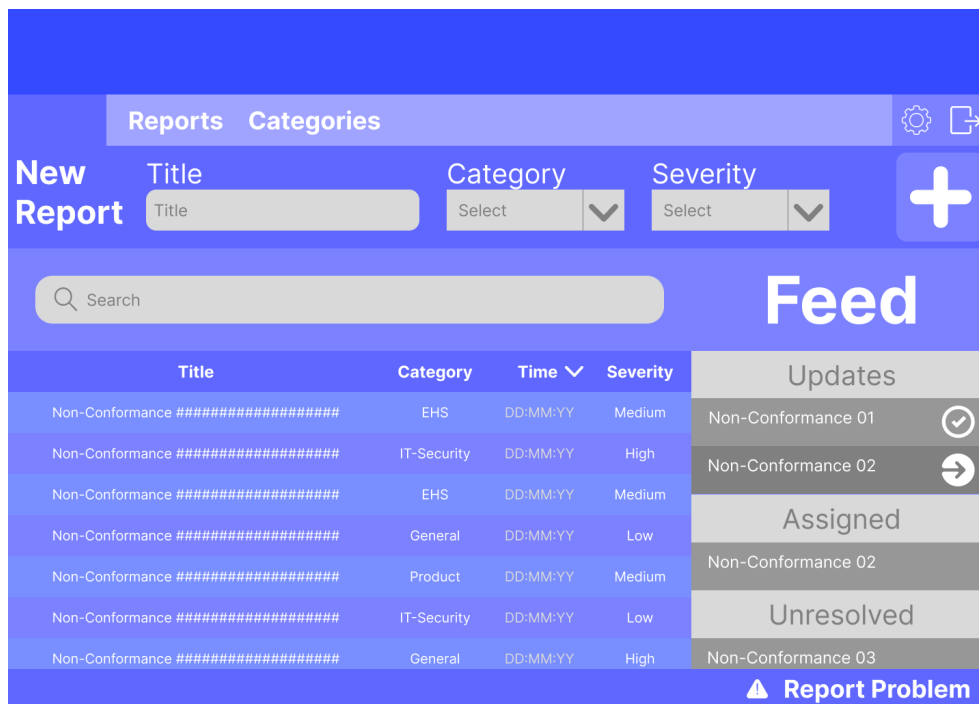


Figure 3.3: Firma Model: "Homepage"

By pressing "Login" on the "Login"-page (Figure 3.2a), the user is presented with the system's "Homepage" for authenticated users, shown in Figure 3.3.



Figure 3.4: Firma Model: Navigation bar

On the top of the "Homepage" there is a navigation bar (Figure 3.4) with the options "Reports", "Categories", "Settings", represented with a gear, and "Logout", represented with an arrow pointing out of a square. The navigation bar also has a house icon on the left side, representing the "Homepage", which is visible while the user is on any other page. Pressing "Reports" sends the user to the "Reports"-page presented in Figure 3.10a. Pressing "Categories" sends the user to the "Categories"-page presented in Figure 3.10b. Pressing "Settings" sends the user to an empty

page where the user’s account settings would be. Pressing "Logout" sends the user back to the "Login"-page (Figure 3.2a).

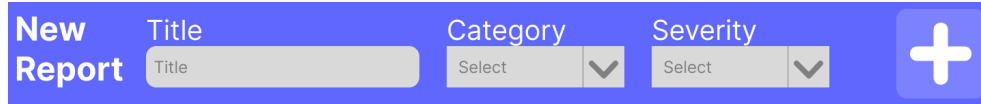
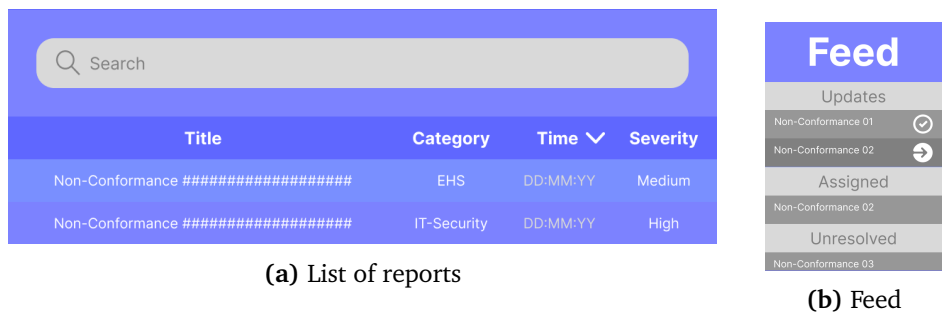


Figure 3.5: Firma Model: "New Report"-bar

Under the navigation bar is a darker bar, the "New Report"-bar (Figure 3.5). A title saying "New Report", 3 input fields, and a big plus-button populate the bar. The input fields are used to input the minimum required information regarding a discovered NC, and the plus is pressed to start registration of the NC, and will send the user to the "New Report"-page shown in Figure 3.7.



(a) List of reports

(b) Feed

Figure 3.6: Firma Model: "Homepage" List of reports and feed

On the left of the page is a list of reports, registered NCs. The presented details are the information requested to start registration of a NC, "Title", "Category", and "Severity", as well as "Time" representing the time of registration. The list is displayed as sortable by each detail, and searchable by the use of the above search bar. Clicking on any report in the list sends the user to the "Report"-page, a page presenting an example of a report, presented in Figure 3.8.

On the right side of the page is a feed (Figure 3.6b). The feed presents the user with relevant updates and an overview of both pending tasks and a history of completed tasks. Clicking on an item in the feed sends the user to the "Improvement Case"-page, a page presenting an example of an improvement case, presented in Figure 3.9.

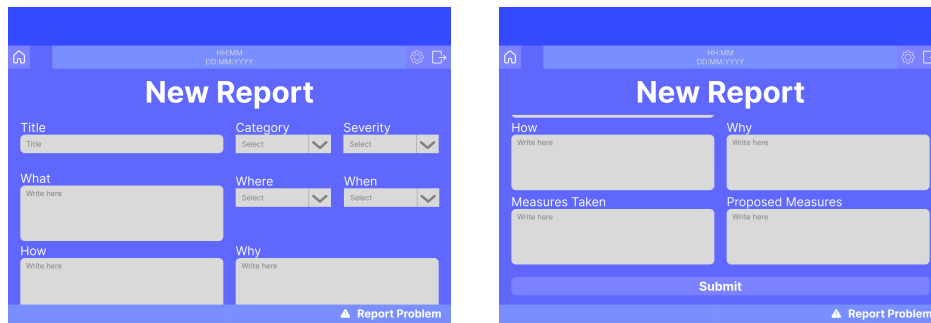


Figure 3.7: Firma Model: "New Report"-page

The "New Report"-page, presented in Figure 3.7, is where the user would input additional information regarding a NC. The requested information would be decided by the chosen category. A report in the category EHS may ask for how the accident or near-accident happened, while a report regarding emissions may only ask for numerical data. Pressing "Submit" sends the user back to the "Homepage" (Figure 3.3).

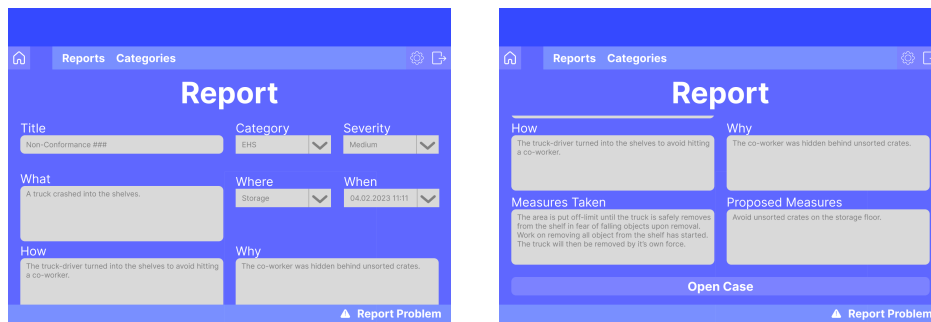


Figure 3.8: Firma Model: "Report"-page

The "Report"-page, presented in Figure 3.8, is a page presenting the user with a specific report. The registered information is presented, and clicking "Open Case" sends the user to the "Improvement Case"-page presented in Figure 3.9.

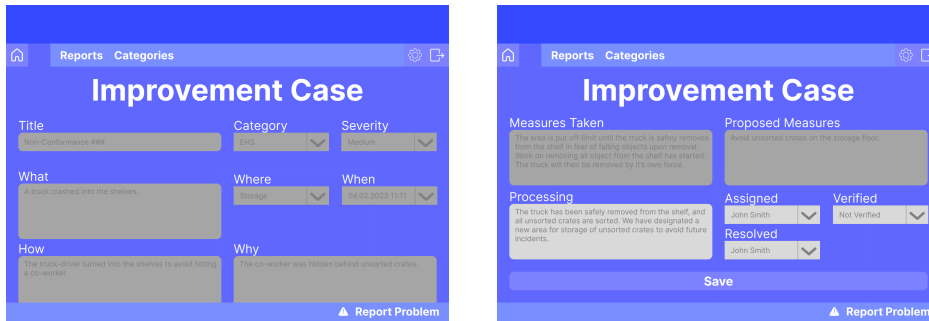
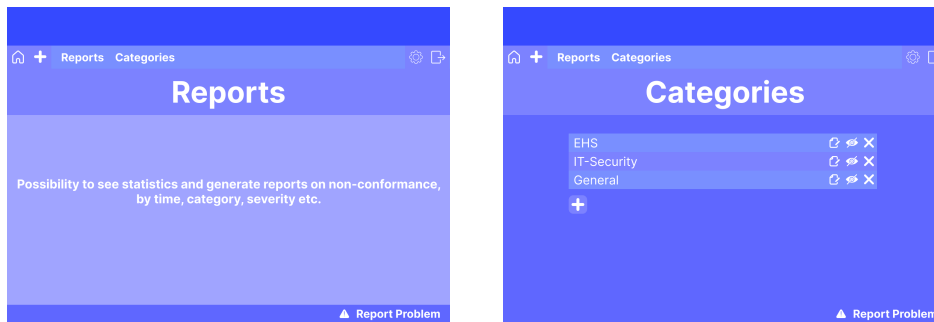


Figure 3.9: Firma Model: "Improvement Case"-page

The "Improvement Case"-page, presented in Figure 3.9, is a page presenting the user with an improvement case connected to a specific report. Here the user would input or edit information regarding the improvement case. Clicking "Save" sends the user back to the "Homepage" (Figure 3.3).



(a) "Reports"-page

(b) "Categories"-Page

Figure 3.10: Firma Model: "Categories"- and "Reports"-pages

The "Reports"-page, presented in Figure 3.10a, is a page that would allow users to see statistics and generate reports regarding NC data.

The "Categories"-page, presented in Figure 3.10b, is a page presenting the user with existing categories. By clicking the plus-button or the edit-button, represented by a piece of paper with a pencil, the user is directed to the "Edit Category"-page, presented in Figure 3.11.

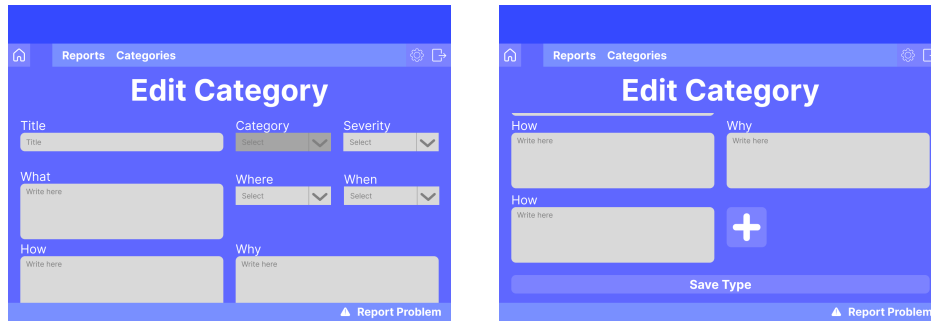


Figure 3.11: Firma Model: "Edit Category"-page

The "Edit Category"-page, presented in Figure 3.11, is where the user would add and edit input fields for a specific category. Input fields would include text fields and select-one inputs. Clicking "Save Type" sends the user back to the "Categories"-page presented in Figure 3.10b.

The border at the top of every page was added to represent the space lost as the system is used in a browser. The icons used for the Firma Model are from the Noun Project [13].

3.6.2 Artifact Evaluation

The first iteration of evaluation was Usability Testing of the Firma Model described in Section 3.6.1. The test was conducted with NCM System expert and study participant "P5" described in Section 3.2.2. The test environment was as described in Section 3.5.3, and the test plan as described in Section 3.5.4.

Tasks
Explore the Firma Model as if interacting with an NCM System. Clickable buttons will light up when you click anywhere on the model.

Table 3.5: Iteration 1: Test Tasks

The task, translated from Norwegian, is presented in Table 3.5.

Questions
Does the model miss any expected functionality of an NCM System?
Does the model contain functionality that does not belong in an NCM System?

Table 3.6: Iteration 1: Follow-up Questions

The follow-up questions, translated from Norwegian, are listed in Table 3.6.

3.6.3 Method Evaluation

The evaluation of a Wireframe early in the project was performed to validate my understanding of an NCM System, described in Section 3.1, that is based on the knowledge base. Developing a Wireframe and evaluating it through expert feedback was performed as an efficient way to build and assess, as described in Figure 3.1.

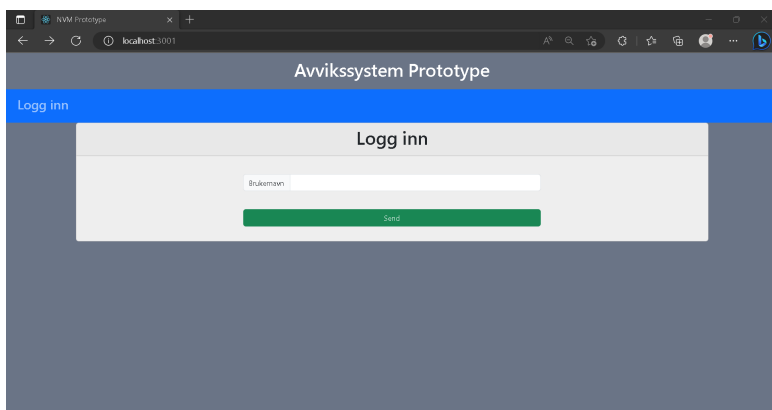
The evaluation's validity is increased by the participant's product experience (Section 3.2.2), but is decreased by the lack of multiple participants. It was chosen to perform the test with only a single participant as it would allow for a quick evaluation, as the planning, scheduling, performance, and analysis would require minimal time. The decreased validity was acceptable with the knowledge of future assessment of the following refined artifact.

3.7 Iteration 2: Minimal Prototype

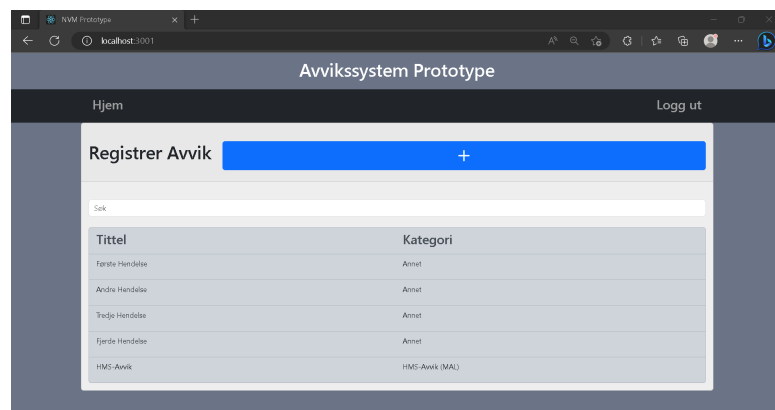
3.7.1 Artifact

A minimal prototype was developed using React, with an Express Server handling communication with a MongoDB (Database) Server. The language is mostly Norwegian, to allow for the use of Norwegian technical terms.

The minimal prototype handles registration and presentation of information regarding NC. As the Firma Model (See Section 3.6.1), the prototype allows the user to register, view, and edit reports on NC, now called "incidents". It also presents the ability to create, edit, and delete categories for incidents. These categories, when selected under registration of incidents, present the user with input fields configured to the specific category.



(a) "Login"-page



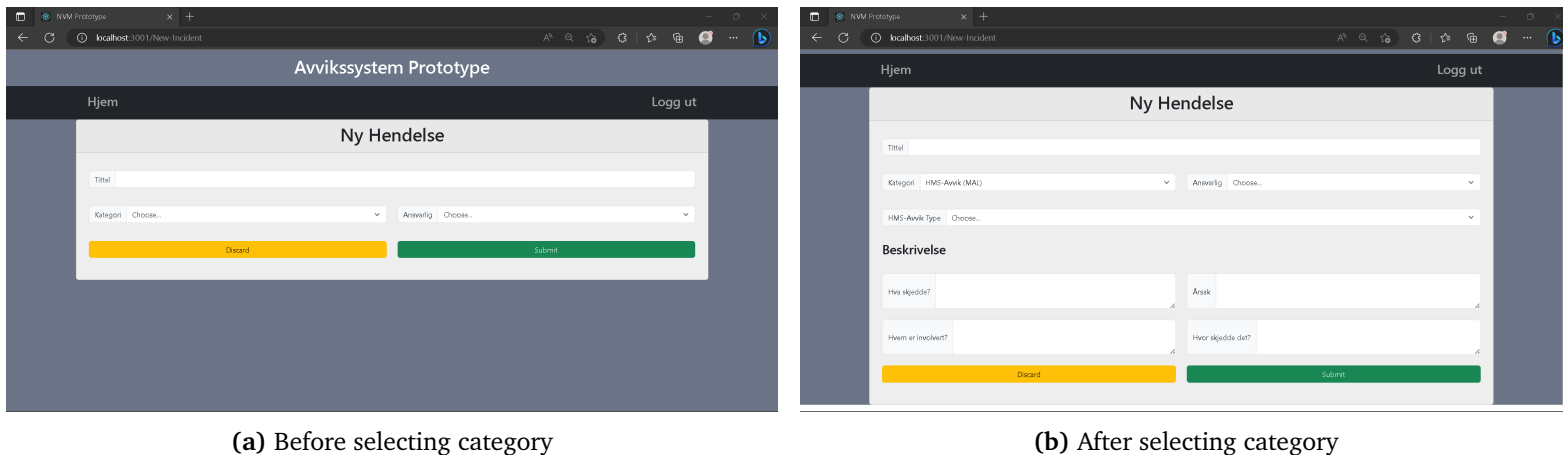
(b) "Homepage"

Figure 3.12: First Prototype: "Login"-page and "Homepage"

The first page that greets the user is the "Login"-page, presented in Figure 3.12a. Here the user is asked for a username. By clicking "Send" the user is logged in with the given username and sent to the "Homepage".

The navigation bar changes as the user is logged in, and when authenticated it has a button "Logg ut" that the user may use to sign out (Figure 3.12).

The "Homepage", presented in Figure 3.12b, presents a searchable list of registered NC and a blue plus button beside the header "Registrer Avvik", translated "Register NC". By clicking the plus button, the user is sent to the "New Incident"-page, presented in Figure 3.13. The search function allows the user to search among registered NCs. The search takes all input regarding the NC that is not explicitly configured to be ignored into account. By clicking on a registered NC the user is sent to the "Incident"-page, presented in Figure 3.14a.



(a) Before selecting category

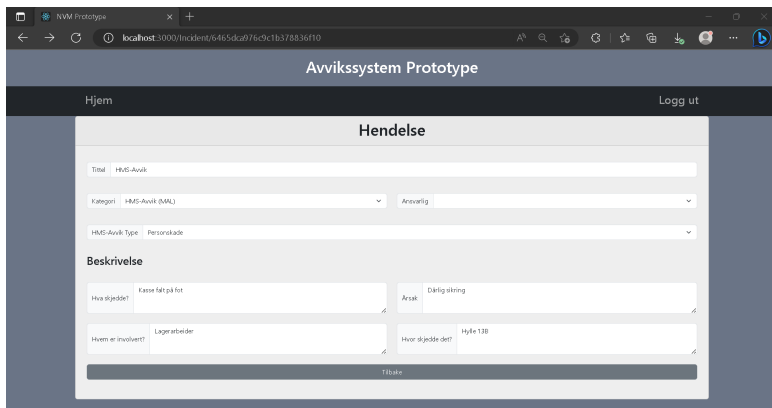
(b) After selecting category

Figure 3.13: First Prototype: "New incident"-page

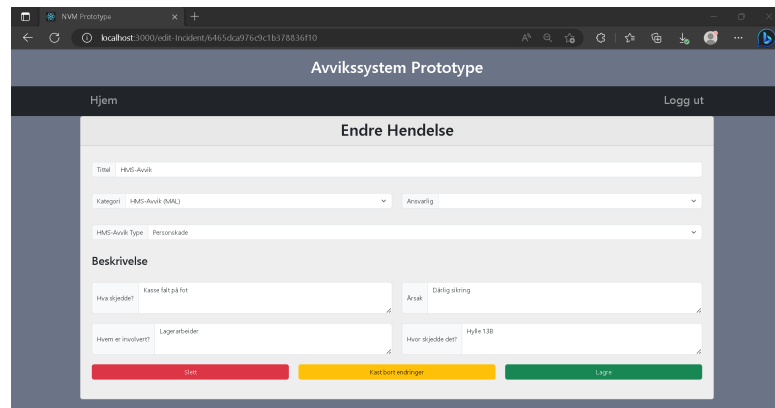
The "New Incident"-page, presented in Figure 3.13a, presents the user with pre-configured input fields. The input fields including "Tittel", translated "Title", "Kategori", translated "Category", and "Ansvarlig", translated "The Responsible", are presented along with the NC in the list on the "Homepage" (Figure 3.12b). The system administrator may also add custom input fields they deem relevant for all NC that should not appear in this list.

As the user selects a category the page will present additional input fields pre-configured to the respective category by the system administrator, see Figure 3.13b.

The page also presents a "Discard" and a "Submit" button. Clicking "Discard" will send the user back to the "Homepage" (Figure 3.12b), while "Submit" will attempt to register the inputted information as an NC. Some or all input-fields may be required, translated they require input to allow submission. Upon submission, the user is sent to the "Homepage" (Figure 3.12b).



(a) "Incident"-page



(b) "Edit Incident"-page

Figure 3.14: First Prototype: Incident display and manipulation pages

The "Incident"-page, see Figure 3.14a presents the user with information regarding a specific NC. Information here is not editable. If the user is the one that registered the NC, or if the user is an administrator, the button "Endre", translated "Edit", is visible. Clicking "Edit" sends the user to the "Edit Incident"-page, presented in Figure 3.14b. Clicking "Tilbake", translated "Back", the user is sent back to the "Homepage" (Figure 3.12b).

The "Edit Incident"-page, see Figure 3.14b, presents the user with editable information regarding a specific NC. The user may discard changes by clicking "Kast bort endringer", translated "Discard Changes", or submit changes by clicking "Lagre", translated "Save". The user may also delete the registered NC by clicking "Slett", translated "Delete". If changes are discarded or submitted, the user is sent to the "Incident"-page (Figure 3.14a). If the NC is deleted, the user is sent back to the "Homepage" (Figure 3.12b).

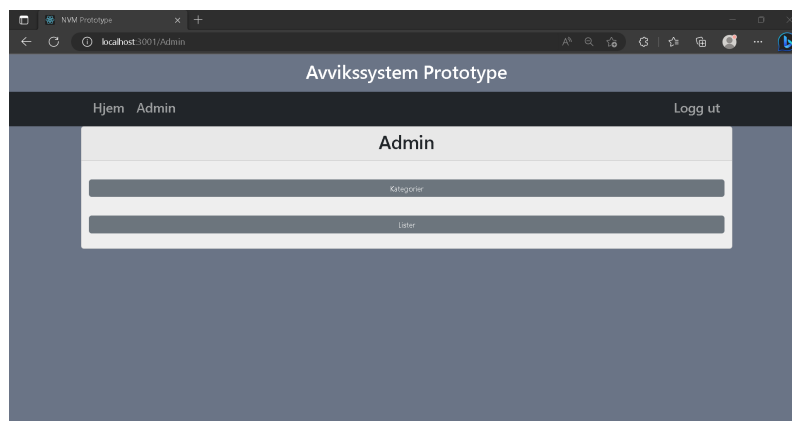


Figure 3.15: First Prototype: "Admin"-page

Logging in as an administrator will reveal the "Admin" tab in the navigation bar. Clicking "Admin" sends the user to the "Admin"-page presented in Figure 3.15. The page presents navigation to "Kategorier", translated "Categories", and "Lister", translated "Lists". Clicking "Categories" sends the user to the "Categories"-page, see Figure 3.18a, while clicking "Lists" sends the user to the "Lists"-page, see Figure 3.16.

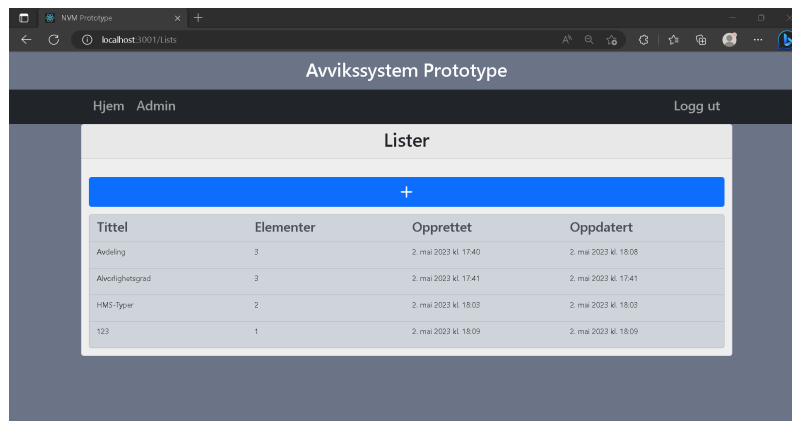
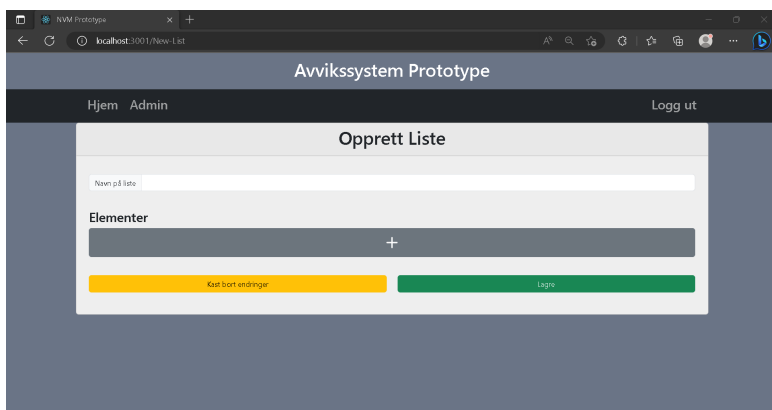
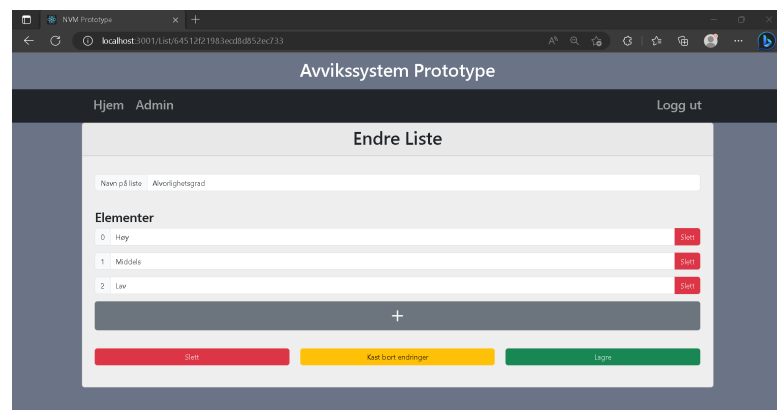


Figure 3.16: First Prototype: "Lists"-page

The "Lists"-page, see Figure 3.16, presents the user with a list over existing lists and a plus button. A list is a list of options, as seen in Figure 3.17b. Clicking the plus button sends the user to the "New List"-page presented in Figure 3.17a. Clicking on any existing list will open the "Edit List"-page, presented in Figure 3.17b for that specific list.



(a) "Create List"-page



(b) "Edit List"-page

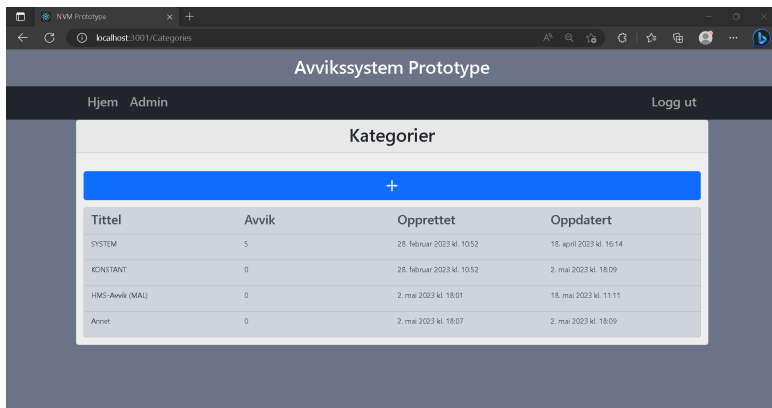
Figure 3.17: First Prototype: List creation and manipulation pages

The "Create List"-page, see Figure 3.17a, has an input for the list name and a

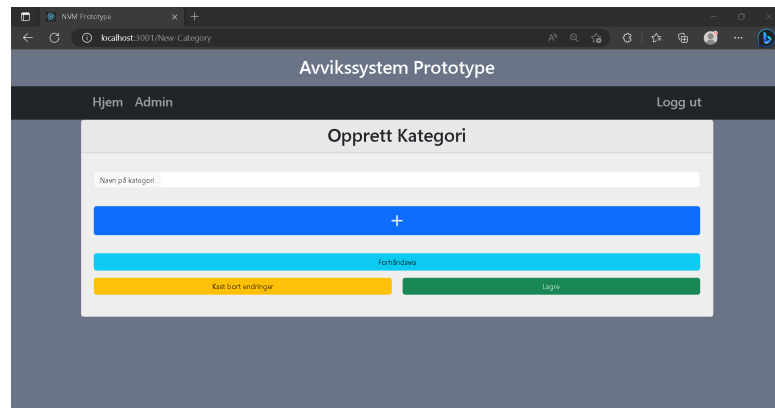
list-editor. The list-editor allows users to add and remove elements/options from the list. Clicking "Kast bort endringer", translated "Discard changes", discards the list, and clicking "Lagre", translated "Save", attempts to submit the list.

The "Edit List"-page, see Figure 3.17b, has the same list-editor as the "Create List"-page, but with a specific list presented. In addition to "Discard changes" and "Save", the "Edit List"-page has a button "Slett", translated "Delete" to delete the list.

Clicking any of the buttons "Discard Changes" and "Save" on both the "Create List"-page and the "Edit List"-page sends the user back to the "Lists"-page (Figure 3.16).



(a) "Categories"-page



(b) "Create Category"-page

Figure 3.18: First Prototype: List of categories and category-editor pages

The "Categories"-page, see Figure 3.18a, presents the user with a list of configured categories and a plus button. Clicking on the plus button sends the user to the "New Category"-page presented in Figure 3.18b. Clicking an existing category sends the user to the "Edit Category"-page, presented in Figure 3.19, for that specific category.

The "Create Category"-page, see Figure 3.18b, has an input for the category name and enables the user to add inputs to the category through an editor. The "New Category" uses the same category-editor as the "Edit Category" page presented in Figure 3.19, without the ability to delete the category, as it is not yet created.

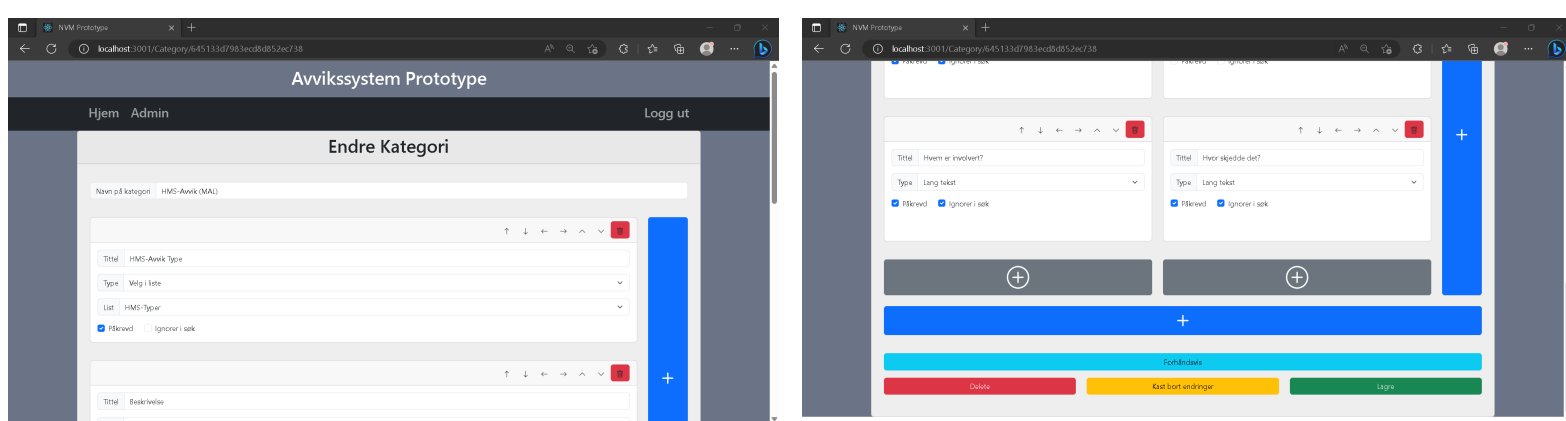


Figure 3.19: First Prototype: "Edit category"-page

The "Edit Category"-page, see Figure 3.19, presents the user with a category editor for a specific category. The user may add, move, edit, and remove inputs, represented by cards.

The blue plus button on the right side adds a new input as a new column, while the blue plus button below adds a new input as a new row. The gray plus button adds input to an existing column. These plus buttons enable the user to customize the layout of their input form for the specific category.

The arrow buttons connected to a card represent, from left to right, "Move to the row above", "Move to the row below", "Move to the column to the left", "Move to the column to the right", "Move over the input above", and "Move under the input below".

The input fields on each card configure the "input", input fields presented on NC registration. "Tittel", translated "Title", sets the input's title. "Type" sets the input type, for example, "Lang tekst", translated "Long text", that represents a text-box. See the connection between Section 3.7.1 and Figure 3.14 regarding the title "Hvor skjedde det" and text-box type. Some input types will ask for additional configuration, like "Velg i liste", translated "Choose from list", which also asks for what list the user should choose from. See Section 3.7.1. Input types, translated, include "Long text", "Short text", "Choose from list", "Auto-fill", and "Header". The option to require the user to fill out the input is represented with a check-box with the text "Påkrevd", translated "Required". The option to ignore the input when searching among NCs is represented with a check-box with the text "Ignorer i søk", translated "Ignore in search". Clicking the red garbage can button in the top right of a card removes the input.

On the bottom of the page are the buttons "Forhåndsvis", translated "Preview", "Delete", "Kast bort endringer", translated "Discard changes", and "Lagre", translated "Save". The "Preview"-button presents the user with a view of the configured category like Figure 3.14a. The "Delete"-button deletes the category. The "Discard changes"-button discards any changes to the category. The "Save"-button attempts

to submit the updated category. Clicking any of the buttons sends the user back to the "Categories"-page (Figure 3.18a).

3.7.2 Artifact Evaluation

The second iteration of evaluation was Usability Testing of the minimal prototype described in Section 3.7.1. The test was conducted on 6 participants (P1, P2, P5, P6, P7, and P8 from Table 3.1). The test environment was as described in Section 3.5.3, and the test plan as described in Section 3.5.4.

Tasks
Log in with username "Ole"
You have witnessed a person-injury of high severity where "Morten" was ran over by a car. Register this non-conformance.
Find the non-conformance "Truck collision" that you, "Ole", have previously registered, describing a collision between a truck and a car, and edit the incident. Add the following proposed measure; "Install traffic-mirror in intersection".
Find the non-conformance "TEST" that was registered by "Morten". Observe that you may not edit this incident. Log out, and then log in with the username "admin". Once again find the non-conformance "TEST" that was registered by "Morten", and delete the incident.
Open the "Admin"-tab and click on "Lists". Create a new list called "Animals", with the elements "Cat", "Dog", and "Deer". Open the "Admin"-tab and click on "Categories". Change the category "Collision with animal" so that the user is required to choose an animal from the newly created list "Animals" under the title "What animal was hit?". Make sure the input is required.
The category names "STANDARD" is included at the top when registering all non-conformance. The input-fields in this category should reflect the common input for all non-conformance. Open the "Admin"-tab and click on "Categories". Edit the category "STANDARD" so that it reflects the common inputs for all non-conformance in your industry/-workplace. If the category needs new or edited lists, then this must be done under "Admin" » "Lists".
Under "Admin" » "Categories", create a new category that is relevant to your industry/workplace. If the category needs new or edited lists, then this must be done under "Admin" » "Lists". Register a non-conformance of this newly created category.

Table 3.7: Iteration 2: Test Tasks

The tasks, translated from Norwegian, are listed in Table 3.7.

Questions
Does the system offer the expected functionality of an NCM System?
Does the system miss any expected functionality of an NCM System?
What functionality should be improved?
Does the system offer any functionality that does not belong in an NCM System?

Table 3.8: Iteration 2: Follow-up Questions

The follow-up questions, translated from Norwegian, are listed in Table 3.8.

3.7.3 Method Evaluation

The project has completed an iteration of the processes refine and assess from Figure 3.1 by developing a minimal prototype (See Section 3.7.1) as a refined artifact from evaluation of the Firma Model (See Section 3.6.2) and assess it using Usability Testing with 6 participants (See Section 3.7.2).

The evaluation's validity is increased by the number of participants, but the number of participants in future evaluations should increase to meet the ISO/IEC 25062:2006 [11] standard's recommended minimum of 8 participants, mentioned in Section 3.5.1.

3.8 Iteration 3: Final Prototype

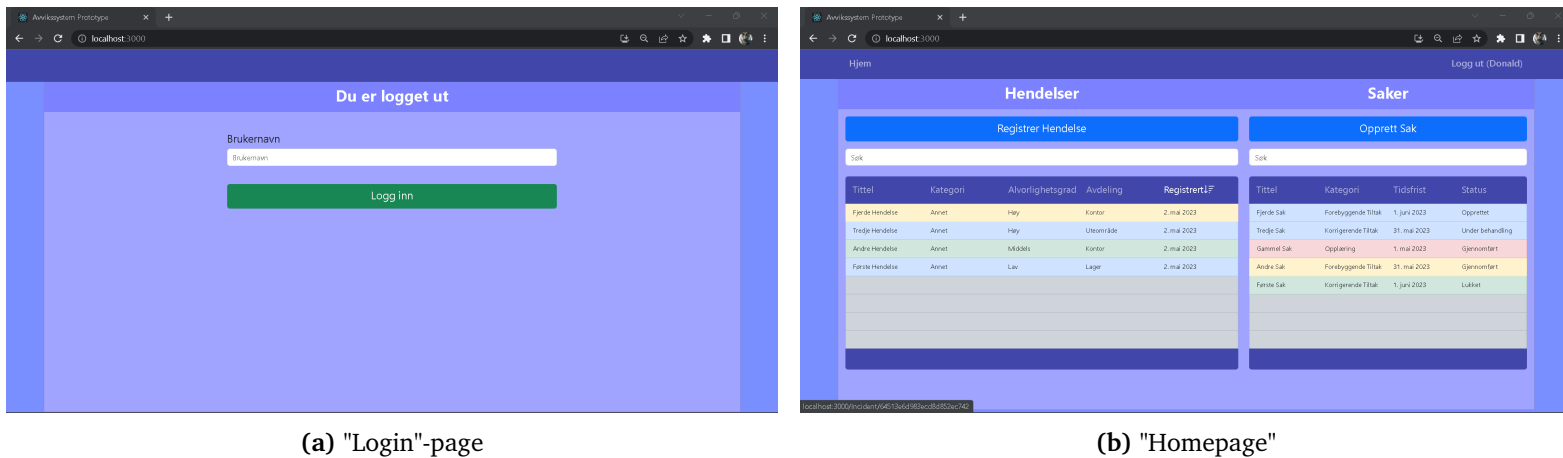
3.8.1 Artifact

An improved prototype was developed based on the minimal prototype (Section 3.7). The second prototype handles registration of NC in the form of incidents, and allows for opening cases regarding these incidents. An example of a case could be an improvement measure meant to prevent the recurrence of an incident.

A case has 4 stages represented by the following statuses:

- "Opprettet" / "Created": The case is created. The responsible user has yet to accept the responsibility.
- "Under Behandling" / "Under Handling": The responsible user has accepted responsibility, but has yet to perform the tasks.
- "Gjennomført" / "Performed": The responsible user has marked the tasks as performed, but the user that created the case has yet to confirm that the tasks are performed.
- "Lukket" / "Closed": The user that created the case has confirmed that the tasks are performed and closed the case.

There are tooltips and placeholders for any input to assist users in understanding the usage of the system.



(a) "Login"-page

(b) "Homepage"

Figure 3.20: Second Prototype: "Login"-page and "Homepage"

Before the user is logged in they will see the "Login"-page, see Figure 3.20a. By inputting a username and clicking "Logg inn", translated "Log in", the user is sent to the "Homepage".

The navigation bar changes as the user is logged in, and when authenticated it has a button "Logg ut ([USERNAME])", translated "Sign out ([USERNAME])", that the user may use to sign out (Figure 3.20b) and return to the "Login"-page (Figure 3.20a).

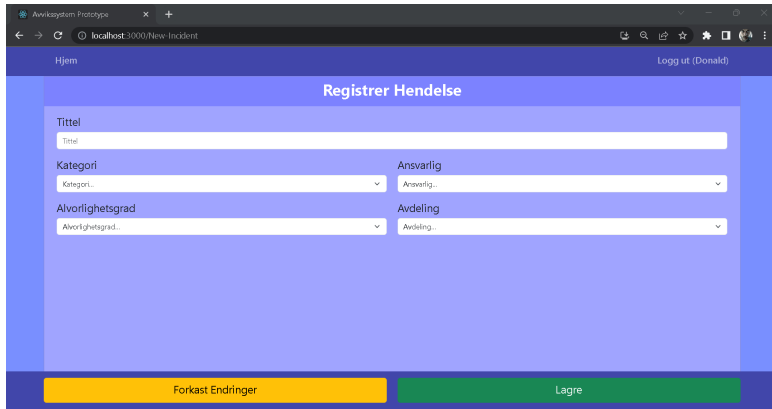
The homepage, see Figure 3.20b, presents the user with sortable and searchable lists of "Hendelser", translated "Incidents", and "Saker", translated "Cases". It also presents a button "Registrer Hendelse", translated "Register Incident", and a button "Opprett Sak", translated "Open Case".

The lists of incidents and cases can be searched, and all information regarding the incident or case will apply to the search unless specified by the system administrator to be ignored. The information presented in the list is configurable by the system administrator, and the list can be sorted by each of these configurable headers. Incidents and cases are also color-coded:

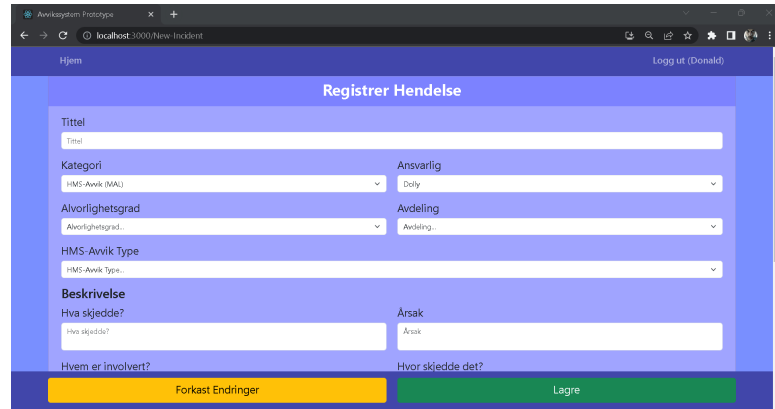
- Blue: The user has no responsibility for the incident or case.
- Red: The user has a pending task regarding the incident or case, or a case that the user has some responsibility for has surpassed the deadline without being closed.
- Yellow: The user has some responsibility regarding the incident or case, but not for the pending task.
- Green: The user has some responsibility regarding the incident or case and the user has completed their tasks.

By clicking "Register Incident", the user is sent to the "Register Incident"-page, presented in Figure 3.21. By clicking on an incident in the incident-list the user is sent to the "Incident"-page for the specific incident (See Figure 3.22). By clicking

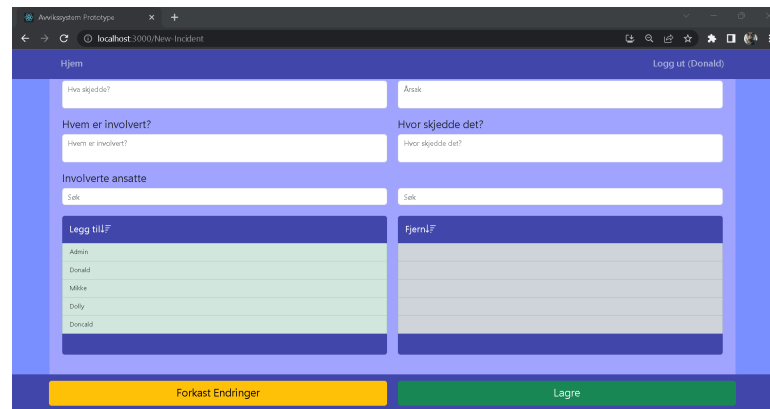
"Open Case" the user is sent to the "Open Case"-page, presented in Figure 3.23. By clicking on a case in the case-list the user is sent to the "Case"-page for the specific case (See Figure 3.24a).



(a) Before selecting category



(b) After selecting category (1)



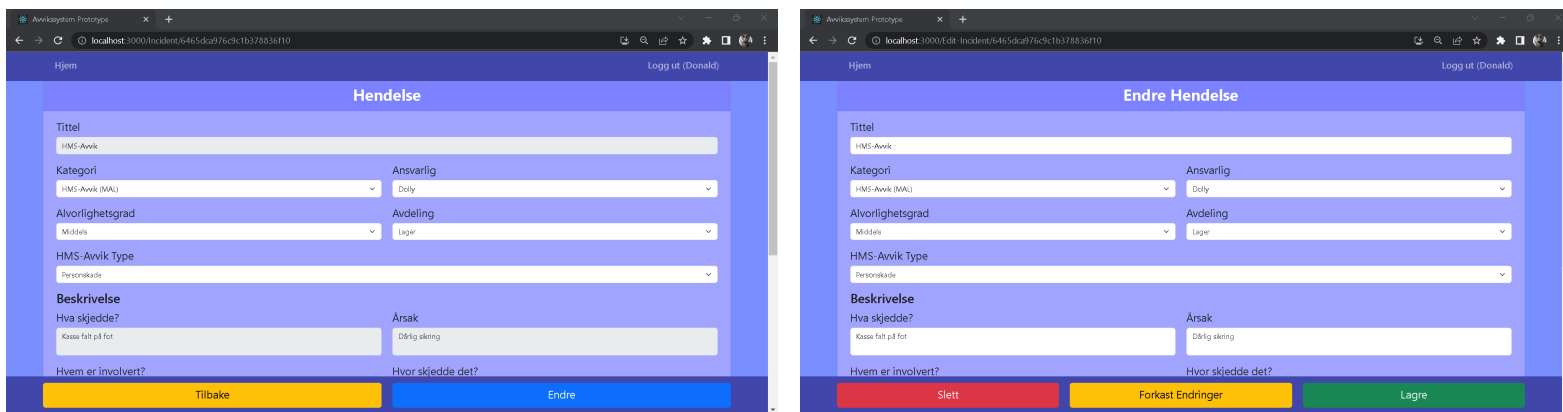
(c) After selecting category (2)

Figure 3.21: Second Prototype: "Register Incident"-page

The "Register Incident"-page, presented in Figure 3.21, presents the user with pre-configured input fields. The inputs including "Tittel", translated "Title", "Kategori", translated "Category", and "Ansvarlig", translated responsible, are non-configurable input-fields. The following input-fields, "Alvorlighetsgrad", translated "Severity", and "Avdeling", translated "Department", are from the "Global Hendelse-Input", translated "Global Incident Input", and is configurable by the system administrator. The non-configurable input fields and selected input fields from "Global incident Input" are presented along with the NC in the list on the homepage (Figure 3.20b).

As the user selects a category the page will present additional input fields pre-configured to the respective incident-category by the system administrator, see Figure 3.21 and Figure 3.21c.

The page also presents a button "Forkast Endringer", translated "Discard Changes", and a button "Lagre", translated "Save". Clicking "Discard Changes" will send the user back to the "Homepage" (Figure 3.20b), while "Save" will attempt to register the inputted information as an incident. Some or all input fields may be required, translated they require input to allow submission. Upon submission the user is sent to the "Incident"-page (Figure 3.22) for the registered incident.



(a) "Incident"-page

(b) "Edit Incident"-page

Figure 3.22: Second Prototype: Incident display and manipulation pages

The "Incident"-page, see Figure 3.22a presents the user with information regarding a specific incident. Information here is not editable. If the user is the one that registered the incident, or if the user is an administrator, the button "Endre", translated "Edit", is visible. Clicking "Edit" sends the user to the "Edit Incident"-page, presented in Figure 3.22b. Clicking "Tilbake", translated "Back", the user is sent back to the homepage (Figure 3.20b).

The "Edit Incident"-page, see Figure 3.22b, presents the user with editable information regarding a specific incident. The user may discard changes by clicking "Forkast Endringer", translated "Discard Changes", or submit changes by clicking "Lagre", translated "Save". The user may also delete the registered incident by clicking "Slett", translated "Delete". If changes are discarded or submitted, the user is sent to the "Incident"-page (Figure 3.22a). If the incident is deleted, the user is sent back to the "Homepage" (Figure 3.20b).

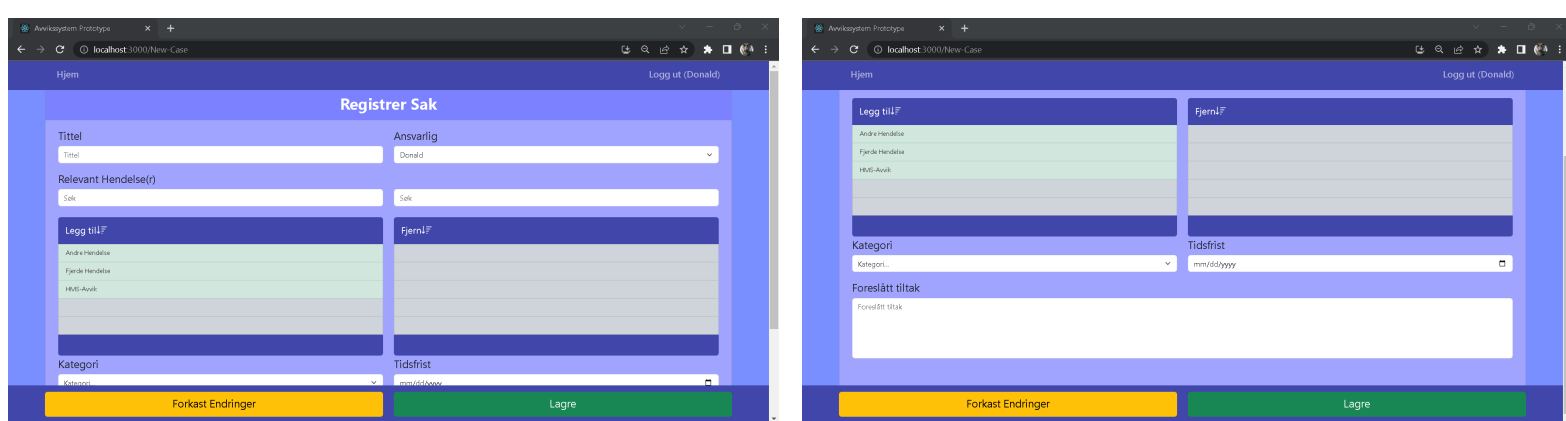


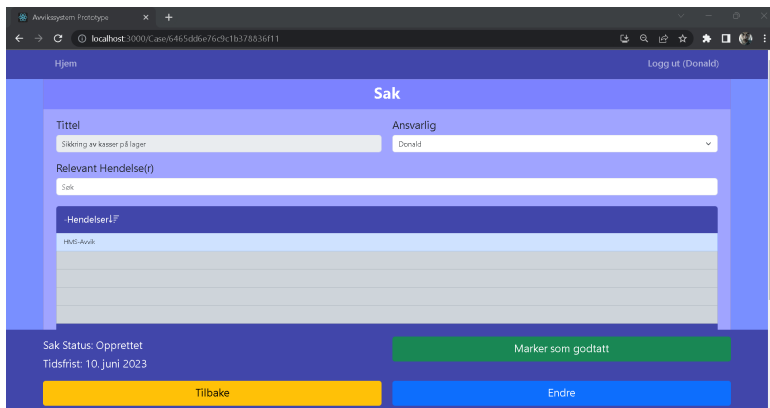
Figure 3.23: Second Prototype: "New Case"-page

The "Open Case"-page, presented in Figure 3.23, presents the user with pre-configured input fields. The inputs including "Tittel", translated "Title", "Ansvarlig", translated responsible, "Relevant Hendelse(r)", translated "Relevant Incidents", "Kategori", translated "Category", and "Tidsfrist", translated "Deadline" are non-configurable input-fields. The following input field "Foreslått tiltak", translated "Proposed Measure", is from the "Global Sak-Input", translated "Global Case Input", and is configurable by the system administrator. The non-configurable "Title", "Category", and "Deadline" input-fields and selected input-fields from "Global incident Input" are presented along with the NC in the list on the homepage (Figure 3.20b), accompanied by a case-status.

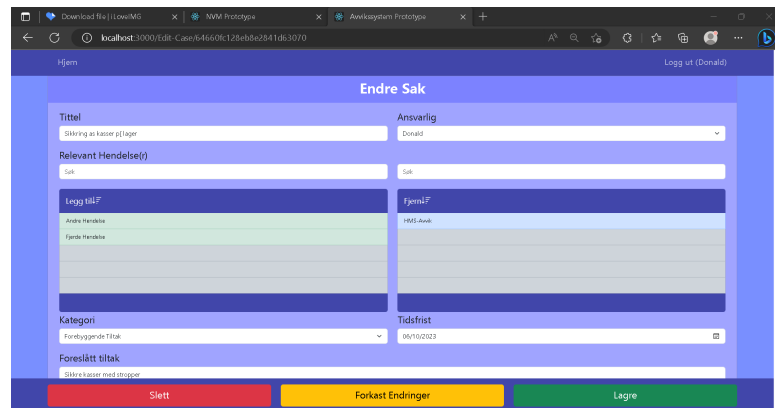
The input "Relevant Incidents" allows the user to reference none, one, or more incidents related to the case by selecting incidents from a list of incidents the user has responsibility for.

As the user selects a category the page will present additional input fields pre-configured to the respective case-category by the system administrator, similar to when registering an incident (Figure 3.21).

The page also presents a button "Forkast Endringer", translated "Discard Changes", and a button "Lagre", translated "Save". Clicking "Discard Changes" will send the user back to the "Homepage" (Figure 3.20b), while "Save" will attempt to register the inputted information as a case. Some or all input-fields may be required, translated they require input to allow submission. Upon submission the user is sent to the "Case"-page (Figure 3.24a) for the registered incident.



(a) "Case"-page



(b) "Edit Case"-page

Figure 3.24: Second Prototype: Case display and manipulation pages

The "Case"-page, see Figure 3.24a presents the user with information regarding a specific case. Information here is not editable. If the user is the one that registered the case, the one marked as responsible for the case, or if the user is an administrator, the button "Endre", translated "Edit", is visible. Clicking "Edit" sends the user to the "Edit Case"-page, presented in Figure 3.24b. Clicking "Tilbake", translated "Back", the user is sent back to the "Homepage" (Figure 3.20b).

The "Edit Case"-page, see Figure 3.24b, presents the user with editable information regarding a specific case. The user may discard changes by clicking "Forkast Endringer", translated "Discard Changes", or submit changes by clicking "Lagre", translated "Save". The user may also delete the registered case by clicking "Slett", translated "Delete". If changes are discarded or submitted, the user is sent to the "Case"-page (Figure 3.24a). If the case is deleted, the user is sent back to the "Homepage" (Figure 3.20b).



(a) Status: Created



(b) Status: In-Progress



(c) Status: Performed



(d) Status: Closed

Figure 3.25: Second Prototype: Case status steps

The statuses listed in Section 3.8.1 are changed on the "Case"-page (Figure 3.24a) by the user responsible for completing the next task. The green and red buttons signaling the change of status in Figure 3.25 are only visible to the relevant user. A green button progresses the status down the list, while a red button regresses the status up the list.

The responsible user for a case with the status "Created" is presented with the green button "Marker som godtatt", translated "Mark as accepted", see Figure 3.25a, that will progress the case's status to "In-Progress".

The responsible user for a case with the status "In-Progress" is presented with the green button "Marker som gjennomført", translated "Mark as performed", and the red button "Marker som ikke godtatt", translated "Mark as not accepted", see Figure 3.25b, that will progress the case's status to "Performed" or regress the status to "Created".

The user that created a case that has the status "Performed" is presented with the green button "Marker som lukket", translated "Mark as closed", and the red button "Marker som ikke gjennomført", see Figure 3.25c, that will progress the case's status to "Closed" or regress the status to "In-Progress".

The user that created a case that has the status "Closed" is presented with the red button "Marker som ikke lukket", see Figure 3.25d, that will regress the case's status to "Performed".

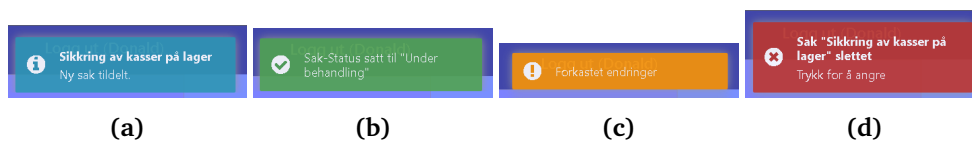


Figure 3.26: Second Prototype: Notification types

User feedback upon clicking buttons that sends the user to new pages is delivered in the top right corner of the screen, as pictured in Figure 3.26. The notifications are color coded as followed:

- Blue notification: Pending task (See Figure 3.26a)
- Green notification: Successful submit (See Figure 3.26b)
- Yellow notification: Discarded changes (See Figure 3.26c)
- Red notification: Successful deletion (See Figure 3.26d)

Blue notifications are triggered upon visiting the "Homepage" (See Figure 3.20b).

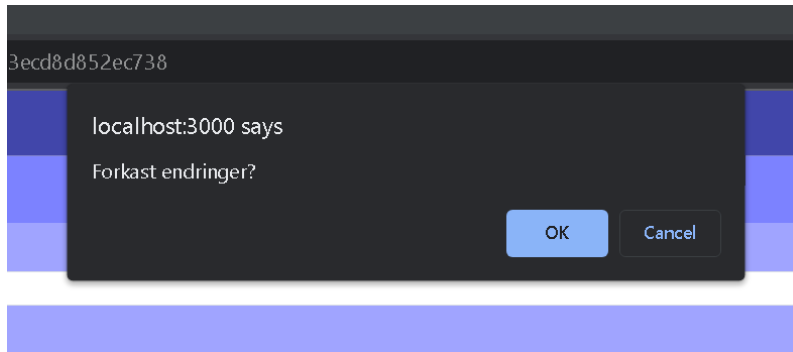


Figure 3.27: Second prototype: Confirmation Prompt

The confirmation prompt pictured in Figure 3.27 is triggered whenever the user tried to navigate away from unsaved input, either through the use of "Discard Changes"-buttons or other navigation buttons. The prompt's message reads "Forkast endringer?", translated "Discard changes?". Only upon confirmation, by clicking "OK", the user is navigated to the next page.

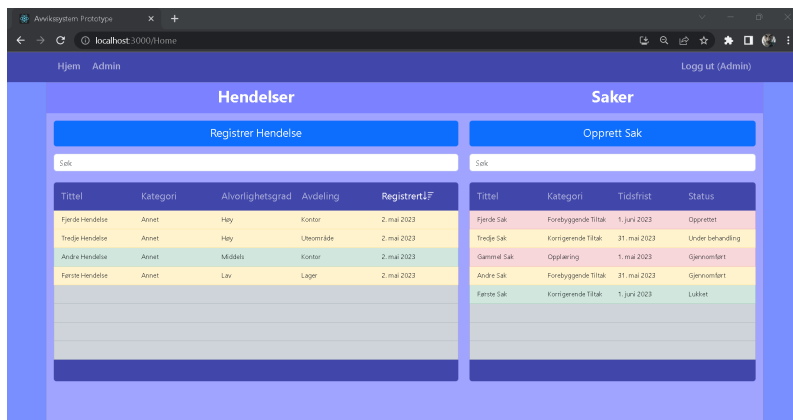


Figure 3.28: Second prototype: "Homepage" as administrator

Logging in as an administrator will present the "Homepage" with administrator color-coding and reveal the "Admin" tab in the navigation bar, see Figure 3.28. The administrator color-coding is as follows:

- Green: Closed case or incident with related case(s) closed
- Yellow: Open case or incident with an open case
- Red: Non-accepted case or incident without related case

Clicking "Admin" in the navigation bar sends the user to the "Admin"-page presented in Figure 3.29.

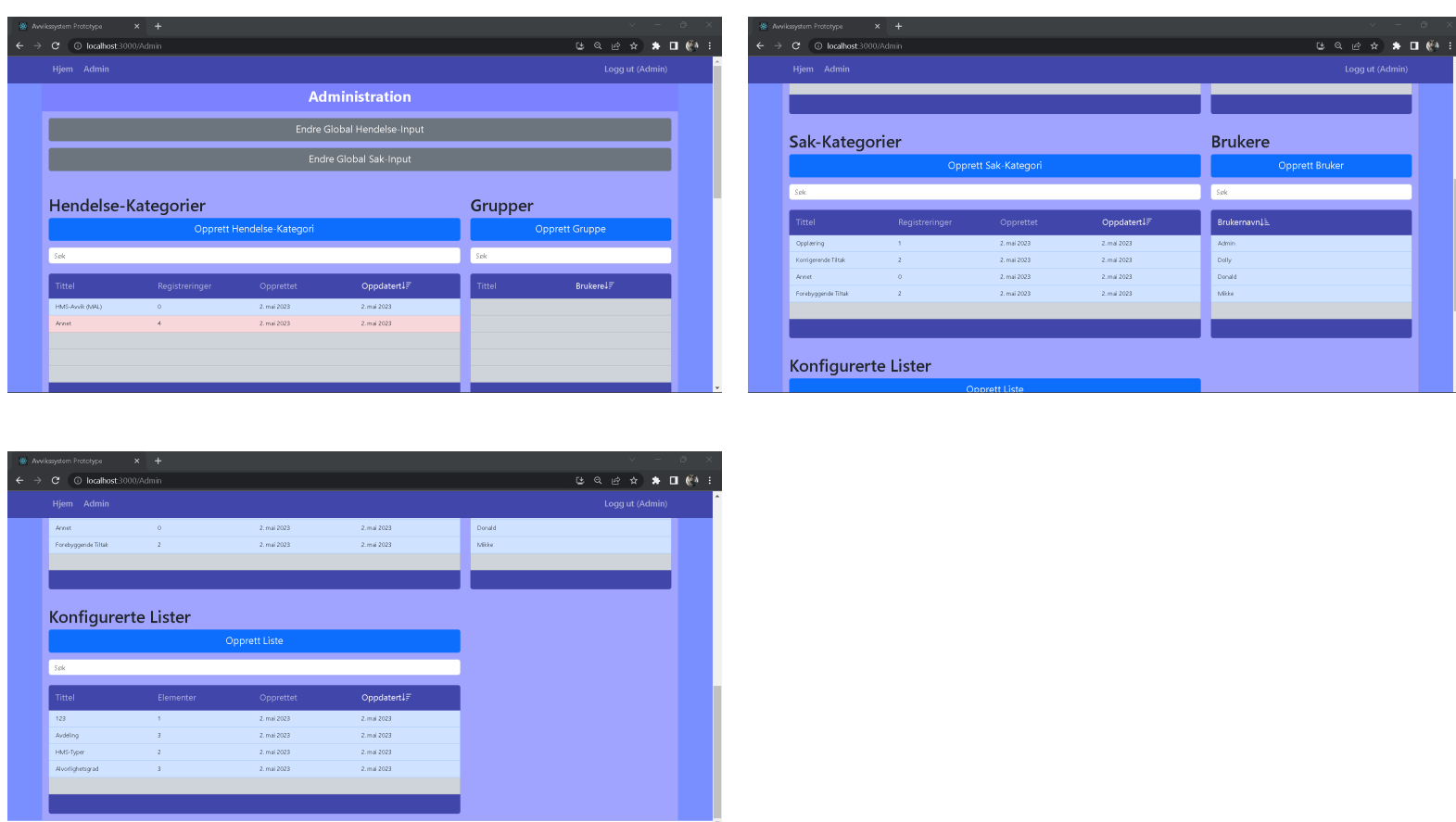


Figure 3.29: Second Prototype: "Admin"-page

The "Admin"-page, see Figure 3.29, presents sortable and searchable lists for users, groups, lists, incident-categories, and case-categories, as well as buttons for the creation of each.

Clicking on "Opprett Bruker", translated "Create User", sends the user to the "Create User"-page presented in Figure 3.30a. Clicking an existing user sends the user to the "Edit User"-page, presented in Figure 3.30b, for the specific user.

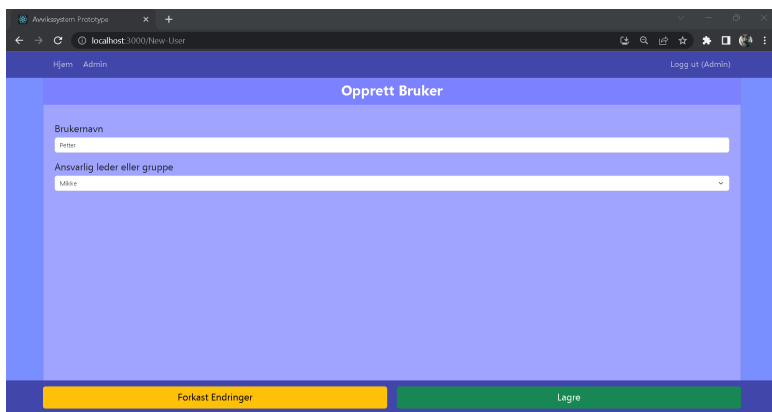
Clicking on "Opprett Gruppe", translated "Create Group", sends the user to the "Create Group"-page presented in Figure 3.31a. Clicking an existing group sends the user to the "Edit Group"-page, presented in Figure 3.31b, for the specific user.

Clicking on "Opprett Liste", translated "Create List", sends the user to the "Create List"-page presented in Figure 3.32a. Clicking an existing list sends the user to the "Edit List"-page, presented in Figure 3.32b, for the specific list.

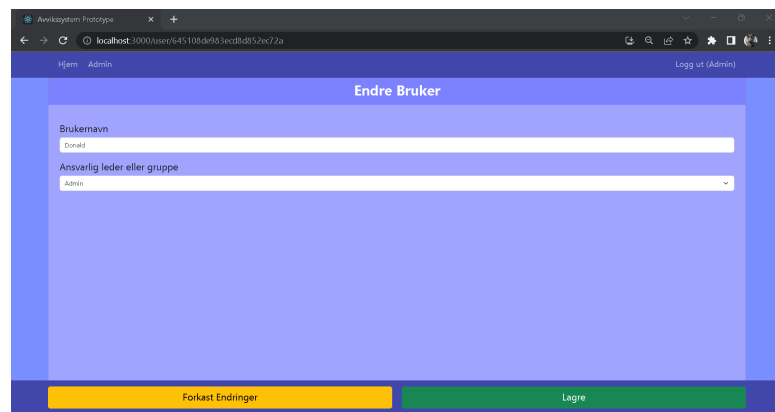
Clicking on "Opprett Hendelse-Kategori", translated "Create Incident-Category", sends the user to the "Create Category"-page presented in Figure 3.33a. Clicking an existing incident-category sends the user to the "Edit Incident-Category"-page, presented in Figure 3.34, for the specific incident-category.

Clicking on "Opprett Sak-Kategori", translated "Create Case-Category", sends the user to the "Create Category"-page presented in Figure 3.33b. Clicking an existing case-category sends the user to the "Edit Case-Category"-page, similar to the "Edit Incident-Category"-page presented in Figure 3.34, for the specific case-category.

The "Admin"-page also presents the button "Endre Global Hendelse-Input", translated "Change Global Incident-Input", that sends the user to an "Edit Incident-Category"-page (Figure 3.36a) for the "Global Incident-Input". The "Global Incident-Input" is input that is requested for all incidents, regardless of incident-category. It also presents the button "Endre Global Sak-Input", translated "Change Global Case-Input", that sends the user to an "Edit Case-Category"-page (Figure 3.36b) for the "Global Case-Input". The "Global Case-Input" is input that is requested for all cases, regardless of case-category.



(a) "Create User"-page

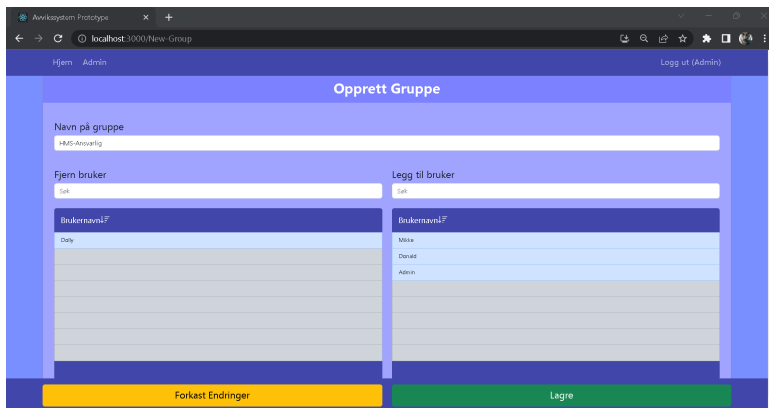


(b) "Edit User"-page

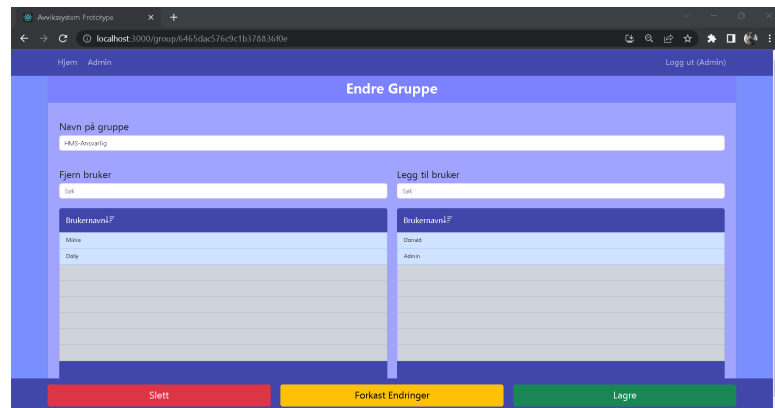
Figure 3.30: Second Prototype: User management pages

The "Create User"-page, see Figure 3.30a, has inputs for the username and who is responsible for the user. The "Edit User"-page, see Figure 3.30b, presents the user with editable information regarding a specific user. For both pages, clicking "Forkast Endringer", translated "Discard changes", discards the user or changes, and clicking "Lagre", translated "Save", attempts to submit the user or updated user.

Clicking any of the buttons sends the user back to the "Admin"-page (Figure 3.29).



(a) Create group

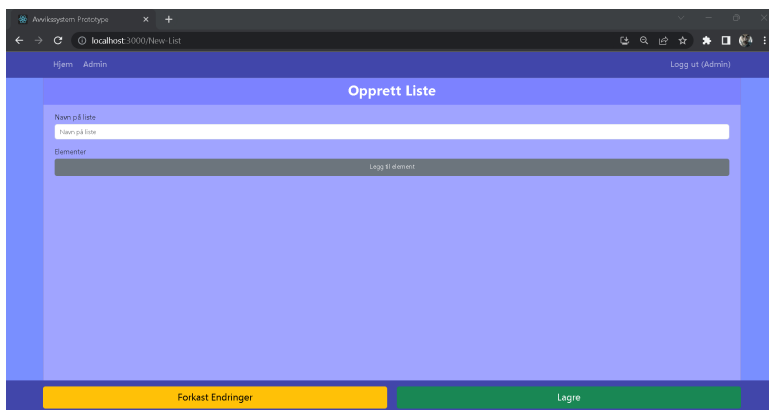


(b) Edit group

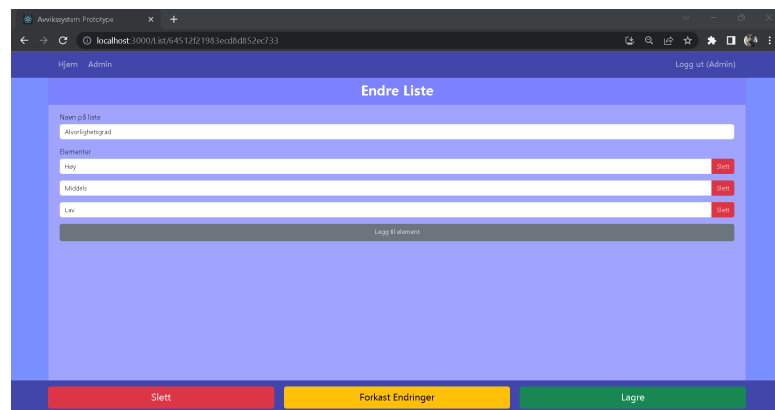
Figure 3.31: Second Prototype: Group management pages

The "Create Group"-page, see Figure 3.31a, has an input for the group name and a user selection to select group members. The "Edit Group"-page, see Figure 3.31b, presents the user with editable information regarding a specific group. For both pages, clicking "Forkast Endringer", translated "Discard changes", discard the group or changes, and clicking "Lagre", translated "Save", attempts to submit the group or updated group. In addition, the "Edit Group"-page has a "Slett"-button, translated "Delete". Clicking "Delete" attempts to delete the group.

Clicking any of the buttons sends the user back to the "Admin"-page (Figure 3.29).



(a) "Create List"-page



(b) "Edit List"-page

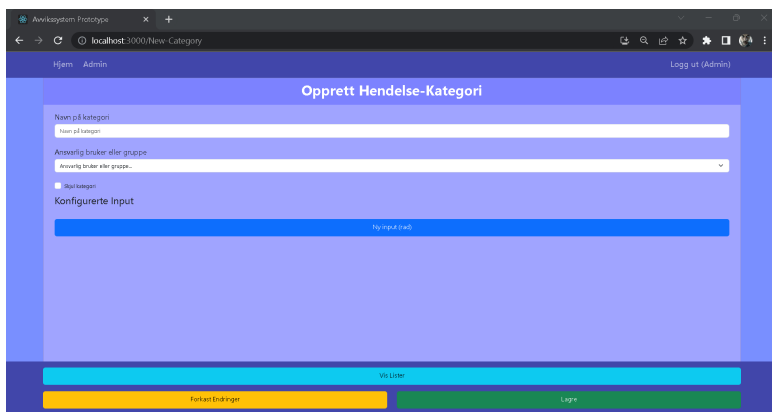
Figure 3.32: Second Prototype: List creation and manipulation pages

The "Create List"-page, see Figure 3.32a, has an input for the list name and

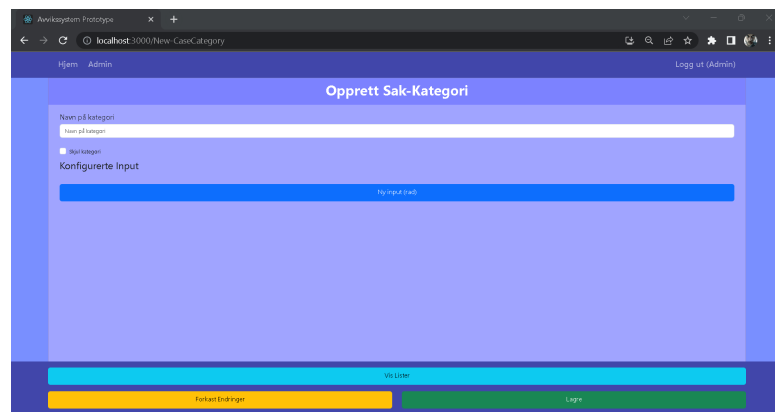
a list editor. The list editor allows for users to add and remove elements/options from the list. Clicking "Forkast endringer", translated "Discard changes", discards the list, and clicking "Lagre", translated "Save", attempts to submit the list.

The "Edit List"-page, see Figure 3.32b, has the same list-editor as the "Create List"-page, but with a specific list presented. In addition to "Discard changes" and "Save", the "Edit List"-page has a button "Slett", translated "Delete" to delete the list.

Clicking any of the buttons sends the user back to the "Admin"-page (Figure 3.29).



(a) "Create Incident-Category"-page



(b) "Create Case-Category"-page

Figure 3.33: Second Prototype: Pages for manipulation of incident- and case-categories

The "Create Incident-Category"-page, presented in Figure 3.33a, has inputs for category name and responsible user or group, and a category-editor. The "Create Case-Category"-page, presented in Figure 3.33b, has an input for category name and a category-editor.

Both pages also have a check-box for hiding the category, either incident-category or case-category, from users. The category-editor is described in detail under Figure 3.34.

The pages have the buttons "Forkast endringer", translated "Discard Changes", and "Lagre", translated "Save". Clicking "Discard Changes" will discard changes to the category and send the user back to the "Admin"-page (Figure 3.29). Clicking "Save" will attempt to submit the category. Upon submission, the user is sent to the "Admin"-page (Figure 3.29).

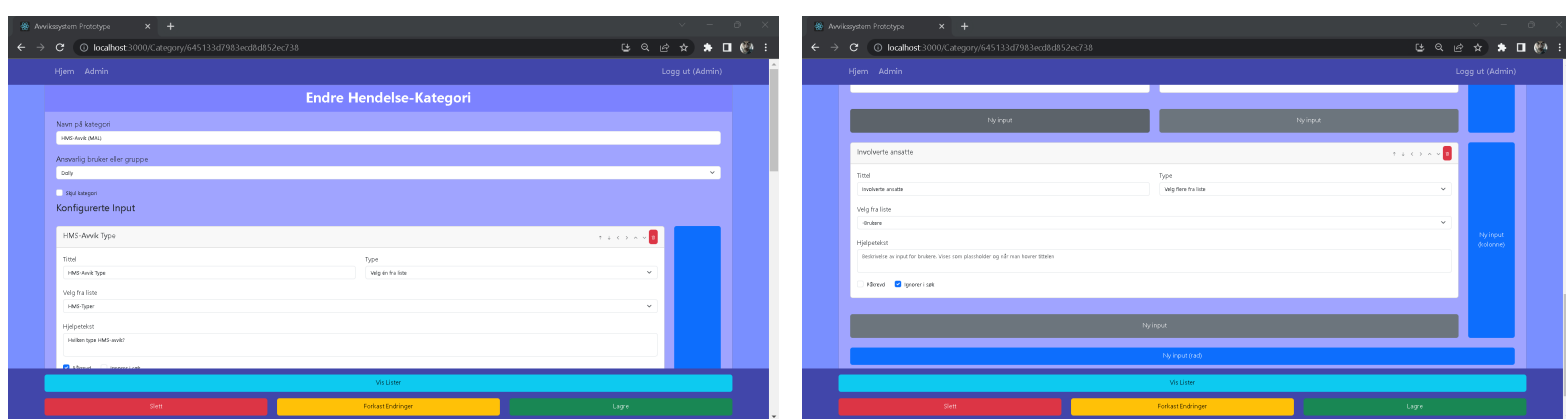


Figure 3.34: Second Prototype: "Edit Incident-Category"-page

The "Edit Incident-Category"-page, presented in Figure 3.34, has the same input-fields and category-editor as the "Create Incident-Category"-page, but with a specific category presented. The page also has a "Slett"-button, translated "Delete", to delete the category.

The category-editor let's the user add, move, edit, and remove inputs, represented by cards.

The blue button on the right side adds a new input as a new column, while the blue button bellow adds a new input as a new row. The gray button adds input to an existing column. These buttons enable the user to customize the layout of their input form for the specific category.

The arrow buttons connected to a card represents, from left to right, "Move to row above", "Move to row bellow", "Move to column t the left", "Move to column to the right", "Move over input above", and "Move under input below".

The inputs-fields on each card configure the input. "Tittel", translated "Title", sets the input title. "Type" sets the input-type, for example "Lang tekst", translated "Long text", that represents a text-box. "Hjelpetekst", translated "Help-text", sets the tooltip and placeholder for the input-field. See the connection between Figure 3.34 and Figure 3.21b.

Some input types will ask for additional configuration, like "Velg flere fra liste", translated "Choose multiple from list", which also asks for what list the user should choose from.

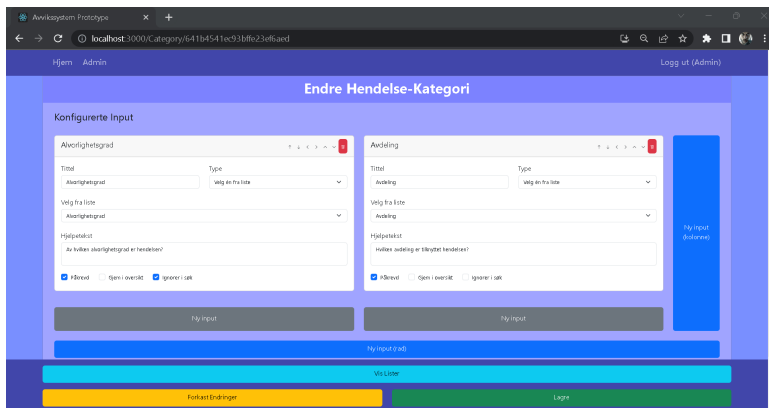
Input types, translated, include "Long text", "Short text", "Choose one from list", "Choose mulitple from list", "Number", "Date", "Auto-fill", and "Header". The option to require the user to fill out the input is represented with a check-box with the text "Påkrevd", translated "Required". The option to ignore the input when searching among NCs is represented with a check-box with the text "Ignorer i søk", translated "Ignore in search". Clicking the red garbage can button in the top right of a card removes the input.

Figure 3.35: Second prototype: List editor while editing category

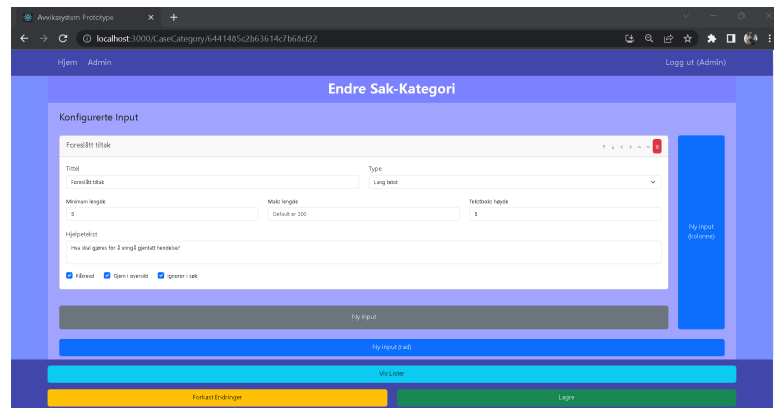
On the bottom of the page is the buttons "Vis Lister"/"Gjem Lister", translated "Show Lists"/"Hide Lists", "Slett", translated "Delete", "Kast bort endringer", translated "Discard changes", and "Lagre", translated "Save".

The "Show Lists"/"Hide Lists"-button presents the user with a list of lists and a list-editor as shown in Figure 3.35. Clicking "Opprett Liste", translated "Create List", the list-editor enables the user to create a new list. Clicking on an existing list from the list, the list-editor enables the user to edit an existing list. The list editor itself works as described under Figure 3.32.

The "Delete"-button deletes the category. The "Discard changes"-button discards any changes to the category. The "Save"-button attempts to submit the updated category. Clicking any of these buttons sends the user back to the "Admin"-page (Figure 3.29).



(a) Edit global incident-input



(b) Edit global case-input

Figure 3.36: Second Prototype: Global input categories

The "Edit Global Incident-Input"-page, presented in Figure 3.36a, and the "Edit Global Case-Input", presented in Figure 3.36b, has a category-editor each, controlling input-fields that are requested for all incidents or cases respectively, unaffected by the selected category. The pages have a "Forkast Endringer"-button, translated "Discard Changes", and a "Lagre"-button, translated "Save".

The "Discard changes"-button discards any changes. The "Save"-button attempts to submit the updated inputs fields. Clicking any of these buttons sends the user back to the "Admin"-page

3.8.2 Artifact Evaluation

The third iteration of evaluation was Usability Testing of the final prototype described in Section 3.8.1. The test was conducted on all participants listed in Table 3.1. The test environment was as described in Section 3.5.3, and the test plan as described in Section 3.5.4.

Tasks
<p>Get to know the system as a user:</p> <ul style="list-style-type: none"> • Log in with username "Donald" • Click around and explore the homepage • Register an incident with made-up information, and set "Donald" as responsible • Open a case with made-up information, and set "Donald" as responsible • Log out
<p>Get to know the system as an administrator:</p> <ul style="list-style-type: none"> • Log in with username "Admin" • Open the "Admin"-tab • Get an overview of available options on the "Admin"-page • Click on "Change Global Incident-Input" and observe the configured input-fields that are requested under incident registration, no matter the category • Discard changes • Click on "Change Global Case-Input" and observe the configured input-fields that are requested under case opening, no matter the category • Discard changes
<p>As admin</p> <ul style="list-style-type: none"> • Create the new group "EHS-Responsible", and make sure to add "Dolly" as a member • Create an incident-category called "EHS Incident", where you set "EHS-Responsible" as responsible, and add input fields you find relevant to specifically EHS incidents. • Log out
<p>As Donald</p> <ul style="list-style-type: none"> • Log in with username "Donald" • Register an EHS incident with made-up information, and set "EHS-Responsible" as responsible for the incident • Observe the homepage (Color-coding explained) • Log out

Table 3.9: Iteration 3: Test Tasks (1)

Tasks
<p>As Dolly</p> <ul style="list-style-type: none"> • Log in with username "Dolly" • Observe the homepage (Color-coding explained) • Open a case for Donald's newly registered incident, and set "Donald" as responsible for the case • Observe the homepage (Color-coding explained) • Log out
<p>As Donald</p> <ul style="list-style-type: none"> • Log in with username "Donald" • Observe the homepage (Color-coding explained) • Find the newly opened case and accept responsibility • Edit the case by updating the information under "Execution", and mark the case as performed • Observe the homepage (Color-coding explained) • Log out
<p>As Dolly</p> <ul style="list-style-type: none"> • Log in with username "Dolly" • Observe the homepage (Color-coding explained) • Find the newly performed case and close it • Observe the homepage (Color-coding explained) • Log out
<p>Explore the system further until satisfied</p>

Table 3.10: Iteration 3: Test Tasks (2)

The tasks, translated from Norwegian, are listed in Table 3.9 and Table 3.10.

Questions
Does the system lack any functionality that is expected of an NCM System?
Is there any information that the system can't handle that an NCM System should handle?
Does the system offer any functionality that does not belong in an NCM System?
Is there anything you would like to add?

Table 3.11: Iteration 3: Follow-up Questions

The follow-up questions, translated from Norwegian, are listed in Table 3.11.

Questions
Should the system output some type of statistics regarding the input and handling of information? What statistics would be relevant?
Should the system handle the storage of files or images? What functionality should it provide regarding handling files?
The system notifies users of pending tasks on the homepage. Do you have any thoughts regarding how the system should notify users?

Table 3.12: Iteration 3: Leading Follow-up Questions

Some leading follow-up questions, translated from Norwegian, are listed in Table 3.12. These questions were asked, if the participant did not already discuss the topics, to further probe for the system's shortcomings.

3.8.3 Method Evaluation

The project has completed another iteration of the processes refine and assess from Figure 3.1 by developing a final prototype (See Section 3.8.1) as a refined artifact from evaluation of the minimal prototype (See Section 3.7.2) and assess it using usability testing with 8 participants (See Section 3.8.2).

The evaluation's validity is further increased, compared to the evaluation described in Section 3.7.2, by the number of participants as it meets the ISO/IEC 25062:2006 [11] standard's recommended minimum of 8 participants, mentioned in Section 3.5.1.

Chapter 4

Findings

The following sections present the results from the evaluations of the artifact, analysis of said results, and refinement notes for future refinement.

4.1 Iteration 1: Figma Model

4.1.1 Evaluation Results

Results from the evaluation of the Firma Model described in Section 3.6.2. The results are summarized and translated from Norwegian.

Participant	Feedback during test
P5	The settings normally include the possibility to change username and password, configure email and phone number, and change system language. The colors for the user interface should follow common standards. For example, green means add or save, while red means delete, close, or back.

Table 4.1: Iteration 1: Feedback during test

Feedback from the participants as they were thinking out loud during the test is presented in Table 4.1.

Does the model miss any expected functionality of an NCM system?	
Participant	Answer
P5	<p>When reporting a NC, the user should be able to tag his manager as responsible for follow-up on the report.</p> <p>The improvement cases should be listed by themselves through a cases-tab. They should also have a status describing the progress. Proposed statuses include "Proposed", "In-progress", "Resolved", and "Verified". Improvement cases should also reference the relevant NC report.</p> <p>The list of reports should allow search on multiple values related to the report and present filters. I suggest allowing to filter on category by using a drop-down selection of category. The list should be sorted by the value/header that is clicked, for example "Time". It should also be possible to filter on reports from the X latest days, and improvement cases that are unresolved. Searching the list should ignore time-limiting filters. Allowing for a configurable field in the reports list would allow more flexibility. An example would be to add the registered department of the report to the overview.</p> <p>There should be an administrator-tab where the administrator may change the categories, customize interface, and manage users.</p> <p>Categories should maybe be grouped.</p>

Table 4.2: Iteration 1: Feedback from Follow-up Questions (1)

Does the model contain functionality that does not belong in an NCM system?	
Participant	Answer
P5	No, it does not.

Table 4.3: Iteration 1: Feedback from Follow-up Questions (2)

Feedback from the participants from follow-up questions (See Table 3.6) is presented in Table 4.2 and Table 4.3.

4.1.2 Result Analysis and Refinement Notes

The general understanding of NCM systems, described in Section 3.1, seemed to be correct, based on the evaluation results presented in Section 4.1.

The next iteration of development, the development of a minimal prototype (See Section 3.7.1), was to focus on incorporating the main functionality presented and simulated in the Firma Model (See Section 3.6.1), seen as NC registration and category configuration to allow customization for different industries. As the purpose of the study is to explore the expected functionality specific to an NCM system, the implementation of working authentication was not prioritized. The color theme and design also received minimal priority, except the color coding of interactive buttons which was to follow standards as suggested by participant P5 (See Table 4.1). The "Settings"- and "Reports"- (See Figure 3.10a) pages, as well as the feed (See Figure 3.6b) was to be cut in the minimal prototype to prioritize the main functionalities.

The following suggestions taken from Table 4.2 were to be implemented:

- The ability to tag a user as responsible for a report
- Advanced search and sort on list of reports

4.2 Iteration 2: Minimal Prototype

4.2.1 Evaluation Results

Results from the evaluation of the minimal prototype described in Section 3.7.2. The results are summarized and translated from Norwegian.

Participant	Feedback during test
P1	The plus-buttons are confusing. (See Figure 3.19)
P2	When an incident is updated, the user should be sent to a view of the updated incident, not the homepage. Buttons that save should be standardized. The use of "Save", "Submit", and "Send" introduces incoherence. I suggest adding the words "Row" and "Column" to the "Add"-buttons, together with the plus symbol to communicate that they add columns and rows. (See Figure 3.13b and Figure 3.14b)
P5	Change button on login. (See Figure 3.12a) There are many plus-buttons with no explanation. The plus buttons in the category-editor are especially bad. The preview functionality is difficult to use. The category-editor is messy, including the text. The language is inconsistent. There should be an option to make the "Long Text" text-box bigger. (See Figure 3.19) In required fields, a single "space" is an accepted input. It should be possible to enforce some kind of minimal input. There is no confirmation prompt when navigating away from unsaved input. There should be more feedback from user interactions. Both buttons and the navigation bar may be hidden by scrolling. I suggest moving the buttons to the top and fix their position. I would also fix the navigation bar position. (See Figure 3.19) Buttons are bigger than necessary.
P6	The colors, white and gray, make it unclear where the information is.
P7	The button on login called "Send" should be renamed. (See Figure 3.12a) The system should give more feedback on user interaction. Test tasks should be more clear on expressions like "Type". "Title" of input in the category-editor is not intuitive. (see Figure 3.19) Input-fields should have help text or descriptions. Input is deleted upon navigation without warning.
P8	Buttons should be more visible, as they are hard to find when you have to scroll. I suggest fixed positions on the screen. They are also not intuitive. Figure 3.19)

Table 4.4: Iteration 2: Feedback during test

Feedback from the participants as they were thinking out loud during the test is presented in Table 4.4.

Observations during tests
"Add"-buttons are confusing. As every "Add"-button is only symbolized by a plus symbol, the users click the first one they see when they want to add something, even tho different "Add"-buttons do different things. (see Figure 3.19)
Users have the ability to delete the category-selection input field. Deletion of this field would break the system.
Exaggerated padding between input fields during registration of incidents forces unnecessary scrolling and disrupts the user.
Cursor is moved to the end of the input-value upon every keystroke, disrupting user input.
Preview functionality hides the "Save"-button, and does not allow for test-input.

Table 4.5: Iteration 2: Observations during test

Observations of participants during the test is presented in Table 4.5.

Does the system offer the expected functionality of an NCM System?	
Participant	Answer
P1	Yes.
P2	As far as I know.
P5	It offers the expected functionality but requires administrators to understand how to use the system.
P6	Yes. It was nice that the use could create and configure their own categories.
P7	Some functionality, but not all.
P8	It offers the expected functionality, as you are able to customize the system and expand it. You get to make many choices yourself, including if it should be simple or advanced.

Table 4.6: Iteration 2: Feedback from Follow-up Questions (1)

Does the system miss any expected functionality of an NCM System?	
Participant	Answer
P1	No.
P2	No.
P5	<p>It could be an option to change the language under administrator settings.</p> <p>The system lacks functionality for follow-up on incidents. The improvement system functionality could work just like the incident registration, but be named something else. An improvement proposal should be linked to the relevant incident.</p> <p>Including functionality of an improvement system for follow-up on incidents opens for the life cycle of a NC, from registration through follow-up.</p> <p>It also lacks notification of responsible parties through email or in-system notification. All the responsible parties must be notified, but that does not include all managers for every incident.</p> <p>If for commercial use, offer the option to customize colors, logos, and titles.</p>
P6	<p>The system lacks functionality for follow-up on incidents. There should also be registered a deadline and someone responsible for the follow-up. Responsible parties for follow-up include administrators and parties responsible for EHS. It should be possible to configure different roles that are responsible for different categories of incidents.</p> <p>There should also be functionality for proposing measures, with the option to submit the proposal anonymously.</p> <p>It may be relevant with a calendar for scheduling of fire-safety instruction, EHS-planning, etc. The calendar could support action plans and scheduling of measures. This may be relevant only for systems that handle more than only NC, but may also be relevant for NCM Systems, especially thinking of action plans.</p>
P7	<p>It should be possible to ask for user input of date or timestamp.</p> <p>The functionality of an improvement system may be included in an NCM System, as the information an NCM System handles will be used for improving processes, and therefore used in combination with an improvement system if the NCM System does not provide the functionality itself. A NC has a life cycle from registered to resolved. An example of stages is "New", "In-Progress", "Performed", and "Closed".</p> <p>It lacks personal statistics, like the number of registered incidents.</p> <p>It lacks user management and access control.</p>
P8	<p>The system should offer statistics.</p> <p>The system should handle follow-up of incidents, in other words, information regarding measures. This includes information on the party responsible for follow-up, deadlines, and the measures themselves. These measures must be accepted by the party responsible for follow-up, and verified by the leadership afterwards. The progress should also be tracked.</p>

Table 4.7: Iteration 2: Feedback from Follow-up Questions (2)

What functionality should be improved?	
Participant	Answer
P1	The different editors that administrators access are not intuitive. I suggest adding text to the "Add"-buttons to provide an explanation of their use. This was especially bad in the category editor.
P2	Creation and editing of categories must be more intuitive. It must be clearer what the different buttons do, especially buttons symbolized with plus. It is also not clear what an "Input" is, which seems central to the category editor. To simplify the configuration of input-placement, I suggest the use of drag-and-drop.
P5	The system should come with templates, pre-configured categories. Moving input fields in the category-editor is not intuitive, I suggest the use of drag-and-drop. It is difficult when lists can not be created from the category-editor.
P6	Usage of the category-editor should be simpler and more intuitive. It is important that this functionality (creating and editing categories) is only accessed by administrators, or by roles with selected members. It was difficult to see the connection between creating and using "Lists". The list creation should be available while using the category-editor. When you choose a list in the category-editor, the list should be presented. I missed the option to upload files, images, and video under registration on an incident. The time of registration of an incident should be presented.
P7	The category editor should use drag-and-drop to organize input. It should be possible to create lists from the category editor, as the need of a list is discovered when creating or editing a category.
P8	The language was a mix of Norwegian and English. Options need to be more intuitive. There is an unnecessary amount of clicking to get through the administration menu. There should be less padding between input fields to display more on the same screen. It should feel more like filling out a form.

Table 4.8: Iteration 2: Feedback from Follow-up Questions (3)

Does the system offer any functionality that does not belong in an NCM System?	
Participant	Answer
P1	No.
P2	No.
P5	No.
P6	I don't see any functionality that doesn't belong.
P7	No.
P8	No, it does not.

Table 4.9: Iteration 2: Feedback from Follow-up Questions (4)

Feedback from the participants from follow-up questions (See Table 3.8) is presented in Table 4.6, Table 4.7, Table 4.8, and Table 4.9.

4.2.2 Result Analysis and Refinement Notes

Based on feedback from the evaluation described in Section 4.2, presented in Table 4.9, no functionality was present that didn't belong, and I could therefore focus on the improvement of existing functionality and the implementation of missing functionality.

The "Add"-buttons symbolized with plus symbols were noted by participants P1, P2, P5, and P8 to not be intuitive. The feedback regarding the buttons, presented in Table 4.4 and Table 4.8, was that it was multiple buttons symbolized with plus on the same page, and their function were unspecified. Observations, presented in Table 4.5 also noted the users' tendency to click on the first "Add"-button they saw when they wanted to add something, without observing the button's context. Some participants suggest adding text to the buttons, to specify its use. These comments were ground for adding text to the plus buttons to improve intuitiveness and usability.

The submit-buttons for login called "Send" and multiple variations of "Save" and "Submit" were noted by participants P2, P5, and P7 as confusing and in need of improvement (See Table 4.4). It was suggested that the buttons be standardized and that the login button was changed. These comments were ground for changing the login button to simply "Login" and standardizing the remaining submit buttons to "Save".

The navigation bar and crucial buttons can be hidden when pages overflow requiring users to scroll, as noted by participants P5 and P8 (See Table 4.4). These comments were ground for, as suggested, fixing the locations of the navigation bar and crucial buttons, eliminating user disruptions caused by the inability to locate said components.

The category-editor was noted by participants P2, P5, P6, and P7 as not intuitive. The feedback, presented in Table 4.4 and Table 4.8, point out the ambiguity of the word "Input", the difficulty managing input-field placement, and lacking options in input-field configuration. To improve the understanding of the word "Input", and to guide users in the usage of the category-editor, informative placeholders and tool-tips were to be added. A suggested solution to the issue involving input-field placement was the use of drag-and-drop. This solution was unfortunately deemed too difficult to implement because of the data structure of categories. As this functionality was implemented to improve configurability, not to implement a feature specific to NCM Systems, the improvement of said functionality will not be prioritized. To improve the configuration of input fields, options for minimum value, maximum value, and optional help text were to be added.

The list-editor, available separately from the category-editor, was requested to be accessible from the category-editor by participants P5, P6, and P7 (See Table 4.8), as the need to create or update a list was discovered while using the category-editor. Participant P6 also requested that a selected list would be presented upon selection. These comments were ground for adding access to the

list-editor in the category-editor.

Dates and timestamps as possible input was requested by participant P7 (See Table 4.7). The following refinement was to include the implementation of an input type for dates. Participant P6 noted the handling of files as missing functionality (See Table 4.8). Because of the way information is stored, the implementation of file handling would be complex and involve redeveloping the way that values for different input fields are stored, it was therefore decided not to implement file handling, but the functionality of file handling would still be explored through follow-up questions.

The preview functionality in the category-editor was observed (See Table 4.5) to interrupt users while creating categories, as noted by participant P5 (See Table 4.4). Because the preview functionality was ignored by most users, and the complexity of the functionality, it was decided to be best to remove the functionality entirely.

Inconsistent language in the prototype was noted by participants P5 and P8 (See Table 4.4, Table 4.7, and Table 4.8). The language was originally English, but was changed to Norwegian to allow for the use of Norwegian technical terms. The following refinement was to include confirming consistent use of Norwegian language.

The color scheme, mainly white and shades of grey, was noted by participant P6 (See Table 4.4) as disruptive while locating input-fields and information. This comment was ground for changing the color scheme so that white fields would represent information and input fields to improve the users' ability to locate key components.

Increased feedback from user-system interactions was requested by participants P2, P5, and P7 (See Table 4.4). It was also noted that the system did not always redirect users where they expected upon submitting forms. Based on these comments, future refinement was to include making the system redirect users to submitted content, and notify on user-system interactions like successful submit, delete, and discard through timed and color-coded notifications in the corner.

Future refinement was also to include adding placeholders and tooltips on all input fields, as suggested by participant P7 (See Table 4.4).

Padding was observed (See Table 4.5) and noted by participant P8 (See Table 4.8) as excessive. Participant P8 also noted that the system displayed few options on each page (See Table 4.8), and suggested the system layout be more like a form. Participant P5 suggested reducing button sizes, as they were unnecessarily big. These comments were grounds for reducing padding and button sizes, as well as gathering administrator options on a compact administrator page, to improve the system's ability to present the user with information and options.

The lack of a confirmation prompt, as noted by participants P5 and P7 (See Table 4.4), allows for the discard of changes without the user's knowledge. These comments were grounds for the implementation of a confirmation prompt upon discarding changes, as well as upon deletion of information, to increase user awareness and increase usability.

The lack of notification, noted by participant P5 (See Table 4.7), was decided

to be solved by using the same notification feature implemented for user feedback, by displaying a timed notification for each pending task displayed every time the user visits the "Homepage" (Figure 3.12b).

User management and access control were noted by participant P7 as missing (See Table 4.7). Access control was decided not to be implemented, as the system prioritizes functionality specific to NCM Systems. User management, as it has relevance to assigning users their managers and roles, was to be implemented as administrator functionality for managing users and groups.

The ability to register and track information regarding follow-up on incidents was requested by participants P5, P6, P7, and P8 (See Table 4.7). These comments were grounds for implementing "Cases", with configurable categories, deadlines, and references to relevant incident(s). The "Cases" was to have a status, presenting its stage in the life-cycle of "Cases". The statuses chosen were "Created", "In-Progress", "Performed", and "Closed", based on suggestions from participants.

The lack of statistics, noted by participants P7 and P8 (See Table 4.7), was not to be addressed in the following refinement, as the type of statistics relevant for an NCM System is unknown and the implementation itself requires extensive time, but would be explored through follow-up questions.

The calendar features suggested by participant P6 (See Table 4.7) were not to be implemented, as they were deemed of little relevance to an NCM System.

The time of registration was to be presented in the list of incidents, as requested by participant P6 (See Table 4.8). The ability to delete category-choice from incidents, which would break the system, was to be removed, and the bug where the caret, sometimes called "text cursor", was moved to the end of input-value upon change was to be fixed (See Table 4.5).

Based on the analysis, the refinement included the following improvements to increase the usability of implemented functionality:

- Added text to "Add"-buttons instead of plus symbols
- Added list-editor access from category-editor
- Added help-text for all inputs as placeholders and tool-tips
- Added presentation time of incident-registration
- Improved input-field configuration
 - Added option for text-box height for "Long text"
 - Added option for minimum and maximum value
 - Added option for help-text used for placeholders and tool-tips
 - Added option of input-type "Date"
- Improved navigation-flow
- Improved color-scheme
- Standardized submit-buttons
- Gathered administrator options on a single page
- Reduce padding and button sizes
- Confirmed consistent language (Norwegian)
- Fixed positions of the navigation bar and crucial buttons as "Edit", "Save",

"Discard changes", and "Delete"

- Fixed value-input bug (See Table 4.5)
- Removed category-editor preview-functionality
- Removed possible system-breaking configuration

Based on the analysis, the refinement included implementation of the following functionality:

- Confirmation-prompt for confirmation when discarding changes or deleting information
- Timed notifications for:
 - Feedback on user-interactions
 - Notification of pending task
- Management of "Cases" for follow-up on "Incidents", including
 - Configurable categories
 - Status representing stages
 - Deadline and responsible party
 - Reference to relevant incident
- User management
- Group management for user-role configuration

The following evaluation was to use shorter tasks with more precise language, aimed to improve task communication. The precise language would hopefully negate misunderstanding revolving around terms like "type", as noted by participant P7 (See Table 4.4).

4.3 Iteration 3: Final Prototype

4.3.1 Evaluation Results

Results from the evaluation of the final prototype described in Section 3.8.2. The results are summarized and translated from Norwegian.

Participant	Feedback during test
P1	When selecting multiple from a list, I would prefer selecting from a list on the right and sending them to the list on the left.
P2	The two search bars while choosing multiple from a list should be reduced to a single search bar for both lists, both selected and unselected.
P3	Nothing mentioned.
P4	The tasks are a little unspecific.
P5	The word "Hover" (used in an explanation) is unfamiliar to me.
P6	While selecting multiple from a list (users), it is not clear who is chosen.
P7	The fixed buttons are small and far down on the screen, making them hard to spot. The category-editor is still messy and not intuitive to use, especially the name of input fields. The "List"-concept is not self-explanatory. The lists can be used by both incident- and case-categories. There are both advantages and disadvantages. Lists can be reused, but the global use of lists can be confusing and needs to be explained. The words "Incident" and "Case" are not self-explanatory. I am not used to split the incidents and cases like it is done in the system, but I can see some advantages.
P8	It is difficult to understand what a "Case" is. It is not describing without an explanation.

Table 4.10: Iteration 3: Feedback during test

Feedback from the participants as they were thinking out loud during the test is presented in Table 4.10.

Observations during tests
Compared to earlier evaluations, the system seems to be more intuitive.
The search bars connected to the functionality "Select multiple from a list" distracts users from the lists, as they seem unrelated.
Users took time before they spotted the tooltips on titles over input fields.
Laptops' screen size limited the system's display capacity.

Table 4.11: Iteration 3: Observations during test

Observations of participants during the test is presented in Table 4.11.

Does the system lack any functionality that is expected of an NCM System?	
Participant	Answer
P1	It has the functionality I would need, except functionality for image input, that is uploading of files.
P2	I believe the needed functionality is present, except the handling of files.
P3	It seems robust and has the functionality for my needs, but functionality for uploading images, documents, or other files would be useful.
P4	I can't think of anything.
P5	It should be presented statistics on incidents. Relevant numbers are total incidents and frequency. Statistics should be filterable on "category", and choices from lists, for example; "Department". The user should be presented with numbers on pending tasks and the total number of unresolved incidents and cases.
P6	Nothing is missing.
P7	The expected functionality is present, except for the handling of files and images.
P8	Not that I can think of.

Table 4.12: Iteration 3: Feedback from Follow-up Questions (1)

Is there any information that the system can't handle that an NCM System should handle?	
Participant	Answer
P1	No.
P2	No.
P3	No.
P4	The timestamp of when an incident happened. As of now, the system seems to only handle the time of registration. It is possible to configure this, but it should be standard to include an input for this.
P5	No.
P6	No.
P7	No.
P8	When an incident happened is important. The timestamp, not only the date. When analyzing incidents you need to look for common variables, which can be shift changes, night shifts, or other times of the day. To see these connections you need timestamps.

Table 4.13: Iteration 3: Feedback from Follow-up Questions (2)

Does the system offer any functionality that does not belong in an NCM System?	
Participant	Answer
P1	It may handle some things a little more automatically than needed, but it is good.
P2	No.
P3	All functionality is relevant.
P4	No.
P5	No.
P6	The functionality is relevant.
P7	No.
P8	The functionality is relevant. There is nothing that doesn't belong.

Table 4.14: Iteration 3: Feedback from Follow-up Questions (3)

Is there anything you would like to add?	
Participant	Answer
P1	I would like more information on users, for example, employment numbers, especially my own.
P2	The security of the system is important as users may input and access sensitive information. The color-coding of incident- and case-status is not explained in the system itself and requires training. I would not have understood the process if it was not explained. Somehow communicate the life-cycle of incidents and cases. There is also no explanation of the different case statuses, for example "Performed" and "Closed". Maybe use some kind of tooltip or other form of explanation.
P3	The color codes are not intuitive, as the colors are not explained. Tooltips on hover, including status or similar and a description of pending tasks could help explain the colors.
P4	The system requires some form of training, or the user will need guidance.
P5	The color-coding helped see relevant tasks, but relevant tasks should be presented separately as well.
P6	Some things were not intuitive and required some guidance. As I am not used to making decisions regarding non-conformance, the configuration as administrator was difficult.
P7	The system requires training or guidance to set up. Not everything is intuitive. The flow of information and tasks between users is handled behind the scenes and is hard to keep track of. This flow should somehow be presented to the user. There should be a clear overview of who has been given what task so that managers can make sure tasks are performed. Accessibility on mobile devices is important. The system is very flexible. When a product like this is delivered to a customer then it should have already been configured for their use, but with a little technical insight into how to use the system the customer could set it up themselves.
P8	A lot of functionality in the system requires training. There should maybe be more definitions and explanations presented to the user. Examples of things that need more descriptions are the concepts of "Lists" and "Categories". The color coding was good. It was good that you could select someone responsible for incidents and cases. The statuses presenting the life-cycle of a case were good. There were some good help texts. With the use of configurable categories and lists, you can expand the system to offer any needed functionality. It is good the system offers functionality for follow-up on incidents, but I am not used to calling it a "case".

Table 4.15: Iteration 3: Feedback from Follow-up Questions (4)

Feedback from the participants from follow-up questions (See Table 3.11) is presented in Table 4.12, Table 4.13, Table 4.14, and Table 4.15.

Should the system output some type of statistics regarding the input and handling of information? What statistics would be relevant?	
Participant	Answer
P1	I can't think of any relevant statistics.
P2	Users of such a system would be interested in statistics on the total number of incidents and cases of different categories, the average time from an incident is registered to the case regarding the incident is closed, and other numbers related to follow-up. The timestamp of status registration on cases can add value through statistics. I am sure there are many other numbers that could prove valuable as well.
P3	Statistics on the total and frequency of incidents on category, severity, user, location, etc to help locate "hot spots".
P4	Yes. Relevant numbers are the total and frequency of incidents and cases by different categories, and the time used to solve them.
P5	(See Table 4.12)
P6	I am not sure. Total incidents per location, category, etc. could be relevant, for example, numbers on incidents with a given severity or incident type such as "EHS-incident".
P7	Statistics are important. Relevant data is the total number of incidents in the last year or month by category, severity, department, and list options, as well as the time used on follow-up. Trends should be presented, and it should be possible to compare with previous years. The statistics should be accompanied by drawn graphs. Common variables should be highlighted, such as categories and departments with a high frequency of incidents, to help guide improvements. The statistics will assist analysis. There should be a dashboard presenting KPIs, with links to data. Avoid huge amounts of numbers and use colors to communicate the current situation.
P8	Many types of statistics may be relevant. First of all numbers on the total and frequency of incidents by different categories, locations, types, options from lists, and other groupings. This may help locate common variables, such as a certain piece of equipment that leads to a high number of incidents.

Table 4.16: Iteration 3: Feedback from Leading Follow-up Questions (1)

Should the system handle storage of files or images? What functionality should it provide regarding handling files?	
Participant	Answer
P1	(See Table 4.12)
P2	(See Table 4.12)
P3	(See Table 4.12)
P4	It would be good to be able to upload files to prove or describe incidents. Files could also include documentation.
P5	It is expected to be able to upload images and files, and that is a must. Images from mobile devices are especially relevant if the system is available as an app. Images can be central in reporting EHS-incidents.
P6	The ability to upload files would be good.
P7	(See Table 4.12)
P8	Handling files are important. Pictures were central in my old workspace, as they are very descriptive. A picture can explain some things much better than words. Sometimes you think you know how something described in an incident look, but in reality, it is much different. It is also easier to describe damaged equipment with the use of pictures. Pictures can be valuable regarding all types of non-conformance.

Table 4.17: Iteration 3: Feedback from Leading Follow-up Questions (2)

The system notifies users of pending tasks on the homepage. Do you have any thoughts regarding how the system should notify users?	
Participant	Answer
P1	Pending tasks should be available on a bell symbol or something. It would also be good to receive mail if you were given a new task. All users should be connected to an email.
P2	The notification in the system disappeared after some time. I'd prefer a tab or section with pending tasks and permanently visible notifications. The color codes help, but would not solve the problem of keeping track of pending tasks if the volume of registered incidents and opened cases surpass the homepage display limit. There should be a filter for relevant tasks for the lists of incidents and cases. I presume that users will check the system less frequently than optimal, therefore, the notification should also be external, through either email or SMS, so that users get notifications on their mobile phones. Alternatively, though push-notifications if the system is used as an app.
P3	It is good that the user was notified, but I would prefer a bell symbol, with a notification-counter, that does not disappear. Something like the "Reddit"-app notifications. It is also important to notify users by mail if there is an update.
P4	Notification should happen separately from the system, for example through email. There should also be a permanent red circle somewhere in the system if there is a notification. Help guide the user towards unseen notifications or pending tasks.
P5	Notification must also happen outside the system itself. The notification in the system should be more visible, and not disappear.
P6	Notifications would preferably come through email. The in-system notification through color codes is good, as it makes new and pending tasks clearly visible.
P7	I am used to notifications shown by a red symbol, presenting the number of notifications, that does not disappear. It should be clearly visible at all times to clarify the pending tasks. It should also be configurable to notify users through email or SMS, with the possibility for notification only of tasks regarding incidents or cases of a set severity limit. The users should also receive reminders if tasks are not performed.
P8	It is important that the system itself notifies you visibly when using the system if there is a pending task. If the system is on a computer that belongs the user alone, then notification inside the system may be enough, but otherwise, the system should notify users through SMS or email. It is important that users are informed in some way if deadlines are nearing.

Table 4.18: Iteration 3: Feedback from Leading Follow-up Questions (3)

Feedback from the participants from leading follow-up questions (See Table 3.12) is presented in Table 4.16, Table 4.17, and Table 4.18.

4.3.2 Result Analysis and Refinement Notes

Based on feedback from the evaluation described in Section 4.3, presented in Table 4.14, no functionality was present that didn't belong, and I could therefore focus on missing functionality.

The process of selecting multiple elements from a list was noted by participants P1, P2, and P6 as confusing (See Table 4.10). It was also observed that users

needed time to see the connection between the search bars for each list and the lists (See Table 4.11). It was suggested to make do with a single search bar, and to select from right to left instead of from left to right. Based on these comments, future refinement would include a complete rework of the input presented for selection of multiple elements. It was decided that the user should be presented with a single searchable list, with clear indication of selected elements. A possible implementation would be the use of multi-select from the Select2 library.

The category-editor was noted as messy and not intuitive by participant P7 (See Table 4.10). As only one participant noted difficulty with the category-editor, and as the category-editor's purpose is to allow customization for administrators who likely have time to explore or training to understand the interface, it was decided not to improve the category-editor.

The fixed buttons, on the bottom of the screen, were noted as too small and hard to spot by participant P7 (See Table 4.10). As only one participant noted this as a problem, there might be a problem with scaling the system interface to the users' screens. As observed (See Table 4.11), the system has difficulty displaying information on small screens. Future refinement would include improved styling that adapts better to displays.

The tooltips in the category-editor were observed to be hard to spot, as they only appeared when hovering input-field titles (See Table 4.11). Based on the observations, future refinement would include increasing the area that triggers the tooltip to include both the title and the input-field itself.

Input of type timestamp was requested by participants P6 and P8 (See Table 4.13). It was noted that the registration time of an incident does not correspond to the time the incident actually happened and that the time of an incident is important for analysis. Based on these comments, future refinement would include implementing the option to ask for timestamps as input.

The concept of "lists", "Incidents", and "Cases" was noted to be unfamiliar and not self-explained by participants P7 and P8 (See Table 4.10 and Table 4.15). Participants P2 and P3 note that the color-coding of "Incidents" and "Cases" require explanation (See Table 4.15). Additionally, participants P4, P6, P7, and P8 note that users need training in the use of the system, or they will require guidance (Table 4.15). These comments were ground for future refinement including adding tooltips and descriptions on functionality involving "Lists", "Incidents", "Cases", and color-codes to better communicate the concepts and their use.

The word "Hovre", an attempted translation of the word "Hover" was not understood by participant P5 (See Table 4.10). The text including the word "Hovre" would be changed to communicate its meaning using real Norwegian words.

Pending tasks were requested to be presented clearly for the users by participant P5 (See Table 4.12 and Table 4.15), and participant P7 requested an overview of all pending tasks, as the flow of information and tasks between users are not clearly communicated (See Table 4.15). These comments were grounds for adding an overview of both personal pending tasks, as well as an overview of pending tasks to communicate the flow of tasks to the users.

Extended user information was requested by participant P1 (See Table 4.15), and they mention specifically the presentation of employee numbers. The research has focused on the development of functionality specifically related to NCM Systems, and has implemented only simplified user management. The information required to be presented regarding users may vary between industries and businesses. The study has barely explored the user management side of an NCM System. To explore expectations related to user management, future refinement would include implementing simplified authentication with minimal registration to explore expectations through follow-up questions in future evaluation.

The security of information in an NCM System is noted by participant P2 to be important (See Table 4.15). The study has not explored the security aspect of an NCM System, as the focus has been on expected functionality. The security of an NCM System would need focus on the same level as any information system handling potentially sensitive personal and business-critical information.

The importance of mobile accessibility was noted by participant P7 (See Table 4.15). The development has focused on building a final prototype for presentation on computers. Future refinement would need focus on styling so that the system would be accessible also from mobile devices.

Statistics were noted as missing expected functionality by participant P5 (See Table 4.12) in the evaluation presented in Section 4.3, and participants P7 and P8 in past evaluation presented in Section 4.2. All participants were asked about relevant statistics in the evaluation, and results are presented in Table 4.16. The understood relevant statistics include numbers on total and frequency of incidents and cases by category, severity, location, and other list choices, as well as numbers on time used on follow-up, including data on time from registration of an incident or opening of a case until the closing of the case. It should be possible to limit the time frame the data is from and compare different time frames, like comparing the last year to the previous year. The statistics will assist managers in the analysis of NC, including locating "hot spots", common variables in NC such as specific equipment or locations, tracking progress, and seeing trends. Participant P7 suggests a dashboard presenting KPIs (Key Performance Indicators), and the use of colors and graphs to simplify the communication of the statistics, requiring less numbers to be presented for the relevant manager to get an overview. Based on the improved understanding of expectations for statistics, future refinement would include the implementation of the statistics.

File handling, the ability to upload files, including images, as information regarding incidents and cases, was noted as missing expected functionality by participants P1, P2, P3, and P7 (See Table 4.12), and confirmed as expected functionality by the remaining participants P4, P5, P6, and P8 (See Table 4.17). File handling was also requested by participant P6 in past evaluation presented in Section 4.2. The importance of providing functionality for uploading files when registering and handling both incidents and cases was noted by close to all participants. In future refinement, the implementation of functionality for handling files would be highly prioritized.

As only simple in-system notification was implemented, participants were asked to describe expectations for notifications (See Table 4.18). The common expectation was that pending tasks should be clearly visible inside the system. A combination of suggestions would be a permanently visible bell symbol signaling notifications with a red circle, optionally numbering the notifications. The system is also expected to notify users of pending tasks outside the system, commonly by email or SMS, or alternatively by push notifications. It was also suggested that incidents with a set severity are to trigger notification by SMS, while other incidents notify by email. The system should also send notifications for reminders of pending tasks and tasks nearing deadlines.

Based on the analysis, future refinement would include the following improvements to increase the usability of implemented functionality:

- Added tooltips and descriptions to communicate concepts of "Lists", "Incidents", and "Cases"
- Added tooltips to communicate the meaning of color-codes for "Incidents" and "Cases"
- Added separate presentation of pending tasks relevant to the user
- Added overview of pending tasks and responsible party
- Increased size on tool-tip triggers
- Improved multi-select using Select2-library
- Improved styling to better adapt to display sizes, including mobile displays
- Improved language in tooltips, placeholders, and other descriptions
- Improved notification as feed under bell-icon

Based on the analysis, future refinement would include the implementation of the following functionality:

- Option for input-type "Timestamp"
- Simplified authentication with minimal registration
- Presentation of statistics regarding "Incidents" and "Cases"
 - Total, frequency, and time usage
 - Dashboard presenting a summary using colors and graphs
 - Filterable by category, list options, and time-frame
- File handling, including the option for input-type "File/Image"
- Notification by email

The tasks used in the evaluation were divided into short and precise tasks, but participant P4 still thinks the task should have been more specific (See Table 4.10). It was decided that any more precise tasks would take away any need for the participant to think for themselves, and therefore lower the value of evaluation.

Chapter 5

Discussion

The use of the Design Science Research Framework, described in Section 3.4, was helpful in exploring user expectations for NCM Systems, as the iterations of development and evaluation allowed for effective improvement of the understanding of the context of use for an NCM System [6]. The process involved users, both system users and business managers, in the Systems Development, and therefore followed the principle presented in Section 2.1.2; "System users, business managers, and information systems professionals must work together to build a successful information system" [3]. The purpose of the project was to perform Systems Investigation and Analysis, described in Section 2.1.2, but System Design, Implementation, and Review, described in Section 2.1.2, was also performed using agile development principles [12] to achieve the goals.

A challenge with this approach to develop an NCM System, with a limited understanding of the context of use, was that some improvements were challenging to implement late in the development, as they would require restructuring the way the system saved information. The challenge limited exploration of some expected functionalities through usability testing, but the research still uncovered them and instead used interview questions to explore them alongside the Usability Testing.

The results from the Usability Testing were consistent, which, as mentioned in Section 3.5, indicates high reliability of the evaluation. The evaluations' validity, the accuracy of measuring product usability and the ability to improve the understanding of the context of use, affected by the users, the tasks, and the environment (See Section 3.5), seems high. The users had the opportunity to interact with a prototype of an NCM System and provide their understanding of use and expectations for functionality. Follow-up questions further explored these understandings and expectations and also explored functionality that was not implemented in the prototype. The validity could still be increased by increasing the number of participants and involving additional roles and industries.

Through the performed evaluations the study has verified and improved the understanding of an NCM System described in Section 3.1 and verified the definition of NCM Systems presented in the review (See Section 1.1), both from the

in-depth study "Mapping Expectations for a Non-Conformance Management System" [1].

In addition to verifying the understanding presented in the Research Context (See Section 3.1), the study has found additional and improved expectations for functionality regarding input, processing, output, and feedback (See Section 2.1.1).

Users expect to be able to register Input regarding both NC and follow-up measures. The input includes information in the form of text, selected element(s) from lists, and data values such as numbers, dates, timestamps, and files.

Users expect to perform manual Processing of information regarding NC and follow-up measures through updating or registering additional Input, as well as the system storing all historic information for manual lookup and inclusion in the presentation of statistics (computer-assisted Processing). The life-cycle of follow-up on NC needs to be defined and may vary in implementations of NCM Systems. In the study, the stages were decided to be "Created", "In-Progress", "Performed", and "Closed", allowing for tracking (processing) of task acceptance, performance, and verification. Other possible stages include allowing for evaluation of follow-up.

Users expect Output in the form of an overview of registered NC and follow-up measures, and a presentation of statistics regarding NC and follow-up measures to communicate a picture of the work situation to users and decision-makers. Relevant statistics include numbers on total, frequency, and time-usage of NC and follow-up measures by category and other factors, and should present comparisons of data from different time periods. The statistics will assist managers and decision-makers in the analysis of NC, including locating "hot spots" (common factors), to assist decision-making.

Users expect immediate in-system Feedback from all manipulation and registration of information in the NCM System. They also expect Feedback in the form of notifications, through in-system notification functionality, email, and/or SMS, upon registration of relevant NC or receiving a task to perform, such as manual processing of information regarding NC.

The identified expectations add the following knowledge regarding the construct of NCM Systems to the knowledge base; It verifies and improves the understanding of an NCM System, its context of use and expected functionality, from the in-depth study "Mapping Expectations for a Non-Conformance Management System" [1].

From the improved understanding of NCM Systems, to answer the research question "How do users interact with an NCM system?"; Users interact with an NCM System by registering and processing data and information, including both manual and computer-assisted processing, regarding NC and corrective, preventative, and improvement measures for follow-up on NC. How users interact with an NCM System tells us the context of use for an NCM System. The context of use will assist Systems Development, including the determination of tasks in Usability Testing [11]. Usability Testing is relevant for System Investigation and Analysis

(See Section 2.1.2), System Review (See Section 2.1.2) [3], as well as IS research.

The context of use for an NCM System seems to align with the idea of Continuous Improvement, described in Section 2.1.3. The systematical registration, informing, processing, and follow-up on NC to perform corrective, preventative, and improvement measures correspond with Continuous Improvement's routine actions taken to constantly seek improvement in business processes, products, and services [3]. Users interact with an NCM System on a day-to-day basis, following routines to improve business processes, products, and services.

To allow for the expected interaction with an NCM System, and to answer "What expectations are there for an NCM System?"; Users expect to be notified when required to perform tasks, offered functionality to input and manipulate data and information, and be presented with relevant information, historical information, and varying forms of compromised statistics on information for decision-making. What expectations users have for an NCM System tells us what functionality must be implemented during Systems Development, assisting with requirement determination. As stated in the review (See Section 1.1), it is important to involve users in requirement determination [5] [6] [7]. The determined requirements will guide System Design and Implementation (See Section 2.1.2).

As stated in the review (See Section 1.1), an NCM System is a type of IS. After verifying and improving the understanding of an NCM System's context of use presented in Section 3.1, we can try to define the construct of an NCM System, categorizing it according to the types of IS presented in Chapter 2, to further answer "What is an NCM System?".

An MIS, presented in Section 2.1.1, provides routine information to managers and decision-makers and focuses on operational efficiency. This description aligns with the use of an NCM System, as it is used by employees to register NC and decision-makers to decide on corrective, preventative, and improvement measures to improve business processes, which include improving and maintaining operational efficiency. And as informing the correct user through notification regarding NC and follow-up procedures is important in an NCM System, the principle "The MIS must provide the right information to the right person in the right format at the right time" [3] from Section 3.1 also align.

A DSS, presented in Section 2.1.1, support problem-specific decision-making and focus on making effective decisions. An NCM System fits this description of a DSS as it is used to register information on NC, which is used to identify possible improvements to business processes. Future data/information available through the system can also be used to verify the decisions' effectiveness. As an NCM System is used by senior-level executives to decide on improvements to business processes, products, and services, it can also fit the description of an EIS, a DSS for executive decisions. But as the system is also used by bottom-level employees and all levels of managers, an NCM System is not accurately described by the term EIS alone, but better fit the general description of a DSS.

An ERP, presented in Section 2.1.1, enhance the internal functions of business through information systems that support the routine, day-to-day activities and

help add value to its products and services. An NCM System would fit the description of an IS included in an ERP, as it is used for Continuous Improvement, routine actions taken to constantly seek improvement in business processes, products, and services (See Section 2.1.3) [3]. Integration of an NCM System into an ERP would increase access to information and usability through connecting ISS' databases.

5.1 Future Work

If I were to perform the study again, I would approach the initial stage of System Design (See Section 2.1.2) in Systems Development differently by not limiting the system's data structure to only allow for initial functionality. Customization of NC categories was implemented to meet the expectations of varying industries, but its advanced features required a lot of time to implement and resulted in a complicated data structure. With simpler customization and other improvements to make the system more intuitive, the Usability Testing tasks could be less specific and represent general use cases, which could lead to better results. I would also have included more participants from the first evaluation, and if possible, perform the Usability Testing in person, to allow for a more controlled test, as there were some difficulties with the remote setup for older participants.

Possible future work includes the performance of further refinement, described in Section 4.3.2, and assessment. The focus of further refinement should be to explore functionality for user management, authentication, notification, file handling, and statistics. Involving more participants, and additional roles and industries, would further increase the validity of the assessment and findings. If the prototype is deemed sufficient for meeting expectations of an NCM System by the participants and researcher, a field test could uncover additional requirements.

Chapter 6

Conclusion

The study explores expectations for an NCM System using the Design Science Research Framework by performing Usability Testing on a prototype. It verifies and improves the understanding of NCM Systems, its context of use and expected functionality, from the in-depth study "Mapping Expectations for a Non-Conformance Management System" [1]. Using the improved understanding of NCM Systems, the study finds the construct of an NCM System to be both an MIS and a DSS that support Continuous Improvement, and that businesses may increase access to information and usability of ISs by involving it in their ERP.

The findings fill a gap in knowledge regarding NCM Systems, and advance research on ISs. The new knowledge builds a foundation for understanding how to perform Systems Development of NCM Systems and allows for further research on NCM Systems.

Future work includes further refinement and assessment of the prototype using the Design Science Research Framework, involving more participants, roles, and industries, to further explore user expectations and increase the validity of the findings.

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Appendix A

Informed Consent Form

The informed consent form used to inform about the study and collect consent from participants.

Vil du delta i forskningsprosjektet

”Explore NCM system expectations using Design Science Research framework”?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å kartlegge forventninger til et avvikssystem. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål

Prosjektet er et masterprosjekt. Formålet er å kartlegge forventninger til et avvikssystem gjennom iterativ utvikling og brukertesting av en prototype ved bruk av Design Science Research rammeverket. Forskningsspørsmålet som utforskes er; Hvilke forventninger stilles et avvikssystem? Det vil utforskes hvilken funksjonalitet som kreves av et avvikssystem for å dekke behov fra forskjellige industrier.

Hvem er ansvarlig for forskningsprosjektet?

NTNU Fakultet for informasjonsteknologi og elektroteknikk (IE), Institutt for datateknologi og informatikk er ansvarlig for prosjektet.

Prosjektet gjennomføres i samarbeid med bedriften Applica Consulting.

Hvorfor får du spørsmål om å delta?

Du har enten vært en bruker av et avvikssystem, eller hatt ansvar for HMS, datasikkerhet eller avvik i en bedrift. Dette gir deg kunnskap om hvilke krav som vil stilles til et avvikssystem.

Hva innebærer det for deg å delta?

- Hvis du velger å delta i prosjektet så innebærer det at du vil delta i en brukertest av en avvikssystem prototype. Brukertesten vil ta mellom 30 min og en time, og vil bestå av oppgaver som skal gjennomføres på prototypen mens deltageren tenker høyt. Det vil tas lydopptak og skjermopptak av deltagerens interaksjon med systemet. Skjermopptaket vil være anonymt og slettes ved prosjektslutt, mens lydopptak vil bli transkribert og anonymisert så fort som mulig.

Det er frivillig å delta

Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykket tilbake uten å oppgi noen grunn. Alle dine personopplysninger vil da bli slettet. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger

Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

Lydopptak vil bli transkribert og anonymisert så fort som mulig, for deretter å slettes.

Skjermopptak vil kun inneholde anonyme opplysninger.

Deltagere vil ikke kunne gjengjennes i publikasjon.

All data vil oppbevares på NTNU OneDrive for sikker lagring.

Det vil kun være student Henrik M. Berg ved NTNU som har tilgang til dine opplysninger og oppsamlet data.

Hva skjer med personopplysningene dine når forskningsprosjektet avsluttes?

Prosjektet vil etter planen avsluttes 12.06.23, og all data oppsamlet fra deltagere vil slettes.

Hva gir oss rett til å behandle personopplysninger om deg?

Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra NTNU har Personverntjenester vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Dine rettigheter

Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke opplysninger vi behandler om deg, og å få utlevert en kopi av opplysningene
- å få rettet opplysninger om deg som er feil eller misvisende
- å få slettet personopplysninger om deg
- å sende klage til Datatilsynet om behandlingen av dine personopplysninger

Hvis du har spørsmål til studien, eller ønsker å vite mer om eller benytte deg av dine rettigheter, ta kontakt med:

- NTNU veileder, Elena Parmiggiani, parmiggi@ntnu.no
- NTNU student, Henrik M. Berg, henrimbe@stud.ntnu.no
- NTNU personvernombud: Thomas Helgesen, thomas.helgesen@ntnu.no

Hvis du har spørsmål knyttet til Personverntjenester sin vurdering av prosjektet, kan du ta kontakt med:

- Personverntjenester på epost (personverntjenester@sikt.no) eller på telefon: 53 21 15 00.

Med vennlig hilsen

Prosjektansvarlig

Veileder
Elena Parmiggiani

Student
Henrik M. Berg

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet «*Explore NCM system expectations using Design Science Research framework*», og har fått anledning til å stille spørsmål. Jeg samtykker til:

- å delta i brukertester
- at det blir tatt lydopptak under brukertest som vil slettes så fort det er transkribert
- at det blir tatt anonymt skjermopptak under brukertest

Jeg samtykker til at mine opplysninger behandles frem til prosjektet er avsluttet

(Signert av prosjektdeltaker, dato)



 **NTNU**

Norwegian University of
Science and Technology