



# **Dynamic vs Static user-interface**

**Which one is easier to learn? And will it make you more efficient?**

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## **ABSTRACT**

Excel offers great flexibility and allows non-programmers to create complex functionality – but at the same time, it can become very nested with cells pointing to other cells, especially if there have been many changes over a more extended period. This has happened to ICS – a small company who has its focus on calibration, out of an array of different things relating to material testing.

The system they have for field calibrations today have been overly complicated and hard to maintain and consists of multiple Excel spreadsheets. The conclusion has been that a new system needs to be developed – but question how, remains. By creating a prototype using modern web-technologies, this study has evaluated if a web application can meet the specific functional requirements ICS have and if it is a suitable solution for a new system. The prototype was put under manual user test, and the results find that the prototype meets all the requirements, meaning that a web-application could work as a replacement.

During the user tests, this study has also evaluated the differences in learnability and efficiency of users, between the static user interface of the current Excel-based system and the dynamic user interface of the web-based prototype. The users have performed a calibration with both systems, and parameters such as time to completion or number of errors made have been recorded. By comparing the test results from both systems, this study has concluded that a dynamic user interface is more likely to improve learnability for novice users, but have a low impact on efficiency for expert users.

**Keywords:** Usability, learnability, user interface, web-application

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# 1 INTRODUCTION

This study will investigate if a web-based application could replace ICS Sweden's current system that is used for field calibrations. By creating a prototype, tests will be performed based on requirements from ICS Sweden to find out how well a web-based application could meet the requirements. This study will also compare the static user interface of the current system, with a dynamic user interface of the prototype, and measure the differences in learnability and efficiency for the users.

## 1.1 Background

### 1.1.1 The client

ICS Sweden is a small company based in Gislaved, Sweden with about 7 employs and a revenue of 9 million SEK. It is part of MTS Systems, which is one of the biggest suppliers in the world of test equipment. MTS Systems operates in a wide variety of different industries, such as aerospace, ground vehicle, motorsports, to name a few. ICS has its focus on material testing, and they supply, maintain and calibrate machines and other types of equipment, used in material testing, to their customers.

ICS cover almost everything needed in a material testing laboratory, and for different types of materials. The primary types of materials are rubber, plastic and metal – and the equipment used for these materials are, tensile testers, scales, hardness testers and rheometers to name a few. Most of the equipment used in material testing, have a variety of different sensors, where most of them needs to be calibrated. For example, a tensile tester usually has a load cell which measures force, a displacement transducer to measure elongation and sometimes even an extensometer.

A big part of the service ICS offer to their customers is calibration, which is performed accredited in accordance with ISO 17025. ICS is accredited in a wide variety of different dimensions, such as force, extension, hardness. When calibrating equipment, data is collected at predefined data points from both the equipment being calibrated and a known reference. The deviation between the equipment and the known reference is then presented in a calibration certificate.

### 1.1.2 A generational shift in the company

ICS have developed a system for calibrations using Excel spreadsheets. When performing field calibrations, these Excel spreadsheets are used to collect various information, such as data at the data points, customer information, machine information.

The system was initially developed by a small team, and today, there is only one employee left that has full knowledge about the current system. Over the years there have been changes to the system, and additional functionality has been added, where in some cases multiple cells are connected and nested together, making it very difficult for someone from the outside to maintain the system.

Developing a new system could be very expensive and need many resources, and since the current system works, a new system has not been prioritized. However, to prevent a situation where no one can make changes to the calibration system, a new system needs to be developed within the near future — preferably using programming languages or methods commonly known by other developers, making it easier to get help from outside of the company.

### 1.1.3 The current system for calibrations

The current system contains different Excel documents for each dimension, because the different dimensions require different data input, and uses different methods. These Excel spreadsheets are used to perform the calibration and to generate calibration certificates. The calibration certificate is presented with information about the calibration equipment used, customer information, and data points collected along with measurement uncertainty. In order to present this information in the certificate, each Excel document must contain all relevant information about the calibration equipment along with calculations for the measurement uncertainty.

The Excel spreadsheets consist of multiple input fields that the user must fill with information to perform a calibration. This consist of customer information (such as name, address), information about the machine (manufacturer, model, serial number), sensor information, etc. Since the user interface is static, all these fields live on the same page, at the same time. Even input fields that are used in edge cases must live on the page, fighting for the focus of the user.

Today's system is not dependent on an internet connection since all necessary information is stored and used in the Excel files. Each time a user connects to the company network, the latest version of the Excel files is downloaded to the user's computer automatically. It is crucial that the user is always using the latest version of the Excel files because there could be changes that have a significant effect on the calibration result. Even though the latest version is downloaded automatically, the user needs to make sure what version is used manually. This manual control could be made fully automatic with a new system.

### 1.1.4 Alternative solution

A new system for calibration can be developed in different ways. For example, it could be made as a native type software that is installed on the machine, or it could be created as a web-based system.

A web application would make the new system independent of a specific platform (such as Windows) and potentially be used via smartphones, compared to native applications that usually needs another code base to support different platforms. It would also be easy to install since the needed software would be automatically downloaded when the website of the system is visited. Making updates to the system is therefore easily distributed to the clients since the only actions needed by the client is to revisit to website [17].

	<b>Pros</b>	<b>Cons</b>
<b>Native</b>	<ul style="list-style-type: none"><li>• Doesn't require internet connection.</li><li>• Easy access via installation</li><li>• Generally better performance.</li></ul>	<ul style="list-style-type: none"><li>• Needs to be installed</li><li>• Versioning is hard to maintain.</li><li>• Needs to be developed for a specific platform (such as Windows).</li></ul>

<b>Web</b>	<ul style="list-style-type: none"> <li>• Can be run through the browser without installation.</li> <li>• Updates can be pushed out quickly.</li> <li>• Only one code base.</li> <li>• Accessible from multiple platforms or devices.</li> <li>• Can be used without an internet connection.</li> <li>• A lot of open source tools available.</li> </ul>	<ul style="list-style-type: none"> <li>• Requires a server as host.</li> <li>• Lesser performance.</li> <li>• Potential security problems, since the application resides online.</li> </ul>
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## 1.2 Purpose

This study will investigate if a web-based system can meet the functional requirements that ICS has and will do so by creating a prototype. Through user testing, it will also evaluate how a dynamic user interface, compared to a static user interface that exists in the current system, will affect learnability and efficiency for the users.

## 1.3 Scope

As mentioned previously, ICS performs calibration on a great variety of equipment. Different equipment or sensors are used for different dimensions – for example a loadcell is used to measure force. The Excel documents is not divided amongst different types of equipment but is depending on what dimension that will be calibrated. There could be other types of sensors that also measure force that is not a loadcell, but nonetheless the same Excel document will be used as when calibrating a loadcell.

The majority of force calibrations performed, is done on a tensile tester using a loadcell – and that is what this study will focus on. Force calibration on a tensile tester. This study will not include the entire quality system. It will focus on the part of the accreditation that concerns calibration and generating calibration certificate.

When evaluating the learnability, the focus will be on the system rather than calibration. Performing a calibration means going through multiple steps, where the usage of the system is one of them, and that is where the focus lays in this study. Same applies for efficiency. The consequence of increasing efficiency when using the system will be an increase in efficiency in calibration, but this is a side effect and not the focus of study.

## 2 QUESTIONS TO BE ANSWERED

This study can be divided into two focus areas. One is how well a web-based system would perform in the environment that the current system operates in (functionality), and the other being the effects of a dynamic user interface compared to a static user interface (user interface).

### **Focus on functionality:**

**RQ1:** Will a web-based system meet the requirements the client has regarding functionality?

### **Focus on the user interface:**

**RQ2:** How will a dynamic user interface effect efficiency of fieldwork?

**RQ3:** Will a dynamic user interface make it easier to learn?

By answering RQ1, ICS can better understand if a web application is a good path to choose when a new system needs to be developed. Investing in a new system can be very expensive, and RQ1 will help in the decision making of a new system. It will also act as an example of a way that web-technologies can be used to create applications that are not primarily intended as a traditional web application.

RQ2 and RQ3 have their focus on the user interface. The hypothesis is that a dynamic user interface can better instruct a user in performing the task by introducing different steps. Guiding the user can have different effects on learnability and efficiency. Making a system more learnable does not have to make the users more efficient using it.

## 3 METHOD

To be able to answer the research questions, a prototype has been developed. The prototype was developed using client-side rendering, as a Single Page Application (SPA), with the help of the modern framework Vue. See section 4 for an explanation of these terms. Using a framework such as Vue, will speed up the development process and by developing the prototype as a SPA will make it possible for the users to install the application on the machine for offline usage – which is one of the requirements from the client. Offline usage is made possible with the help of service workers, information about service workers can be found in section 4.

The prototype will have a central role in this study, and there are two significant aspects when comparing the prototype with the current system — functionality and user interface. Both these aspects have been determined by performing user tests.

There have been two types of user tests and both tests were performed using the same methods but with two different intents. One was to evaluate the efficiency, and the other was to evaluate learnability. During the test, the users had to perform a calibration with each system while being supervised and metrics was collected. What metrics that was collected are described in respective method below.

### 3.1 RQ1 - Meeting the requirements

Requirements for the new system have been given by the client and is being presented in Appendix I, Requirements from the client. These requirements are functional requirements which must be met by the prototype. The ability for the prototype to meet these requirements will determine if a web-based system will work as a replacement for the current system.

The prototype will be developed with the requirements in regard and manually tested alongside development to ensure functionality. Finally, when a working prototype is complete, final user testing can be performed. Testing functionality will be done simultaneously as testing for efficiency and learnability. The test result will answer RQ1.

The prototype will not represent a final product but will demonstrate the functionality compared to the requirements that the client has.

### 3.2 RQ2 - Measure efficiency

This test took was performed on a test machine that is located at ICS facility. This machine is well known amongst the personnel at ICS and is therefore suitable for the test since the mechanical bits will not draw unwanted focus during testing.

To be able to measure the efficiency of the test subjects, the users had to have experience from the current system. The participants in the test was therefore ICS employees that have previous experience in calibrating with the current system. In total, there were three users for this test.

**Metrics that will be used during the observations:**

- The time it takes to complete the task
- Number of errors made

### 3.3 RQ 3 - Measure learnability

The test subjects in this test was not the same as when measuring efficiency. There are personnel that works for MTS, the parent company of ICS that have no prior experience from the current system used by ICS but have experience from calibrating. This makes them a good fit for this test since they know how to perform a calibration, which is a complicated task.

In this test there was a total of three users. The users were selected based on calibration experience and availability.

The method used in evaluating learnability in both the current system and the prototype will be using the "question-suggestion protocol" [2]. This protocol means that a user who is unfamiliar with the application will perform given tasks; in this case, perform a calibration, with the guidance of an expert or an experienced user.

#### **The instructions to the participant:**

1. Ask relatively specific, procedural questions.
2. Try to answer your own questions first, but do not engage in extensive problem-solving.
3. Focus on getting the task done, as you would in the real world.

#### **The instructions to the coach:**

1. Reply with specific procedural answers, to the underlying form of the question.
2. Do not tutor or explain at length.
3. Maintain focus on the task, even when providing suggestions.
4. Provide suggestions if you notice inefficient usage behaviors and if the suggestions would likely be welcomed and beneficial to the user.

#### **Metrics that will be used during the observations:**

- The time it takes to complete the task
- Number of interactions with the coach

### 3.4 Finding literature

The primary tool to find literature will be the library tool supplied by Blekinge Institute of technology called Summon. Other tools such as Google or Google Scholar will also be used. To be able to find relevant literature, specific search terms will be used, such as "Learnability user interface", "UI design principles", "Offline first", "Offline web system". Criteria's for literature will be:

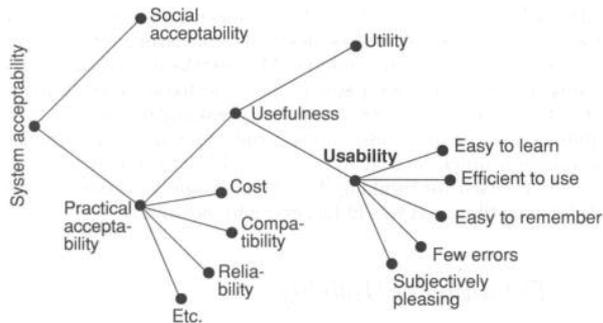
- Relevance for the study
- Publish date
- Type of literature (e.g., Research paper, Book, Article)

## 4 LITERATURE REVIEW

### 4.1 Usability

The word usability has long been understood as an essential component in any product. As early as the 1930s, there have been refrigerator commercials that include usability as a feature, listing characteristics such as "handier to use," "saves steps, saves work" [5]. However, defining the meaning of the word has proven more difficult. Gray & Salzman describes it; "Attempts to derive a clear and crisp definition of usability can be aptly compared to attempts to nail a blob of Jell-O to the wall." [6].

Jakob Nielsen defines usability and its different components in the book "Usability Engineering" [7]. According to Nielsen, usability is just one of many pieces in system acceptability. System acceptability is the question if the system can meet the requirements and needs of the users and other stakeholders. System acceptability is a combination of social- and practical acceptability where usability fits in practical acceptability.



**Figure 4.1** A map over system acceptability Image from Jakob Nielsen's book, *Usability Engineering* 1993.

Just like system acceptability, usability is composed of multiple components. Traditionally usability has been associated with the following attributes:

- Learnability
- Efficiency
- Memorability
- Errors
- Satisfaction

This study will be focusing on learnability and efficiency.

### 4.1.1 Learnability

Just like usability, learnability is hard to define, and a consensus amongst the different authors is not easy to find. Tovi Grossman, George Fitzmaurice, and Ramtin Attar have looked through a lot of research material in the search for a clear definition but found that the idea about what learnability means and how it should be measured varies [2][1].

They have also come up with a methodology to evaluate learnability in a system by a way they call "Question-suggestion protocol". This methodology is a coaching type of protocol, where users get to interact with the software while having support by some expert, or someone used to the system. The coach only interacts if the user gets stuck and provides as little as possible information to get the user moving forward. This approach is more like a natural environment where a new user would perform tasks next to a colleague.

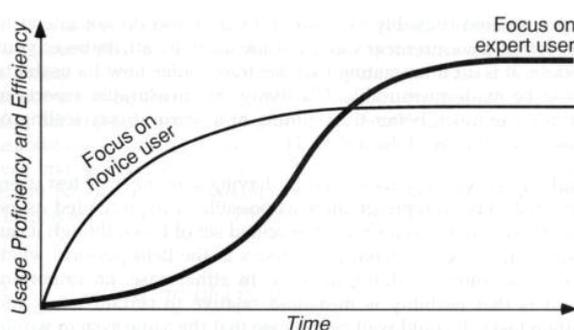
Learnability is recognized as an essential quality in software, but the definition varies. In this study, learnability will be defined as a measure of how easy it is to perform basic tasks the first time they encounter the software application [2]. Due to the limitations of time, the focus will be on initial learning [2].

### 4.1.2 Efficiency

The word efficiency means the correlation between performing a task and resources needed to perform it. If more resources are needed to perform the same task, the efficiency is lowered. Resources could be money, time, materials or even energy. This definition is true even in Human-Computer Interaction (HCI) or usability terms [9].

In this study, the only measurable resources used by the user while using the software is time. For example, if a user makes many errors that need to be adjusted, a user will use more time to complete the same task and therefore have a lower efficiency. This definition corresponds with Jakob Nielsen. Nielsen defines efficiency as to how quickly a user can perform a task [8].

When a user first starts to use new software, the user will enter different levels of proficiency when learning the software. The proficiency effects the efficiency of the user. Therefore, it is crucial to keep in mind the user's previous experience when measuring efficiency and doing so at an expert level of performance, where the learning curve flattens out (see figure 4.2) [7].



**Figure 4.2** Learning curve for a user. A system focused on learnability might reduce the efficiency of an experienced user. Image from Jakob Nielsen's book, *Usability Engineering* 1993.

## 4.2 Usability testing

The point of usability testing is to test the usability attributes of the software. Usability testing is done with users and can be performed in different ways. Usability testing can also be divided into two types of testing - formative and summative usability evaluation.

Formative evaluation is often done in an early stage of development, using a smaller sample size. It can be performed using methods such as think-aloud and does not require a complete design. The goal is to find what aspects of the design that work or do not work and why.

Summative evaluation requires a complete, or near complete, design to perform. It uses a larger sample size, and the goal is to determine if the design meets specific requirements or to establish a usability benchmark. Such a benchmark can be used to compare the design against competitors [10].

### 4.2.1 Sample size

The idea of how many users that is needed for usability testing, is widespread. Jacob Nielsen claims that five participants are enough [11], while Jared Spool and Will Schroeder claims that five is nowhere near enough [12]. According to Nielsen, five users are enough to catch 85% of usability problems where Spool and Schroeder found approximately 35% of the problems with five users.

In the Spool and Schroeder case, users were given one task, to buy a product from an e-commerce website. They evaluated the entire shopping process and recorded the problems that were discovered. There were 49 participants in the test, but the paper does not reveal what kind of profile these users have. Even though Nielsen claims that five users are enough, this is not always the case. According to Nielsen five users is not enough if "a website has several highly distinct groups of users" - meaning that if the five users selected out of the 49 participants, in the Spool and Schroeder example, had a vast difference in profile, these five users would not be enough.

In this study, the users have a very similar profile, where the technical knowledge is very high amongst all users, and they are all very familiar in using computers. The focus of this study is not to find usability problems, which is the case in both Nielsen and Schroeder -Spool but to compare usability features between two systems. This study performed two tests, and each test had three participants.

## 4.3 Web technologies

This section will explain some of the technical terms used in this paper. The web technologies used when creating the prototype, is selected based on this information and the features of these web technologies is necessary to be able to meet the functional requirements from the client.

### 4.3.1 Single page application (SPA)

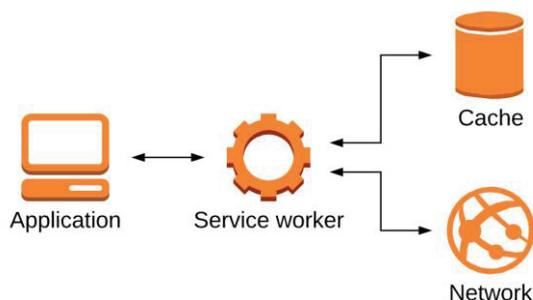
A traditional web application uses server-side rendering. Server-side rendering means that a client (web browser) makes a request to a server, the server applies some business logic (such as fetching data from a database), creates an HTML file and sends it to the client. Every time the user needs to update information or move to a new page, a new request needs to be made to the server. Each request forces a page refresh for the browser, and all content needs to be re-rendered. Using this method makes the user experience not fluid, and it makes offline functionality very difficult if not impossible.

Instead of having the server create the HTML content, the client can create this content using JavaScript. An initial request to the server is necessary to get the JavaScript, but once the code is downloaded everything will be run from the JavaScript code. New content and changes will be dynamically updated using just the JavaScript code, and no new requests must be made to the server, meaning no browser refreshes are needed.

Technically, using this method, the user stays on the same page during the visits, hence the name single page application (or SPA). Since the SPA does not need to make any more requests to the server, offline functionality can be implemented, and the software gets the feel of a traditional desktop application [4].

### 4.3.2 Service workers

Service workers is essentially a script that sits between the browser and the network, giving the developer control on where to fetch resources. When the client makes a request, instead of going straight to the server, the request is being handled by the service worker, that can determine to fetch information from local storage or the network [3].



*Figure 4.3 Service worker acts as a middleware between the application and the source.*

Combining service workers with a SPA makes it possible to store the entire application in the client local storage making the web application fully functional even without an internet connection. When the internet connection is established again, the service worker can check for updates in the background and prompt the user the refresh the page, reducing the risk of a user running on an old version.

### 4.3.3 JavaScript framework

Coding can be a very repetitive task. Often you find yourself writing a lot of lines of code just for setup, that looks almost the same every time you use it. This type of code is called “Boilerplate code” [13]. A framework packages commonly used code in a format that is easier to use and reduces the amount of lines of code [14]. Often times, frameworks are tested and used by a large number of users, this means that if you use frameworks, there is less code you need to test yourself and less risk to make mistakes.

Frameworks also help to induce a certain structure in the code. Having the same kind of code structure amongst many different applications, makes it easier for new developers to jump into a new project they haven’t seen before.

The number of different JavaScript frameworks that exist today, is vast – and the numbers keeps on increasing [15]. However, there are three major frameworks that have gained the most traction and are the most popular ones. These frameworks are React, Angular and Vue, where Vue have had a significant popularity increase in 2016 [16]. Being one of the top three popular frameworks, and having a reputation of being easy to learn, yet powerful and robust, led to the choice that Vue would be used for the prototype.

One of the great benefits of Vue, is how easy it is to install. The Vue team have developed a CLI-tool that lets you install a new project using the command line interface. When you install your project the first time, you get to choose several different features you would like to include, and one of these are service workers. By using Vue CLI to install, you get a scaffold for a working application. It also comes packed with a development server that runs the application as localhost.

## 5 ANALYSIS AND RESULTS

### 5.1 Results

#### 5.1.1 Prototype

The prototype is created as a Single Page Application (SPA) - making it possible to store the entire application on the client. It does not utilize any database and does not interact with any online API of any sort. It is made that way to make it fully functional even without an internet connection. However, this does not prevent the application to connect to a database or API in the future, if necessary.

The prototype is served using a simple Node server that is hosted on Heroku during the test period.

##### 5.1.1.1 Framework

The majority of the application is written in JavaScript, and just like any other web application, it uses HTML and CSS as well. The application is created using the framework Vue, which helps to speed up the development process and maintain a good code structure. The application is created using the Vue CLI-tool, which is a command line interface tool that helps to set up the structure and boilerplate code, for a functioning application.

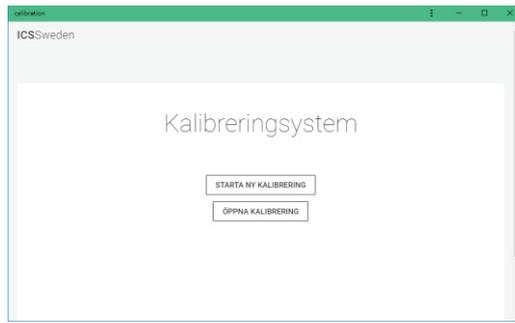
Vuetify is used to create components that will be rendered on the page. Vuetify is UI toolkit, specifically created to be used with Vue.js, that comes packed with pre-defined UI components. Not only does it speed up development, but it also helps to create nice looking components that work well and are responsive - meaning it works well on all kinds of screen sizes.

##### 5.1.1.2 Service workers

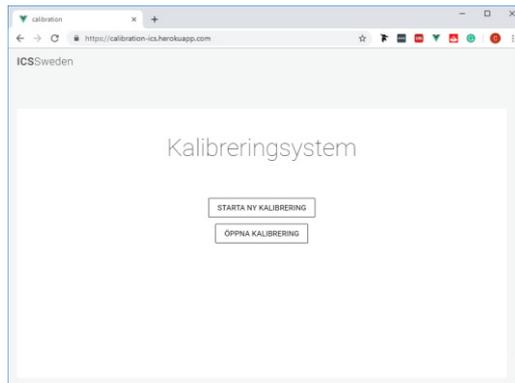
One of the requirements from the client was offline functionality. By using service workers, this application is made functional even without an internet connection. The service worker is installed on the client and runs in the background when the webpage is first visited. When the installation is complete, and the service worker is up and running, every request from the client will pass through the service worker who then decides if the request should continue to the server or serve from the cache memory. More about service workers in 4.3.2.

Vue.js comes prepared with service workers when installing via the Vue CLI. It does this in the form of Workbox, which is a JavaScript library developed by Google. When a user visits this prototype for the first time, the service worker installs itself and stores all necessary files in the cache memory which can then be used when the client goes offline. It is also possible to install the application using an install button on the web page. When the application is installed, a shortcut is created on the desktop, and the application window feels more like a native application rather than a web application. See figure 5.1 and 5.2.

If a user has the application installed, and a new update is available, the application will automatically download the new application and install it in the background. When this is done, it will prompt the user to refresh the application via a pop-up window.



**Figure 5.1** The application window when it is installed.



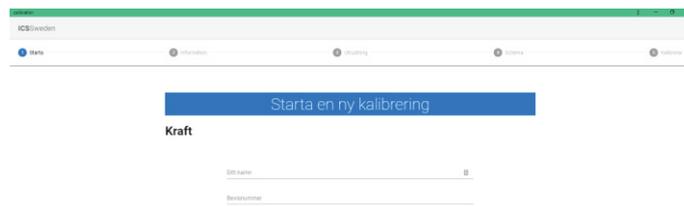
**Figure 5.2** The application window when it is run through the browser.

### 5.1.1.3 Graphical user interface

Because the prototype is a SPA, the browser never refreshes when going between pages. Being able to move between pages without refreshes, makes the experience more fluent and more like a native application.

The first page a user will see is a simple starting page with two options. Start a new calibration or open a saved calibration. See figure 5.1. All the text is in Swedish since all users at ICS speaks Swedish.

To help the user know how many steps that are left, and wherein the process the user currently is, a stepper sits at the top of the screen. See figure 5.3. The calibration process is divided into five different steps, and all steps are clickable for navigational purpose, making it possible for the user to go back and forward.



**Figure 5.3** Navigation stepper with five different steps that the user

When calibration is started, the user is presented with several input fields. All input fields in the application require the same type of information as the old system. Having the same input as the old system makes the user feel more familiar with the new system. The input fields require input to move forward – this helps the user not to miss any critical information. If an input field is not filled and the user tries to move to the next step, a red warning text will appear. See figure 5.4.



*Figure 5.4 Warning message appears when input.*

The first page is where the user enters his or her name, calibration number, order number, date, and if the calibration is performed in tension or compression. Next page is where the user enters all the information about the customer, machine, and sensor. At this stage, there are many input fields. To not overwhelm the user, the input fields are divided into three sections that expand when pressed. See figure 5.5.



*Figure 5.5 All input fields are hidden within dropdown menus.*

When all the information is entered, the user gets to choose what equipment is needed for the calibration. For the most part, what equipment is used is only used for informational purpose and needs to be displayed on the calibration certificate, except for what loadcell is used. The loadcells have different polynomial values that are used to make corrections to the force readings. These values are handed to ICS from the calibration laboratory that calibrates the loadcells annually when each load cell is calibrated. When the force reading is entered during calibration, the system recalculates the actual force based on these polynomial values.

The fourth step is to set the schedule for the calibration. Here the user sets at which datapoints readings will be captured and how many data points there should be. The user also needs to select what equipment will be used for each data point. See figure 5.6.

## Kalibrerings schema

Antal mätpunkter  
5

Mätpunkt	Välj kraft i kN	Välj normal
1	Värd kraft, kN 1	Normal KS00-21 2kN
2	Värd kraft, kN 2	Normal KS00-21 2kN
3	Värd kraft, kN 3	Normal KS00-21 2kN
4	Värd kraft, kN 4	Normal KS00-21 2kN
5	Värd kraft, kN 5	Normal KS00-21 2kN

GÅ VIDARE

**Figure 5.6** Calibration schedule that is used when calibrating.

The fifth and final step is where the user performs the calibration. There are two input fields, one for the force reading of the object being calibrated and one for the force reading of the reference. ICS uses an external device to capture the force reading of the reference called Doli. This device is connected to the computer via USB or ethernet cable, and by pressing a remote, the current force reading is sent to the currently highlighted input field. While capturing the force readings at the different data points, the user will see the error between the object and the reference in real-time along with the repeatability between the runs and the values for all three runs. See figure 5.7.

Serie 1  
Rekning: drag

Mätpunkt	Objekt	Referens	Serie 1	Serie 2	Serie 3	Relativt fel	Repeterbarhet
1kN	1 kN	1 kN	1.0005			-0.05	0
2kN	2 kN	2 kN	2.0009			-0.045	0
3kN	3 kN	3 kN	3.0014			-0.047	0
4kN	4 kN	4 kN	4.0018			-0.045	0
5kN	5 kN	5 kN	5.0023			-0.046	0

**Figure 5.7** Table used when calibrating to enter force readings of both the object and reference.

When all the steps are done, the calibration is complete, and the user can download the certificate in a PDF format. All the information from the calibration can be downloaded in JSON format, which can be opened from the first screen using the open button. Doing this will load the stored calibration and can be used to review the results or make some changes to the calibration.

### 5.1.2 Current system

The system currently used by ICS for calibration consists of an Excel document. The document contains anything needed for calibration, including functions and calculations used for calculating measurement uncertainty.

It is not connected to any database or third-party service. Each time a change is made in the system, all users need to replace the existing Excel document with the latest version.

### 5.1.2.1 Graphical user interface

The user interface of the current system is divided into different tabs of the Excel document. There are also tabs that are not used when calibrating but is strictly made to maintain different calculations.

The two primary tabs that are used during calibration is the field report tab and raw data tab. The field report tab is where you enter all the different information about the customer and the equipment, like step number two in the prototype. However, the field report tab is also where you select which references that is used during calibration and the schedule of the calibration. In the prototype, these steps are split into step number three and four.

The field report tab is divided into different sections. The top section is where you enter information about the customer and the equipment along with other types of information, such as date, order number, nominal force. See figure 5.8.

Figure 5.8 Top section of the field report. Input fields for customer and equipment information.

The midsection is where the calibration schedule is set. See figure 5.9. In the prototype, the schedule is set in step four. In the midsection is also where you enter the resolution for each data point, which reference is used and what method that is used for each data point. ICS has two different methods when calibrating a force transducer – A or B, where A is when using a load cell and B when using a weight set.

28	Lastcelltemp:	Före kal.	Efter kal.	kontroll temp OK				Normal	Metod
29	Pkt.	Vald kraft / N	Obj. Serie 1 / N	Referens / N	Obj. Serie 2 / N	Referens / N	Obj. Serie 3 / N		
30	1		0,		0,		0,		
31									
32	2		0,		0,		0,		
33									
34	3		0,		0,		0,		
35									
36	4		0,		0,		0,		
37									
38	5		0,		0,		0,		
39									
40	6		0,		0,		0,		
41									
42	7		0,		0,		0,		
43									
44	8		0,		0,		0,		
45									
46	9		0,		0,		0,		
47									
48	10		0,		0,		0,		
49									
50	11		0,		0,		0,		
51									
52	12		0,		0,		0,		
53									
54	13		0,		0,		0,		
55									
56	14		0,		0,		0,		
57									
58	0	0			0		0		
59									

Figure 5.9 Midsection, where the user sets the calibration schedule.

The input fields shown in figure 5.9 will also be populated with the force readings captured during calibration, but the capturing is not taking place in the field reports tab but in the raw data tab.

The raw data tab has a simpler look to it. There are three sets of input fields that are used for each series during the calibration. See figure 5.10. During the calibration, the force reading at each data point will be populated in the respective input field at the respective series. The difference between the reference and the object will appear on the far left and next to it is the repeatability between the different series. The object is set to the same value as the target force by default, and if the user needs to change it, the user must change tab to the field reports tab and change it. Different from the prototype where the object and the reference input live right next to each other.

					<b>Resultat</b>			
Relativ onoggrannhet	Relativ repeterbarhet	Mätosäkerhet		Målkraft	Serie 1	Serie2	Serie3	
1		#VÄRDEFEL!	#VÄRDEFEL!	1				1
2		#VÄRDEFEL!	#VÄRDEFEL!	2				2
3		#VÄRDEFEL!	#VÄRDEFEL!	3				3
4		#VÄRDEFEL!	#VÄRDEFEL!	4				4
5		#VÄRDEFEL!	#VÄRDEFEL!	5				5
6			#VÄRDEFEL!					6
7			#VÄRDEFEL!					7
8			#VÄRDEFEL!					8
9			#VÄRDEFEL!					9
10			#VÄRDEFEL!					10
11			#VÄRDEFEL!					11
12			#VÄRDEFEL!					12
13			#VÄRDEFEL!					13
14			#VÄRDEFEL!					14
				Målkraft				0 värde
<b>Klassningsinformation</b>								Extra målpunkt
	Onoggrannhet	0,5		0				1
	Reperterbarhet	0,5		0				2
	Nollpunktsfel	0,5		0				3
	Upplösning	0,5		0				Extra Serie
				0				1
				0				2
				0				3
<b>Skillnad mellan använda normaler</b>								
			1					
			2					
			3					

Figure 5.10 Raw data tab where force readings are captured while performing a calibration.

When the calibration is completed, the user can create a calibration certificate by using the certificate tab. There are four different tabs for creating a certificate. One where the language is set to Swedish, and there are less than nine data points, one where there are more than nine data points and two more with the language set to English. All the information used to create the certificate comes from the other tabs in the document. Everything needed to create the certificates consists within the document itself.

### 5.1.2.2 Calculations

While calibrating, different calculations are being made on the raw data. The majority of these exists within the calculations tab and the reference tab. The reference tab keeps all information about the different load references used and contains the polynomial parameters. The polynomial parameters are then used within the calculations tab to calculate the measurement uncertainty.

The calculations tab does not only contain calculations but also contain some standard text used when creating a calibration certificate. It is in the calculations tab that the measurement uncertainty is calculated using several different variables, and this tab has suffered the most from changes over the years. The calculations tab is hard to follow and have several cells that are pointing to other cells, that in turn are pointing to other cells. There are also several different if-statements and information scattered across the document.

### 5.1.3 User testing

The user testing was performed using the same methods but with two different intents. One was to evaluate the efficiency, and the other was to evaluate learnability. The tests were done during two different occasions and in two different environments, using two types of participants.

It was challenging to get access to participants due to heavy load on the working personnel. The participants needed to have experience in calibration to participate, making it very difficult to find participants outside of the company. The total amount of participants counted to six — three users for each type of test.

#### 5.1.3.1 Testing efficiency

The user tests for efficiency took place at the ICS headquarters. The machine used in the test was one of the demo machines that is also used for training purposes, and the calibration equipment used was the same as they usually use for calibration.

The participants in the test were ICS employees that have previous experience in calibrating with the current system. However, the amount of experience differs amongst the participants. The experience can be seen in the results from the surveys.

Before the test, the participants were given a short walk-through of the prototype. There was not enough time for the participants to get much training of the prototype, but since the input fields were named the same in the prototype as in the current system and the steps in the prototype follow how they usually do a calibration, this was not crucial.

#### Time to perform the calibration:

User	Current system	Prototype
User 1	27min 6sec	27min 24sec
User 2	29min 41sec	28min 30sec
User 3	19min 21sec	22min 31sec

#### The number of errors made:

User	Current system	Prototype
User 1	5	1
User 2	3	1
User 3	0	0

#### 5.1.3.2 Testing learnability

This test took place in the MTS headquarters using MTS personnel. The calibration was performed using one of the demo machines, and the calibration equipment was the same type of equipment that ICS uses typically.

The participants had previous experience in calibrating, but no experience using the system ICS uses nor the prototype. The participants were not given any introduction to any of the systems prior to testing and were instructed to ask specific questions when faced with problems.

While performing calibration using the current system, users found it challenging to understand what the purpose of the different input fields was. It was also unclear for the users if all fields were necessary and which input fields were relevant. This was not the case while using the prototype. It was more transparent for the users what actions that were needed from the user in order to proceed between the different steps.

**Time to perform the calibration:**

User	Current system	Prototype
User 1	17min 22sec	8min 52sec
User 2	12min 41sec	8min 42sec
User 3	15min 32sec	9min 31sec

**The number of times assistance was needed:**

User	Current system	Prototype
User 1	3	1
User 2	5	1
User 3	4	1

**5.1.3.3 Requirements from the customer**

During the user tests, it was also demonstrated that the prototype has the functionality that is required by the customer. The requirements can be found in Appendix I. All of the requirements except for one, have been fulfilled with the prototype. The only requirement that has not been fully implemented is requirement number 5, calculating measurement uncertainty. Calculating the measurement uncertainty is a very complex task and involves many different parameters. However, this requirement was partly implemented by doing some level of computing on the force reading, solely to prove that calculating the measurement uncertainty is possible, but without all the correct calculations.

The prototype has been proven to function in accordance with the requirements from the customer as described below:

1. By removing the internet connection, the calibration was performed with success.
2. At the end of the calibration, the raw data was exported and shown to the client.
3. A calibration certificate was created after the calibration was finished.
4. Force readings from the reference were captured using the Doli-clip with success.
5. Correction of the force reading of the reference as done by using the polynomial values.
6. The users were able to perform the calibration with success, and the users recognized the patterns that the prototype follows.

## 5.2 Analysis

### 5.2.1 RQ 1 - Meeting the requirements

As stated in 5.1.3.3, the prototype did meet the requirements stated by the customer – this shows that a web-based system will work as a replacement to the current Excel-based system and answers RQ1.

A web-based system does not only meet the minimum requirements but could also add extra value to the client. By developing a database and connecting it to the web-based system, customer information along with the customer equipment, could be stored and accessed when performing a calibration. Having this information stored would significantly reduce the number of inputs needed and save time for the user since the majority of data input could be automated.

The techniques used while developing the prototype is well known in the web developer community and consists of open-source tools with many users. Having well-established techniques offers great support from the community and makes it easier to find developers outside of the company.

### 5.2.2 RQ 2 – Efficiency

The number of participants used in the user test was low, with only three participants – making the test data less reliable. Having more participants could have a different outcome – but the participants in this test are the potential end users of the prototype, making the test data more relevant for the client.

The test result is divided into two different type of metrics – time to complete the calibration and number of errors made. Based on the definition of efficiency mentioned in 4.1.2, the time to complete the calibration is the most interesting when measuring the efficiency. The number of errors is also out of interest, but ultimately, the number of errors will affect the time to complete the calibration making the number of errors secondary to the time to complete the task.

When an error is made, the error will have to be corrected. The corrections introduce more work than was initially needed to perform the same task. Given the definition in 4.1.2, introducing more work without an increase in result will lower the efficiency. In this study, the reduced efficiency will be displayed as an increase in time to complete the task. However, the test result shows that even if there are more errors made by the users with the current system, the time to complete the calibration remains close to the prototype and in some cases, even faster. In this case, the errors were discovered and corrected during the calibration as well as being non-critical errors. If the errors had been discovered at a later stage, the impact of the errors could have been more severe.

The total time of all participants is summed and divided by the number of participants for both the prototype and the current system to find the average time of both systems. Based on the test results, on average, the participants were 3% slower to complete the calibration while using the prototype, making the prototype less efficient to use than the current system when focusing on expert users.

With the static interface of the current system, users are exposed to a higher number of input fields at once, compared to the prototype. The high number of input fields makes it more difficult for a user to differentiate between the different input fields and thus introducing more errors. At the same time, not having to change between different

pages to enter information and having all input fields present, makes an expert user faster.

**Time to perform the calibration:**

System	Average time to completion
Prototype	26min 8sec
Current system	25min 22sec

**The number of errors made:**

System	The average number of errors
Prototype	0.67
Current system	2.67

### 5.2.3 RQ 3 – Learnability

Just as in the user test for efficiency, the number of participants was low during the user test for learnability. The participants needed to have experience in calibration to participate since a calibration requires more steps than just using the software, and there was not any more personnel with calibration experience available for the user test.

Both the time to completion and the number of interactions with the coach was signally reduced when using the prototype compared to the current system. The majority of the problems the users experienced when using the current system was being unaware of what steps to take. The static user interface of the current system makes it difficult for a novice user to understand what to do next - but when using the prototype, which has a dynamic user interface, the user is guided through all steps which makes it easier for a novice user.

On average, the users performed the calibration 41% faster with the prototype and needed assistance three times less. The fact that the users can perform the same task (a calibration) faster with the prototype than the current system, shows that a novice user is more efficient with the prototype. A novice user is also able to perform the task with less assistance using the prototype compared to the current system – which corresponds to the faster completion time.

**Time to perform the calibration:**

System	Average time to completion
Prototype	9min 2sec
Current system	15min 12sec

**The number of times assistance was needed:**

System	The average number of times assistance was needed
Prototype	1
Current system	4

## 6 CONCLUSION

Learning a new system can be overwhelming and stressful. Depending on the complexity of the system, being truly efficient can take up to several months. By making a system dynamic and guide the user, the learning curve can be flattened, and a user can get efficient faster.

This study has evaluated the differences between a dynamic user interface and a static user interface in terms of user efficiency and learnability. It did so by creating a prototype with a dynamic user interface and compare it to an existing system which uses a static user interface. Through user testing, both systems have been measured for the efficiency of expert users and learnability for novice users.

The results show that if a system utilizes a dynamic user interface, the learnability is increased where novice users need less assistance to get started and are more efficient, compared to a static user interface. However, for expert users, a dynamic user interface does not increase efficiency but helps reduce the risk of users making errors.

The prototype was developed as a web-based system and used as a tool for field calibrations. The web-based system was done as a proposition for a way to create and replace a current system that consists of Excel spreadsheets – where the prototype was developed to understand if a web-based system could meet the same functionality as the existing Excel spreadsheets. The result was a single page application which uses service workers, where the user can install the application on its device and use even without an internet connection.

During the user tests, the prototype was also tested to reassure that all needed functionality was present. The test result showed that a web-based system could deliver the same functionality as the existing system, and even add extra value.

## 7 FUTURE WORK

The focus of this study has been divided into two parts. One of the focus areas have been a graphical user interface with usability, and the other has had its focus on functionality in a web-based system.

More and more systems are moving towards being web-based, relying on an internet connection. However, access to the internet is not something that should be taken for granted, and the ones who stand without access to the internet is often left out. As a follow up to this study, offline-first as a principle and best practices for a web-based application with offline functionality could be a great topic for future research.

On the topic of usability and graphical user interface, there is plenty of room for more work in regards to learnability. There is a weak consensus around the definition of the word learnability, creating problems on its own. To be able to measure something, it must first be well defined, especially if results from different studies will be compared.

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# APPENDIX I

## Requirements from client

Following requirements have been given by the client and represent functionality that is required in a new system:

- 1. Needs to function without a network connection.**  
User must be able to perform calibration, in the field, even without an internet connection.
- 2. Must be able to export raw data.**  
All data associated with the calibration must be able to be exported in any format for review.
- 3. Creation of calibration certificate in PDF-format.**  
A calibration certificate that with all information that meets the requirements of ISO 17025 needs to be created using the system.
- 4. Needs to function together with Doli-clip.**  
Doli-clip software that is used to capture the current value of the reference must be able to write the data in input fields during calibration.
- 5. Must calculate measurement uncertainty during calibration.**  
The system must be able to calculate the measurement uncertainty during calibration. The measurement uncertainty is used to give the sensor under test a classification.
- 6. Follows calibration methods described in ICS-instructions.**  
The system must request all the necessary information stated in ICS calibration instructions from the user and follow the same pattern.