



# Study of Marine Approved HMIs and Panel PCs

Market analysis of HMIs and panel PCs used in marine environments

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## BACHELOR'S THESIS

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### **Abstract**

This thesis contains a market analysis of what HMIs and panel PCs there are on the market that are approved for marine use. The market for marine approved products is quite limited and therefore a large number of results were not expected.

This is being done to find a substitute for the current HMI that WE Tech Solutions are using. The products that are analyzed are evaluated according to WE Techs' needs and requirements. This limits several things such as the sizes of the products, and some software and hardware requirements. But also that the operating system must be Linux.

The research process consisted of searching for companies that market their products as marine approved, and finding out the relevant information from user manuals and technical specifications. Suppliers were contacted to acquire the information in the previously mentioned documents. The research is from the point of view of WE Techs' needs. That is why information that is not relevant to the requirements will not be brought forward in this thesis.

There were seven products found that fulfilled the DNV certification requirement. These were then evaluated based on the other requirements using a matrix. From this, the two highest-scoring products were an HMI and a panel PC that fulfilled a majority of requirements and could be good substitutes.

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Language: English

Key words: HMI, panel PC, marine approved

## EXAMENSARBETE

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### **Abstrakt**

Detta examensarbete innehåller en marknadsanalys om vilka HMI:er och panel PC:er som finns på marknaden och som är godkända för användning i marin miljö. Marknaden för marina produkter är ganska begränsad och därför förväntas inte ett stort antal resultat.

Detta arbete görs för att hitta ett substitut för det nuvarande HMI som WE Tech solutions använder. Produkterna som analyseras bedöms efter WE Techs behov och krav. Detta begränsar flera saker så som storleken på produkterna, vissa krav på mjukvara och hårdvara, så som att operativsystemet måste vara Linux.

Undersökningen bestod av att leta upp företag som marknadsför sina produkter godkända för marina förhållanden. Där efter ta reda på relevant information från användarmanualer och tekniska specifikationer. Leverantörerna kontaktades för att få den information som inte kunde hittas i de tidigare nämnda dokumenten. Analysen är utifrån WE Techs behov. Därför kommer information som inte är relevant för kraven inte att tas fram i detta dokument.

Det hittades sju produkter som uppfyllde DNV:s certifieringskrav. Dessa utvärderades sedan på de övriga kraven med hjälp av en matris. De två produkter med högst poäng var en HMI och en panel-PC som uppfyllde majoriteten av kraven och kunde vara bra substitut.

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Språk: engelska

Nyckelord: HMI, panel PC, marin godkänd

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## 1 Background

This thesis work was initiated on the grounds that WE Tech Solutions intend to replace their current HMI with one that would fit their needs better. The current HMI has very limited functions that cause a lot of valuable work time to go to waste. That is why a market analysis will be done to see what options there are and to find the best option for WE Tech.

There are multiple variables that will play into this study but the main parameter is that WE Tech Solutions are in the marine shipping industry. That means any product found needs to be suited for use in a marine environment. There are also business aspects to this work where availability and price need to be considered.

WE Tech Solutions is located in the city center of Vaasa. They make and sell hybrid solutions for shipping vessels and other ships. Their objective is to create savings and emissions reduction for the shipping industry. (WE Tech Solutions, 2022)

## 2 Goals

The goal of this thesis is to find suitable HMIs that fits WE Techs' requirements. The HMI needs to at least fulfil the base requirements, that are the product in question is marine classified and supports the current program that WE Tech uses for their current HMI. The other main requirement is that it shall be possible to have a third party to design the HMI interface and UX.

Then there are several other requirements or features that WE Tech desires that the new HMI would have. The requirements range from design details to hardware scalability. There will be an in-depth look at all the requirements and desired features later in this document.

There is also a possibility to replace the current HMI with a panel PC. The difference between a panel PC and an HMI panel will be explained later in this thesis. But the differences do not matter for this thesis because the requirements are the same and they should be interchangeable in the way they will be used.

The scope of this thesis is to find a compatible product that WE Tech can be happy with. Due to the time constraints of this type of work, this will not include any testing of the products. It will be based on what can be found on different products and what information can be acquired from the relevant suppliers. This could possibly be the premise for a future thesis work.

## 3 Theory

This chapter will contain the necessary information that the rest of this thesis will be based on. Only applications and standards that are relevant to the products and for what WE Tech needs are included. By that definition, there will only be the most relevant information here and side tracks that do not affect this research directly will be excluded.

### 3.1 A good HMI

Let us start off with what is an HMI. HMI is short for human-machine interface. The HMI is the connection between a customer and the system provider in this case. The second question you might want to ask is what makes a good HMI. According to Forsgren (2022), there are three main pillars of what makes a good HMI. The first one is that the software needs to be geared to mobility, safety, and UX which stands for user experience. The text elaborates on this by emphasizing the importance that the HMI program is easy to use and feels smooth for the user. (Forsgren, 2022)

The second pillar is hardware durability and appearance. Here Forsgren (2022) emphasizes the value of having an HMI constructed and encapsulated in high-quality material. It is important that the product can handle near-constant use and all types of environments and also that it looks nice and professional. There is also value in that there are customization options when it comes to size to fit the end customer's needs. (Forsgren, 2022)

The third and last pillar of a good HMI is upstream communications. This is because it gives the ability to easily receive updates for the machine's software. You can also send data off-site to better supervise what is happening. Also, this improves the intelligence of a system and helps to enable future development. (Forsgren, 2022)

### 3.2 Panel PC vs HMI

A panel PC is similar to an HMI in the way that for the user it is a touch screen from where you can read certain parameters or execute tasks. Simply put, it is a tool to interact with the machinery that it is connected to.

The difference between these two is that an HMI is always paired with a PLC or similar product and works as an extension of that. The PLC often has a specialised task that it handles. While a panel PC can operate on its own. There is a certain flexibility to this which enables the panel PC to handle a more versatile array of tasks just because it is a PC, while PLCs are more specialized to a certain task. (Trum, 2017)

There are advantages to it being more versatile. Therefore, according to the article by Chris Trum (2017), more and more companies choose to use a panel PC instead of an HMI in their systems. Because both type of products are supposed to fulfil the same task they will be evaluated on the same requirements. You can then apply the lessons from what makes a good HMI to panel PCs also.

### 3.3 What is DNV

One of this study's essential parameters is DNV, which is the marine standards that the components shall adhere to. The reason for choosing to focus on DNV is at the request of the company that ordered this work to be done.

DNV stands for Det Norske Veritas. "DNV is the world's leading classification society and a recognized advisor for the maritime industry" (dnv.com/about, u.d.). For this thesis, the rules for electrical installations on ships will be relevant. Especially the part about

protection against environmental factors. In the section the insulation protection is dependent on what type of equipment you have and where it is located on the ship (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.8., 2022).

### 3.4 Enclosure classification

The protection class is defined in the ingress protection class. Ingress protection can also be abbreviated IP. Which is taken from the standard IEC about IP ratings. IEC stands for International Electrotechnical Commission and the IP ratings system was first established by IEC Technical Committee 70 (International Electrotechnical Commission IP ratings, u.d.). See Figure 1 for clarification on how the IP class is defined.

**IEC** Making electrotechnology work for you.

## Ingress protection (IP) ratings guide

IP ratings are represented by combining the first and second digits of the below columns


1 <sup>st</sup> numeral - solid foreign objects		2 <sup>nd</sup> numeral - water	
<b>0</b>	No protection	<b>0</b>	No protection
<b>1</b>	Protected against solid foreign objects of 50 mm Ø and greater	<b>1</b>	Protected against vertically falling water drops
<b>2</b>	Protected against solid foreign objects of 12,5 mm Ø and greater	<b>2</b>	Protected against vertically falling water drops when enclosure tilted up to 15°
<b>3</b>	Protected against solid foreign objects of 2,5 mm Ø and greater	<b>3</b>	Protected against spraying water
<b>4</b>	Protected against solid foreign objects of 1,0 mm Ø and greater	<b>4</b>	Protected against splashing water
<b>5</b>	Dust-protected	<b>5</b>	Protected against water jets
<b>6</b>	Dust-tight	<b>6</b>	Protected against powerful water jets
<b>Example:</b>  <b>IP 65</b> → Protected against water jets → Dust-tight		<b>7</b>	Protected against the effects of temporary immersion in water
		<b>8</b>	Protected against the effects of continuous immersion in water
		<b>9</b>	Protected against high pressure and temperature water jets

Figure 1 (International Electrotechnical Commission IP ratings, u.d.)

There is a similar table to the one in Figure 1 that DNV reference to what IP ratings certain equipment needs to have according to where they are placed this can be seen in Figure 2. From these two tables, you can clearly see what the requirements on the equipment is.

Table 1 IP requirements (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.8., 2022)

Location		Switchgear and transformers	Luminaries	Rotating machines	Heating appliances	Socket outlets	Miscellaneous such as switches and connection boxes	Instrumentation and communication components
Engine and boiler rooms <sup>15)</sup>	Above the floor <sup>1)</sup>	IP 22	IP 22	IP 22	IP 22	IP 44	IP 44	IP 44
	Below the floor	N	IP 44	IP 44	IP 44	N	IP 44	IP 55
Dry control rooms and switchboard rooms		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20	IP 20
Navigation bridge, radio room, control stations		IP 2X	IP 2X	IP 2X	IP 2X	IP 2X	IP 2X	IP 2X
Closed compartments for fuel oil and lubrication oil separators		IP 44	IP 44	IP 44	IP 44	N	IP 44	IP 44
Fuel oil tanks <sup>2)</sup>		N	N	N	N	N	N	IP 68
Ballast and other water tanks, bilge wells <sup>2)</sup>		N	N	IP 68	IP 68	N	N	IP 68
Ventilation ducts <sup>13)</sup>		N	N <sup>13)</sup>	IP 44 <sup>13)</sup>	N	N	N	<sup>13)</sup>
Deckhouses, forecastle spaces, steering gear compartments and similar spaces		IP 22 <sup>3)</sup>	IP 22	IP 22 <sup>3)</sup>	IP 22	IP 44	IP 44	IP44
Ballast pump rooms, columns below main deck and pontoons and similar rooms below the load line		IP 44 <sup>14)</sup>	IP 34	IP 44 <sup>14)</sup>	IP 44	IP 55 <sup>5)</sup>	IP 55 <sup>5)</sup>	IP 55 <sup>5)</sup>
Cargo holds, keel ducts, pipe tunnels <sup>4)</sup>		IP 55 N	IP 55	IP 55	N	IP 55 <sup>5)</sup>	IP 55 <sup>5)</sup>	IP 56 <sup>5)</sup>
Open deck, keel ducts		IP 56	IP 55	IP 56 <sup>6)</sup>	IP 56	IP 56 <sup>5)</sup>	IP 56 <sup>5)</sup>	IP 56
Battery rooms, paint stores, welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard <sup>7)</sup>		EX <sup>12)</sup>	EX <sup>12)</sup>	EX <sup>12)</sup>	EX <sup>12)</sup>	EX <sup>12)</sup>	EX <sup>12)</sup>	EX <sup>12)</sup>
Dry accommodation spaces		IP 20	IP 20	IP 20	IP 20	IP 20	IP 20 <sup>8)</sup>	IP 20
Bath rooms and showers		N	IP 34 <sup>11)</sup>	N	IP 44	IP 55 <sup>9)</sup> N <sup>9)</sup>	IP 55 <sup>11)</sup>	IP 55 <sup>11)</sup>
Galley, laundries and similar rooms <sup>10)</sup>		IP 44	IP 34	IP 44	IP 44	IP 44	IP 44	IP 55

### 3.5 Environmental classification

Same as for the protection ratings DNV also has rules for equipment. These are according to the temperatures of the environment where the equipment is used. In the DNV standard, they have again a table of what the required class is depending on where the

equipment is located. It is the same as in table 1. (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.9., 2022)

Table 2 Temperature class

<i>Parameter</i>	<i>Class</i>	<i>Location</i>
Temperature	A	Machinery spaces, control rooms, accommodation, bridge
	B	Inside cabinets, desks. etc. with temperature rise of 5°C or more installed in location A
	C	Pump rooms, holds, rooms with no heating

There are also rules for other environmental factors that are defined in the same type of manner. These can be seen in table 2 and 3. The environmental classification is based on the IEC environmental specifications for ships 60092-504. DNV clearly uses the same classification method and the same requirements as in the IEC standard. (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.9., 2022)

Table 3 Humidity, vibration and EMC classes

<i>Parameter</i>	<i>Class</i>	<i>Location</i>
Humidity	D	Open deck, masts and inside cabinets, desks etc. with a temperature rise of 5°C or more installed in location C
	A	Locations where special precautions are taken to avoid condensation
	B	All locations except as specified for location
Vibration	A	On bulkheads, beams, deck, bridge
	B	On machinery such as internal combustion engines, compressors, pumps, including piping on such machinery
	C	Masts
Electro-magnetic compatibility (EMC)	A	All locations except as specified for bridge and open deck
	B	All locations including bridge and open deck

To define these different classes DNV has also in the same document defined the parameters for each notation. The exact parameters can be seen in table 4. (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.9., 2022)

Table 4 temperature class criteria

<i>Class</i>	<i>Ambient temperatures</i>	<i>Test temperatures</i>
A	0°C to +45°C	+5°C and +55°C
B	0°C to +55°C	+5°C and +70°C
C	-25°C to +45°C	-25°C and +55°C
D	-25°C to +55°C	-25°C and +70°C

There are similar criteria for the other environmental factors but it is not as easily defined as for the temperature. For the other factors the table 5 and table 6 represents the humidity and vibration class requirements according to the text in DNV-RU-Ship Pt.4 Chapter 9 (2022).

Table 5 humidity class criteria

Type	Class	Requirements for the corresponding class
Humidity	A	Relative humidity up to 96% at all relevant temperatures, no condensation
	B	Relative humidity up to 100% at all relevant temperatures

Table 6 vibration class criteria

Type	Class	Requirements for the corresponding class
Vibration	A	<ul style="list-style-type: none"> <li>- Frequency range 2 to 100 Hz.</li> <li>- Amplitude 1 mm (peak value) below 13.2 Hz.</li> <li>- Acceleration amplitude 0.7 g above 13.2 Hz.</li> </ul>
	B	<ul style="list-style-type: none"> <li>- Frequency range 2 to 100 Hz.</li> <li>- Amplitude 1.6 mm (peak value) below 25 Hz.</li> <li>- Acceleration amplitude 4.0 g above 25 Hz.</li> </ul>
	C	<ul style="list-style-type: none"> <li>- Frequency range 2 to 50 Hz.</li> <li>- Amplitude 2.5 mm (peak value) below 15 Hz.</li> <li>- Acceleration amplitude 2.3 g above 15 Hz.</li> </ul>

All of these requirements for the class are written into DNV-RU-Ship Pt.4 chapter 9 (2022). But In the DNV standard, it is said that they are based on the IEC 60092-504. This determines the class notations used.

### 3.6 EMC classification

The same method as in the other requirements is used in the DNV document to describe EMC immunity requirements. EMC stands for electromagnetic compatibility. In this context, it is used as how much interference the equipment has to be able to withstand, see table 7 and 8 from the DNV document. The specifications are based on the IEC standard 60945 and 61000. (Rules for classification: Ships — DNV-RU-SHIP Pt.4 Ch.9., 2022)

Table 7 EMC class criteria part 1

Port	Phenomenon	Basic Standard	Performance criteria	Test value
A.C. power	Conducted low frequency interference	IEC 60945	A	50 - 900 Hz: 10% A.C. supply voltage 900 - 6000 Hz: 10 - 1% A.C. supply voltage 6 - 10 kHz: 1% A.C. supply voltage
	Electrical fast transient (Burst)	IEC 61000-4-4	B	2 kV <sup>3)</sup>
	Surge voltage	IEC 61000-4-5	B	0.5 kV <sup>1)</sup> / 1 kV <sup>2)</sup>

Table 8 EMC class criteria part 2

Port	Phenomenon	Basic Standard	Performance criteria	Test value
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms <sup>3)</sup> ; 150 kHz - 80 MHz sweep rate $\leq 1.5 \times 10^{-3}$ decade/s <sup>6)</sup> modulation 80% AM (1 kHz)
D.C. power	Conducted low frequency interference	IEC 60945	A	50 Hz - 10 kHz: 10% D.C. Supply voltage
	Electrical fast transient (Burst)	IEC 61000-4-4	B	2 kV <sup>3)</sup>
	Surge voltage	IEC 61000-4-5	B	0.5 kV <sup>1)</sup> / 1 kV <sup>2)</sup>
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms <sup>3)</sup> ; 150 kHz - 80 MHz sweep rate $\leq 1.5 \times 10^{-3}$ decade/s <sup>6)</sup> modulation 80% AM (1 kHz)
I/O ports, signal or control	Electrical fast transient (Burst)	IEC 61000-4-4	B	1 kV <sup>4)</sup>
	Conducted radio frequency interference	IEC 61000-4-6	A	3 Vrms <sup>3)</sup> ; 150 kHz - 80 MHz sweep rate $\leq 1.5 \times 10^{-3}$ decade/s <sup>6)</sup> modulation 80% AM (1 kHz)
Enclosure	Electrostatic discharge (ESD)	IEC 61000-4-2	B	6 kV contact/8 kV air
	Electromagnetic field	IEC 61000-4-3	A	10 V/m <sup>5)</sup> 80 MHz-6 GHz sweep rate $\leq 1.5 \times 10^{-3}$ decade/s modulation 80% AM (1 kHz)

1) line to line

2) line to ground

3) capacitive coupling

4) coupling clamp

5) special situations to be analysed

6) for equipment installed in the bridge and deck zone (EMC class B) the test levels shall be increased to 10 Vrms for spot frequencies in accordance with IEC 60945 at 2/3/4/6.2/8.2/12.6/16.5/18.8/22/25 MHz. For screened cables, a special test set-up shall be used enabling the coupling into the cable screen.

Performance criterion A: The equipment under test (EUT) shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

Performance criterion B: The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed as defined in the relevant equipment standard and in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance that is self recoverable is however allowed but no change of actual operating state or stored data is allowed.

All of these requirements for class are written into DNV-RU-Ship Pt.4 chapter 9 (2022). However, it says that they are directly taken from the IEC 60945 and 61000, which determines the class notations used.

These were the requirements from the marine classification standpoint. So if a product is certified by DNV you can assume that they follow all the rules that have been listed here. There can be some deviations based on where on the ship the equipment is intended to be used. An example of this can be seen in the environmental protection class. Monitoring equipment have vastly different class depending on the environment. For this thesis, the engine room and control room will be most relevant.

With all this information when it comes up in this thesis that a product is DNV approved. That product needs to fulfil the class demands for being used in the engine room and control room. If the product has a DNV certification but does not have approval for one of these rooms then it will not be considered as DNV approved. Because it would not be a suitable replacement.

### 3.7 Software

For the software, there are a few relevant requirements for this thesis. These are that the product shall run Linux but also that the developer has access to the Linux system. Then it also needs to support the applications in the following chapters or equivalent options.

Linux is the preferred choice for operating system due to it being open source. This gives several possibilities and freedoms. For example, you can use it for any purpose and you can make changes to a program if you want. There is the possibility to modify Linux to make your own version and redistribute it if you wish. (What is Linux, u.d.)

### 3.8 .NET

The first application is .NET that the products need to support. This is a cross-platform open-source developer platform. .NET is maintained by Microsoft and is used for building

many types of applications. .NET supports multiple programming languages. This includes C#, F#, and Visual Basic languages are supported. The relevant one for us is the C# which is similar to C, C++, Java and JavaScript. (learn microsoft, 2022)

For this thesis, it is essential that it supports the .NET Core which is derived from the .NET framework. This is created to suit the new cloud-based technology. While it is still compatible with .NET and it is used for Windows applications, macOS and Linux. (learn microsoft, 2022)

### 3.9 DAI library

DAI is a library used to fetch data logs from Danfoss NXP platform drives. This is relevant for this work because WE Tech uses these drives and they are sort of a backbone in the hardware sense of their solutions. DAI base comes from .NET framework so this should be supported if the product also can support .NET framework. How this operates will most likely not be known until testing has been done. But it is good to keep in mind if it would come up during the research process.

### 3.10 SSH

SSH stands for secure shell and this software enables to safely transfer data over otherwise insecure networks. This achieves this by encrypting the data. This is done by creating a secure connection between the client and the server. All the data between the client and server is encrypted such as user authentication, commands, output, and file transfers. (Ylonen, SSH, u.d.)

The encryption is made possible by the client and the server first setup a connection between each other. This connection is established by a short initial conversation between the server and the client. An illustration of this can be seen in figure 8.

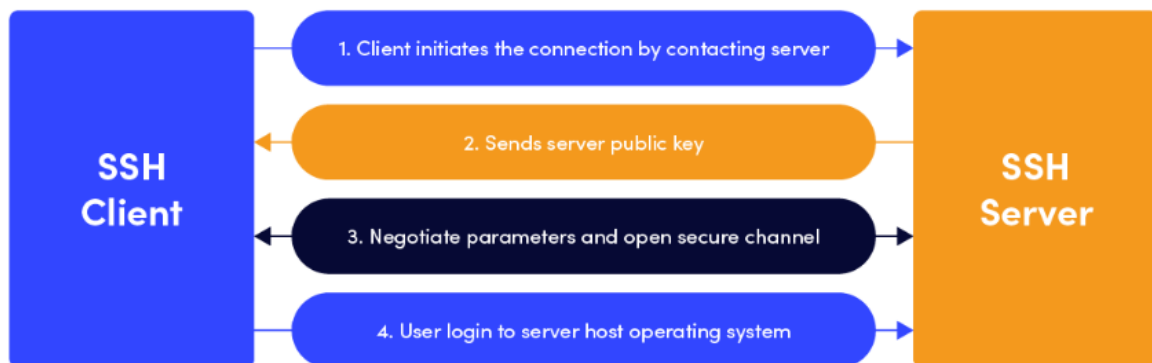


Figure 2 (Ylonen, SSH Protocol, u.d.)

After this initial conversation then a secure connection is established. Then all information transferred between the client and the host will be encrypted. There is also a key generated during the set up phase that makes sure the transferred data can be read when it reaches the end user. SSH is used today to manage a large number of the world's web servers and is used on almost every Linux system (Ylonen, SSH, u.d.)

### 3.11 OPC UA

What is OPC UA it "is a platform independent service-oriented architecture that integrates all the functionality of the individual OPC Classic specifications into one extensible framework." taken from the OPC foundation webpage. is made to become even better than its predecessor OPC Classic. With increased security and smooth flow of information between machines in an industrial network. This communication protocol is safe and adaptable. This adaptability is shown in OPC aiming to be platform-independent. Meaning it supports the following operating software Windows, Apple, Android or Linux. It also works on multiple hardware platforms such as traditional PC hardware, cloud-based servers, PLCs and micro-controllers. (OPC foundation, u.d.)

There are other options for communication that could work. But OPC UA is the preferred alternative. If there for certainly is not possible to use OPC UA then there will be mentioned how the communication can be achieved.

### 3.12 Graphical acceleration

Graphical acceleration works by the software that enables it to offload some computing tasks on specialized parts of the hardware. This does so you get great use out of your hardware and therefore it works more efficiently. (Heavy AI)

Open GL is a graphics library that is platform independent. This is a direct option to the well-known DirectX which is just for Windows. Open GL can be used for drawing 2D or 3D graphics. It is designed to mostly be hardware implemented. This achieves a so-called hardware-accelerated rendering. Which means more efficient use of the hardware. (Open GL, 2023)

### 3.13 Graphics engine

There is also a need for a graphics engine. One of these is the Qt framework that will be most relevant to this thesis. Qt framework is a software that is used for making graphical user interfaces and cross platform applications. As you probably already presumed from the cross platform in the last sentence Qt works on multiple platforms including Linux. This means that Qt and graphics engines, in general, make it easier and more efficient of creating good looking interfaces or platforms. (Qt group, u.d.)

## 4 Requirements

As mentioned in the chapter on goals there are mandatory requirements and then there are optional requirements. This chapter will be dedicated to explaining all of these requirements and the reasons behind them.

### 4.1 Mandatory

These requirements are a must for the HMI or panel PC to be eligible for consideration. The new HMI or panel PC needs to support the current WE Tech base software for

communication between the PLC in use and the product. In short, the product must be compatible with the standard PLC that WE Tech uses. There also have to support WE Tech's remote service product. It will be explained later in this thesis what is required of the HMI or panel PC to be able to support these functions.

For the remote services, it is needed that the product is running Linux. Either 32-bit or 64-bit. It would be preferable if it is 64-bit. But simply running Linux and then running a program on top of that is not enough, WE Tech needs to have access to the Linux level in that case. In addition, there must also be .NET Core.

The operating system should be provided by the manufacturer. The same goes for the necessary drivers. These should also be updated regularly to ensure that the product has a long-life cycle.

There is a need to support DAI 32 bit. Which is a type of library that enables to fetching of data logs from Danfoss NXP platform drives. This is also relevant for the remote service program to work as intended. So this is absolutely necessary for WE Techs' software so it can work as intended. This is something that we can not ensure in this study because this would require testing. But it will be taken into consideration if it might come up during this process.

Then there is also the reason why this work is required. The current HMI that is used by WE Tech does not support third-party programming. By that I mean a software that can be used in every project, as long as there are not any special requirements. With that, I mean software that can be used for all projects. For this current HMI you need to program it separately for every project. This is an unnecessarily time-consuming task that is an annoyance for the application team at WE Tech. The goal is to be able to outsource this task to another company that specializes in HMI design and UX design.

To achieve these future plans there are some further constraints on the product. One is that there needs to be full access to the device all the way to the OS level. The second is full or very wide accessibility to the graphics engine/framework in order to be able to develop this. In addition, it needs to be able to communicate with other machines or

servers for this it should preferably support OPC UA. If this is not possible then Modbus also works.

Then the products need to be marine certified. More specifically the product should be DNV class approved which means it needs to fulfil the rules listed in the theory chapter that is based on DNV-RU-Ship Pt.4 chapter 9 (2022) and DNV-RU-Ship Pt.4 chapter 8 (2022). If the products are having approvals through other classification societies then that will be favourable.

## 4.2 Optional

These features are nice to have and things that will make a product more desirable than those that do not have these. But these things are not deal breakers and products that do not have these functions will still be taken into consideration when searching for the new HMI.

Firstly there it is desired that the HMI should support several design tools or have a large library of design tools. This is because the HMI or panel PC will be one of the main ways the user interacts with WE Techs system and therefore the screen should look nice, professional and modern so it shines a good light on the company. A little in the same spirit the screen should be fast in executing its tasks and responsive when you do something because this shows high quality and in association, WE Tech will be thought of as high quality. All this is supported by the article by Forsgren (2022).

This following point was hard to grade and is on the border of being essential. More important than a cheap and well functional product is the availability of it. This should not be a problem because the projects that WE Tech executes have quite a large time frame. It is due to this that it should not be a problem why this is optional. Still, it needs to be available when it is needed and that is why the availability of spare parts and replacements in case a product is broken will be taken into consideration and be highly valued. Also, I would say that in availability there should also be if the product is available in different sizes. This is a good thing because it opens up the ability to customize it according to the

customer's needs. The importance of this is also pointed out by Forsgren (2022). So different sizes is also a point I will grade them on.

Then there is also the question of the price here it would be optimal if the product was more affordable than the current one. This is maybe not feasible because WE Tech needs the new HMI to have more functionality than the old one and this usually costs more. Therefore if a product is found that has the desired functionality and is in a comparable price range that would be good as well.

The products will also be analysed on if they support graphical acceleration or not. In addition to that what graphical engines can be used. Preferably this would be free choice or Qt framework supported which is what is currently used by WE Tech.

For cyber security reasons, the product needs to support SSH which stands for secure shell. This is used to encrypt data between users. For obvious security reasons, you need protection against cyber threats. So you need some type of software for that and WE Tech has requested secure shell.

One last minor detail is if the product has a speaker then this is favorable. This would open up the possibility of using audio queues for certain tasks or alarms. But this is not a must.

## 5 Research

The research started with trying to find suppliers that had products that were marketed as marine classified. The reason for this was that it got one major requirement out of the way directly. This way of searching was very limiting as there were loads of products that were not suitable for marine use. A very small portion of the product clearly stated that it was marine suitable and also had certifications to prove it.

The research mainly consisted of browsing the web and searching for products that said for marine use. After a suitable product was found, the relevant information was extracted from the datasheets and user manual to find evidence that it could fulfill WE Techs' requirements. There were often a lot of questions left open after reading these technical

documents. Because of this, the suppliers were contacted to get answers and discuss what products they could offer.

I used a requirement matrix to simplify the research and to be able to easily compare components. It is constructed so that the most important requirement is furthest to the left and as you move right it becomes less and less important. There is no separation depending on if the product is a panel PC or an HMI. This is because the requirements are the same for both types of products. This matrix can be seen in table 3 on the next page.

## 5.1 The research process

As previously mentioned the search for suitable products started with looking for components marketed to be used in a marine environment. When such a product was found the first step was to check if it was DNV certified. The next step was to read through the datasheet or user manual to find out if the product could run Linux. If the product only could run on Windows this made it ineligible for further investigation. These two are the main requirements for a product to move on through the research process.

After this the physical and performance information was considered. To see if the product came in several sizes to fulfil this step. The current most common sizes used by WE Tech are 7" and 15" display so if there were these two that is also acceptable. Most products came in several sizes and thus fulfilled this requirement.

Determining the performance of an HMI or panel PC was quite tricky. It was a requirement to have a better performing product than the current HMI. From correspondence with WE Tech, I was provided with some performance demands. The product should run on any modern Intel or AMD CPU and have 4 Gb of RAM. These will be looked at when judging the performance. There would have to be testing done to truly know how the performance will compare to the current products.

After this in the research process discussions with the suppliers were initiated. This was done to learn what software was supported and what was included with the products. Such

as if drivers were included and if the supplier provided updates for these. In some cases, it said in the user manual what was supported but most did not. These were things such as graphical acceleration, CAN communication ports, and development toolsets.

For the software then there were several questions here. Such as regarding communication. This should be OPC UA due to this making communication more secure with this protocol's encryption. But Modbus is also a possible option. It is important for WE Tech to have access to the operating software level required so this was a question for the suppliers also.

Finally for the software questions, there needs to be ensured that WE Techs' current application works as intended. For this, the product should support things like .NET framework and C# scripting. Also for the graphics engine, WE Tech would be preferred if Qt software was supported. All of these were asked of the supplier if it would work or if there was anything in the product documentation to answer these things.

There were discussions about delivery time and availability for spare parts or replacement products in case a product breaks. This provides information on how easily the product can be replaced. Also if the product has far too long delivery time then it might cause problems with the project's timeframe. Another point that came up during these discussions was the question about the price per unit for the products. This was always based on the expected number of units that WE Tech would buy annually. Due to this, there will not be any exact numbers in this analysis. But there will be mentioned if any product is a lot lower or higher than the average price.

For a final point that regards cyber security. This is an important factor but can be managed at a later date. Therefore cyber security will be the factor that is regarded in a good way if a product emphasizes it. But if there is no mention of it then it will not be mentioned in the analysis.



## 5.2 New Candidates

The research that was conducted yielded the following list of suppliers and models. All of these fulfilling the marine approved requirement and that it supports Linux with one exception. Of the requirements set in the goals chapter. There were a few products that were excluded due to these requirements. There was some investigation into those but it showed that they would not be suitable candidates and therefore were excluded fully from the comparison. Now let us compare them with each other and the current HMI.

Table 11 possible substitutes

Supplier	Model
Hatteland technology	series X G2
Hatteland technology	series E
Bejier Electronics	X2 Pro
Bejier Electronics	X2 Web
North Invent	Wave performance Multitouch
ISIC	Dura panel S line
Innova	MRM2

## 6 Comparison

In this chapter, there will be a comparison between the products that were found. This is done so the products can be ranked in order to find the best possible fit. To see if there are any improvements there will be comparisons to the original HMI used.

This comparison is based on all the requirements both essential and non-essential. All the products will be compared to each other and ranked from best to worst. Then the highest scoring product will be the best option to replace the current one.

Most of the information is from the data sheets for the products in question. Also the user manuals for them. Some of the information is from correspondence with the suppliers' sales representatives. The key information that could be found from these sources gives an overall look into how these products stack up to the requirements. Note that nothing from the comparison will be based on actual testing.

## 6.1 Current hardware

The current HMI used by WE Tech is an Omron HMI. The exact model is the Omron NA5. This HMI currently fulfills the software requirements and the requirements for marine certification. The information for these can be found in the relevant subchapters for the theory chapter.

The Omron HMI also fulfills the following requirements. There are different sizes of this model which makes it more adaptable to different needs. Currently, WE Tech uses a 7" and a 15" HMI and therefore they need similar sizes for the substitute. The NA5 HMI supports data transfer over ethernet which is one of the pillars that enables remote service programs that WE Tech uses. (OMRON)

The current HMI is using an Intel Atom x5-E3940 which is not sufficient for the current application. This is the CPU that I have compared the other products to. But a product that uses the same CPU will not be excluded on those grounds directly. (OMRON)

## 6.2 In-depth look

From the search, there were found some candidates for further research, some of them seemed more suitable than others. Due to finding a very limited number of components that fulfilled a majority of the requirements. It was decided to keep several of the products

that did not fulfil crucial requirements for further research. Only if there is no clear good option for that purpose I will keep as many options open as possible.

For further research, discussions with suppliers were conducted to find answers and some additional information. This was what the expected life span of the products was, and what the price per unit is roughly. What design tool sets does it support or what limitations are there in the design options? Are there regular updates for software performances and cyber security reasons?

Later I will do a full comparison where I will deduce which is the best option. Meaning what will suit WE Techs' needs the best based on the requirements set forward in a previous chapter. This is mainly done by using the requirement matrix that was presented in the previous chapter. Which will score all the researched products and hopefully there will be a clear winner.

### 6.3 Option 1 and 2

The first two options come from Hatteland Technology. They have a wide arrange of products including panel PCs for marine use. Hatteland has multiple locations in the Nordic countries and produces their own products in-house. The products that are relevant for WE Tech is their products the X G2 series which is available in multiple sizes including 8". But also their series E which is available in 15.6" including others. These products clearly fulfill the size requirements. Both of the products are DNV approved but also BV, NK, CCS, KR and ABS. This is great because if a customer has a certain preference for the marine approval society then these products would cover most of the common ones. (Hatteland Technology Seires X G2 product details, u.d.)

Both products can use Linux as an operating system. Both of these series use something called LED-backlight technology which is supposed to eliminate lens flare from other light sources. So you always can see what is on the screen clearly. The difference between these is that the series E is of the widescreen type meaning it is more rectangular and the series X G2 is more squared. (Hatteland Technology series E datasheet)

The series X G2 is using Intel Atom x5-E3930 processor this might be on the weaker side but might not be a problem. This will be found out with testing. There are several options for the RAM memory you can get 2, 4 or 8 Gb depending on your needs. The aspect ratio is 16:9. The native resolution for this product is 1280 x 720 which is acceptable. The X G2 series as mentioned can use Linux as an operating system. More specifically it uses Linux Apollo Lake: use kernel 4.10 or later. (Hatteland Technology series X G2 datasheet)

The Series E uses Intel Atom® x7-E3950 as its processor. It also has the same 16:9 aspect ratio and the resolution is 1920 x 1080 which is good. uses Linux Apollo Lake: use kernel 4.10 or later. This model also supports OpenGL 4.6. There are several options for the RAM memory you can get 2, 4 or 8 Gb depending on your needs. (Hatteland Technology series E data sheet)

There are some major drawbacks to these products. The first one is that due to the current state of the world, delivery time is four to seven months. This is expected to get better in the next two years according to their sales representative. But they did not say what they were expecting it to go down to. This creates possible problems if there are issues with products that need replacing. In worst-case-scenario, this could cause other problems with the timeline for projects.

The second bad thing that came up during discussions was that it seems that the operating system is not provided when the customer wants to use Linux. There is not clear how it is with other drivers. There was said also that they provide good support and long lifecycle support. But it was unclear if they meant just spare parts or also updating drivers and other essential software.

There are still a few more good things when asked about cyber security. Then they referred to that they were using Moxa products to ensure secure data transfer for their customers. This at least shows that they are considering cyber security and makes some efforts into improving it. Also, Hatteland Technology has many accessories for their products such as CAN communication ports that you can get for your solution. But the base display has four USB ports already.

Gathering all this information together provides an overview of these products. When filling out the table that was presented previously according to the information. You get the result that can be seen in Table 12 and Table 13.

Table 12 overview of Hatteland part 1

Model	DNV Certified	Linux OS	Drivers provided by manufacturer	communication with OPC UA possible	Life cycle support (regular updates for drivers and software)	Performance
series X G2	X	X			X	X
series E	X	X			X	X

Table 13 Overview of Hatteland part 2

different sizes preferably 7" and 15"	Easy replacement	Free choice for development toolset	Graphics engine free choice	Graphics acceleration	CAN Communication port	Speakers	cyber security
X	O			X	X	O	X
X	O			X	X	O	X

## 6.4 Option 3 and 4

The next two options come from Beijer electronics. Beijer has HMI panels and other monitors for several different industrial sectors including the marine sector. For this analysis, there are a few relevant products but they are just small variations of each other. These are the X2 Pro and X2 Web. Both are approved for marine use by DNV and a few others. These products are HMI panels and not Panel PCs. (Beijer Electronics X2 Brochure )

The X2 Pro version uses a i.MX6DualLite, Dual Cortex-A9 1.0GHz for CPU. It has just 1 Gb of RAM memory. This product is available in sizes 7", 10", 12" and 15". There are possibilities to get a CAN port for this product but it has two USB ports also. This product unfortunately does not support Linux as operating system which makes it unsuitable. (Beijer Electronics X2 Brochure )

The X2 Web version then uses a i.MX6DualLite, Dual Cortex-A9 1.0GHz CPU and it has 1 or 2 Gb of RAM depending on the sizes of the HMI. Speaking of size it is available in 7", 10" and 15". The X2 Web uses HTML5 for visualisation of what you want to show on the HMI. This product can use Linux but it is not optimal. (Beijer Electronics X2 Brochure )

But the main benefit that comes from Beijer Electronics is their iX software. This is marketed as a more efficient workflow. iX software gives you development tools and tools

for communication software. There are prebuilt in functionality for the customers' convenience. It clearly states supports .NET technology, C# scripting and communication via OPC. This system is provided with the product and regularly updated. The drivers for the product is also updated. (Bejier Electronics X2 Brochure )

During the discussion, I learn that this iX software would be provided and Bejier would guarantee that it worked with the rest of our system. Because customer satisfaction is their priority. This of course sounds good but they also showed what previously has been used with their HMIs. Such as PLCs from everything like Siemens, Schneider, Mitsubishi and Omron but also several others.

The iX software would easily be one of the best options for outsourcing the programming of the HMI. Due to the features already implemented into it and that it is focused on making the whole work experience better and easier. This is the reason these products were still included in the comparison even though they did primarily fulfil the requirements.

In the question of delivery time that came up during the discussions with Bejier. They said that if they do an agreement to be the supplier of any products with a customer. Then they will make sure that there are enough products in stock for the customers' needs for a predetermined time period. This would mean that getting a replacement would be easy and fast. There came up that they have a warehouse in Tampere and if WE Tech would order a product it could be at WE Tech the next day.

But because their products mainly use Windows as an operating system this makes these products an invalid choice. The reason why it is still here and being compared is that during the discussions it came up that this X2 series is getting close to its end of life stage. The new series of products that are going to replace them would support Linux according to a representative from Bejier. It was not specified when this new product line will launch. There can be expected that these new products are equivalent to these or better there for these will stay in the comparison. For an overview of how the products from Bejier stack up according to the requirements. See Table 14 and Table 15.

Table 14 overview of Beijers products part 1

Model	DNV Certified	Linux OS	Drivers provided by manufacturer	communication with OPC UA possible	Life cycle support (regular updates for drivers and software)	Performance
X2 Pro	X		X	X	X	0
X2 Web	X	X	X	X	X	0

Table 15 overview of Beijers products part 2

different sizes preferably 7" and 15"	Easy replacement	Free choice for development toolset	Graphics engine free choice	Graphics acceleration	CAN Communication port	Speakers	cyber security
X	X			0	X		
X	X			0	X		

## 6.5 Option 5

The next candidate is from North Invent and the product Wave performance. The wave performance is a panel PC that is marketed for marine use and it comes in several sizes. But these sizes are too big for what WE Tech needs. The smallest one is available in 18.5" but there is currently a 10" model being developed that will launch at the end of 2023. The product is DNV certified and RINA certified. It therefore fulfills the requirements for marine certification. This product supports Linux operating system. The Wave performance has a minimum of 10 lifetime guarantee. (North Invent Wave performance, u.d.)

Through correspondence with the supplier, I learned that the Wave performance uses a Celeron 4305UE 2.2 GHz CPU and has 8 Gb of RAM as standard. The sales representative assured me that this should suit WE Techs' performance needs but if they do not there are three other CPUs that all are stronger that can be used but this affects the price of course. Other technical details that might be of interest are the resolution and which is 1920 x 1080. The aspect ratio is 16:9 and this panel PC has three USB ports. There are also two ethernet ports. (North Invent wave performance datasheet)

In addition to all the mentioned features above I learned from correspondence with representatives from North Invent. That there are no access limitations for this product except for what the Linux OS has. This means that if wanted we can use .NET framework or any other. But these are not provided by the manufacturer. This also means that there are not any relevant limitations on the programming language either.

Some other questions that were answered by North invent representatives are that they install Ubuntu 22.04 on their products if the customer wants Linux as operating system. Then they provide updates for that when such become available but “Post-delivery maintenance should be handled by the customer/operator” this is a direct quote from North Invent representative. Drivers are provided by them for their products and graphical acceleration is possible with either Open GL 4.4 or Direct X 12.1 and also Qt framework is supported.

In the overview Tables 16 and 17. There can be seen that this North invent product clearly fulfils a lot of the requirements in the matrix.

Table 16 overview of wave performance part 1

Model	DNV Certified	Linux OS	Drivers provided by maufacturer	communication with OPC UA possible	Life cycel support (regular updates for drivers and software)	Preformnace
Wave prefomance	X	X	X		X	X

Table 17 overview of wave performance part 2

diffrent sizes preferably 7" and 15"	Easy replacement	Free chosie for development toolset	Graphics engin free choise	Graphics accelration	CAN Communication port	Speakers	cyber security
O		X	X	X	X	X	

## 6.6 Option 6

This option comes from ISIC systems which is a supplier of industrial computers, monitors and panel PCs. The product that is under the scope now is the S-Line product line. This product is available in 10.1" and 15.6" which is acceptable for the multiple sizes requirement. This product has certification from DNV for marine use. It also supports both Linux and Windows as an operating system. (ISIC systems)

Both panels use Atom X5-E3940 1.6GHz CPU which is equivalent to the current HMI panel used by WE Tech. The dura panel has 4 Gb of RAM which is sufficient. Other technical details such as there are two USB ports and two ethernet ports, which is good. (ISIC Durapanel S line datasheet)

The dura panel supports Linux Ubuntu as the operating system and the product is also Open GL 4.3 compliant. Which enables the panel PCs graphics to be more smooth and nicer looking. This is all according to the requirements and makes this product a viable option. (ISIC Durapanel S line datasheet)

There from discussions, it was stated that the delivery time is quite long for this product. It is around 20 weeks. This should not cause problems except in cases where a product needs to be replaced. The Linux ubuntu version is 18.04. The drivers are provided by the manufacturer. For the graphical engine, there are several that can be used but it has to be supported by Intel HD Graphics 500. There is nothing about how cyber security is taken into consideration with their products which is a flaw. But it is hardly not the only product in this list that does not mention anything about cyber security.

There is not any limitation on what software or frameworks you can use except for what Linux would have. That is a good thing so presumably and any requested framework like .NET could be used. How it is with OPC UA communication and that is still unsure. But there is still the possibility that I could be used. There can be seen an overview of this product in Tables 18 and 19.

Table 18 overview of S-line part 1

Model	DNV Certified	Linux OS	Drivers provided by manufacturer	communication with OPC UA possible	Life cycle support (regular updates for drivers and software)	Performnace
S-Line	X	X	X			X

Table 19 overview of S-line part 2

diffrent sizes preferably 7" and 15"	Easy replacement	Free chosie for developent toolset	Graphics engin free choise	Graphics accelration	CAN Communication port	Speakers	cyber security
X	X	X	X	X	O	O	O

### 6.7 Option 7

The next option is from Innova they are a Swedish supplier that sells several types of monitors and PCs that are needed in industrial and marine environments. The product that is relevant for WE Tech is their MRM2 panel PC models. All of them are DNV certified. They also support Linux as the operating system. (Innova Products, u.d.)

Then some technical details. The product uses an intel Dual Core Atom N2600 1.6GHz processor. With a 2 Gb of ram but there is an option for 4 Gb. This product has two USB ports and two ethernet ports. The Linux version that you can get with Linux Ubuntu 20.04. (Innova Products, u.d.)

Through correspondence, additional information came up. Such as the delivery time is 10 to 12 weeks. The sizes that this product is available in 10", 12" and 15". By the time of writing this, some essential questions are still unanswered. Such as if drivers are provided and what the lifecycle of the product is. If there would be a favourable answer for these then this product is a good option. There is too little information for these products to say if it could be an option but on paper, it looks somewhat promising. That is why it is still in this analysis because whatever little information there are shows potential.

when filling out the matrix with the information about Innova products. In Table 20 and Table 21 there can be seen in the overview of the product. In these tables, there are a lot of open requirements. This makes it hard to judge this product.

Table 20 overview Innova product part 1

Model	DNV Certified	Linux OS	Drivers provided by manufacturer	communication with OPC UA possible	Life cycle support (regular updates for drivers and software)	Preformance
MRM2	X	X				X

Table 21 overview Innova product part 2

different sizes preferably 7" and 15"	Easy replacement	Free chosie for developent toolset	Graphics engin free choise	Graphics accelration	CAN Communication port	Speakers	cyber security
X				X	O		

## 6.8 Final comparison

In Tables 22 and 23 there is an overview of the different options that were researched stacked up compared to each other. Some have missing data that is because answers to that requirement could not find information on it or did not get definitive answers from suppliers. But this should provide a clearer picture of what the best options would be.

For this comparison, a few things need to be taken into consideration. The first one is that not all of the requirements are of the same importance. This is represented in different requirements that will give different amounts of “points” when fulfilling a requirement.

The second thing is that it was not so easy to find answers for every single requirement for the researched products. The marking system I will be using for the requirements will be done in the following way. If the requirement is fulfilled then the box will be marked with an X. If the requirement is not fulfilled, then it is marked with an O. Finally if there is no information then it is not marked.

Table 22 First half of filled out matrix.

Suppliers	Model	DNV Certified	Linux OS	Drivers provided by manufacturer	communication with OPC UA possible	Life cycle support (regular updates for drivers and software)	Performance
Hatteland Technology	series X G2	X	X			X	X
Hatteland Technology	series E	X	X			X	X
ISIC Systems	S-Line	X	X	X			X
North Invent	Wave performance	X	X	X		X	X
Beijer electronics	X2 Pro	X		X	X	X	O
Beijer electronics	X2 Web	X	X	X	X	X	O
Innova	MRM2	X	X				X

Table 23 second half of filled out matrix.

different sizes preferably 7" and 15"	Easy replacement	Free choice for development toolset	Graphics engine free choice	Graphics acceleration	CAN Communication port	Speakers	cyber security
X	O			X	X	O	X
X	O			X	X	O	X
X	X	X	X	X	O	O	O
O		X	X	X	X	X	
X	X			O	X		
X	X			O	X		
X				X	O		

So when judging a higher score means a better product. A product that has a lot of blank requirements should not be counted out. This is due to them possibly fulfilling these requirements and the answer just has not been found yet. But for this thesis, the products are judged according to the requirements that products for sure fulfil.

The scoring is done in the following way the yellow categories which are basically a must for all products will give four points this is the case because there is a product that does

not fulfil both of these and therefore it needs to reflect in the score. The following categories will be scored in falling order. Meaning green gives three points, blue is two and red is one.

As there can be seen from the matrix there are a lot of unknowns for some products. These have various reasons. Some of the companies just have not answered my questions yet. In some cases, the answers were open to interpretation. Which means the questions were basically left unanswered. The max score a product could get was 29. Anything above 20 would be great according to this interpretation. Finally, anything under 15 is problematic and would not be a good option.

Table 24 final score

Supplier	Product	Score
Beijer electronics	X2 Web	22
North Invent	Wave performance	21
ISIC Systems	S-Line	20
Beijer electronics	X2 Pro	18
Hatteland Technology	series X G2	18
Hatteland Technology	series E	18
Innova	MRM2	13

From this table, we can clearly see that the best fit according to the requirements is the X2 Web which is an HMI that is supplied by Beijer electronics. If the panel PC options seem more attractive then North invent wave performance is the better scoring one. But the ISIC

systems S-line would possibly be better because it is available in the same sizes as what is currently in use.

The prices compare quite well with the current Omron products. The Beijer electronics HMIs are in the same price range as what is currently used. Then there are the two panel PC options they are a bit more expensive but this is to be expected. Compared to each other the ISIC systems products are cheaper but not by a lot.

There still needs to be testing of the products. For the testing process, a type test should be constructed to check compatibility with the remaining hardware. The order the products should be tested in the same order as listed from the final score table. The Three top products are good alternatives and are likely good replacements.

## 7 Conclusion

All the products that were researched had some good features and most had some drawbacks. But the list that was compiled is likely the best possible option. But if they are suitable that we will not know until they have been tested. To see if there is compatibility and how it works. The analysis is thus completed. Among the researched products there are a couple that shows some potential. The future replacement might be one of these.

It clearly can be seen that the Beijer products are the highest scoring products and would be a good option. When the new X3 line comes that would be something to look into if the purpose is to replace the current HMI with another HMI.

One major reason these products would be a great option is the IX software that Beijer provides. This could simplify the outsourcing of the UX design which is one of the goals of this study.

If you would take the route of using a panel PC then the best option is Wave performance by North invent or ISIC systems S-line panel PC. Both of these suppliers had good products and good support. There are not that many questions left unanswered.

Either of these options would be the best choice depending on if you are looking for an HMI or a Panel PC. There was pretty clear from the beginning that the market for these types of marine products is not that big. This means that you have to make do with what is out there. These three options are clearly the best of what the market has to offer at the moment.

## 8 Discussion

Due to the short time frame, I had to work with and the large number of goals I was unable to test the components in practice. This would have been ideal to see which is the easiest to work with and if there are possibly any hidden conflicts in the compatibility with the HMI and the PLC. Testing these are absolutely the next step in finding a replacement for the current HMI. But I would consider that this work has thinned the herd of potential options to those that fit best at least on paper.

As this work has been mostly finding a substitute based on a purely theoretical level, there is still the question of testing these products. This then opens up the possibility for another thesis work to be made on the basis of testing these products in practice. There is clearly enough here to make this a reality. There firstly has to be a test constructed that clearly tests all the main functions of WE Techs application and then all the products requirements to be tested one by one.

During this work process the discussion with the suppliers for future testing has been opened. This is also the next step that has to be taken even if it is not done as a thesis by someone else. By that said it would be quite easy to start defining tests with all the suppliers as they are now familiar with what the needs and wishes of WE Tech are.

I personally feel that the products that scored 20 or higher could be suitable substitutes. Also, the companies that supplied these products were very forthcoming and engage in answering my questions. Which is a good sign for a company that you would be working with.

I know that it is not the most interesting and clear cut of analysis that I have done. There are a lot of uncertainties when a study is done purely theoretically like this one. Personally, I would regard the task completed and I am happy with the result that I achieved.

With this all said I would conclude this thesis here. Even if this does not result in any changes. I hope this thesis is to help WE Tech in the process of finding a replacement. I also want to thank them for the opportunity to be a part of this very interesting process. Also a final thanks to Joachim Böling for the great guidance during this work.

## 9 References

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