Add-on sight for the Hailstorm product family

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Bachelor's thesis

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Style of the abstract is **Abstract**.

This bachelor's thesis was made for OY Forcit Ab and the overarching task was to come up with a new sight concept for the Hailstorm product family. A client survey was conducted to clarify the requirements and wishes for the new sight and its features. To accompany the client survey, benchmarking of existing sight technologies was conducted, and the technologies used are outlined. A literature review into product development methodologies and techniques was also done, concentrating on trends for small and medium sized enterprises and agile product development. After analyzing the information from market research and the client survey, I designed a new mounting system for a removable sight for Hailstorm devices. The new sighting system consists of two independent sights, a flip up sight built into the shell of the device and a detachable sight with a mount, able to be slid over the flip up sight onto a rail. The goal of the new sight is to improve user friendliness and accuracy while being able to be operated in varying environments.

Key words: Product development, sighting device.

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1 Introduction

This bachelor's thesis was made for OY Forcit Ab, more specifically for the Forcit defence branch, and the goal of this thesis is to serve as a part of the product development process for the Hailstorm product family. One part of the project is the improvement of the sighting system for the hailstorm products and it is what this thesis focuses on. The thesis includes a review of existing technologies used on different styles of sights, currently available on the market, a literature review of product development methodologies and trends, focusing on trends in SMEs (small and medium enterprises) and lastly my own proposal for the improvements to the existing sighting system.

1.1 Client survey

To gather information on the requirements for the new sight, a client survey was conducted. A list of questions was sent to clients over e-mail to give clients time to come up with answers and a follow up interview was then conducted to discuss the detail of the wishes and requirements for a new sight, in more detail. It was not possible to organize a meeting with all the customers in the timeframe this thesis was made, and some answers were gathered by e-mail.

1.2 Product development

As a part of the thesis, a literature review of emerging trends in product development was conducted and trends in product development processes, especially in SMEs, was compiled. Techniques and methodologies of conducting a product development project were studied and evaluated, and recommendations for bettering the product development environment and optimizing the process are showcased. I evaluate product development techniques, leaning on how they would suit this specific project and recommend the use of some techniques.

1.3 Concept development

In this section of the thesis, I conceive and introduce a concept for the new sighting system, taking into account the client requirements and manufacturing restrictions for the sight. As the goal of this thesis is to gather information from clients and conceive a compatible concept for further development. A 3D-model of the sight mount and rail were drawn on Creo-parametric and a physical prototype of the mount was made utilizing laser-cut and machined parts.

2 Research questions and a review of existing sight technologies

The aim of this thesis is to collect knowledge of the requirements for the Hailstorm products and clients wishes for add on sights and to create a concept of an add-on sight. This information is attained from client interviews and techniques for further product development will be compiled from a literature review and explored as a part of the thesis.

2.1 The Hailstorm product family

The Hailstorm product family [1] is a group of area denial products developed by Forcit. These directional explosive devices come in two types. The Hailstorm and Hailstorm-mini are designed to be used mainly against infantry. When detonated the hailstorm product create a fan of projectiles that needs to be aimed in order to be effective. The current version of the hailstorm uses a type of peephole sight consisting of a hollow tube and a mounting on the casing, with raised grooves conveying the projectile fan spread. While the current system is both cheap to produce and relatively easy to use, desired precision is not able to be achieved. The Hailstorm mini relies on an even smaller and simpler sight, which has raised some feedback from clients. The sight on the Hailstorm mini is simply a groove on an extruded plane on top of the device, shaped in a way to convey the fan spread. While the groove is easy to use and is useful to point the device in the general direction of a target, it is not optimal and requires dexterity and experience on the part of the user to be effective. To further develop the Hailstorm products and counter client feedback, a project has been started to improve various aspects of the hailstorm products. One part of this larger project is to improve the sights on the Hailstorm products.

2.2 Research questions

Here I have outlined the main research questions. With the questions written down, working on the thesis can be directed and monitored and by the end it is possible to state that: “The questions were these, and the answers to these questions are as follows…”

i. Which types of sight technologies are there on the market and which of these are best suited for use on the Hailstorm products?
ii. What requirements does the sight have?
iii. How should the sight be developed and what product development methodologies can be used in the project?

2.3 Existing types of sighting devices

Sighting devices fall roughly into two categories: Iron sights and optical sights. Both of these types of sights are widely used in different types of weapons, including handguns, machine guns and a variety of rocket- and grenade launchers. While optical sights are rarely built into the weapon body, multiple types of attachments are available and optical sights can be attached to most types of weapons. [2]

2.3.1 Iron sights

Iron sights are simple and relatively cheap to produce. They usually consist of two sets of reference points, one located near the muzzle of the gun and one nearer to the shooter. The bead in the front sight is to be centred when looking through the rear sight to aim the weapon effectively. Most common type of iron sight used in rifles is the aperture sight. The aperture sight consists of a raised grain near the muzzle of the gun and a plate, or sometimes a ring known as a “ghost ring”, near the rear of the gun. When the grain is centred in reference to the aperture hole, the gun will shoot accurately. [2] [3]

Weapon platforms where the rear of the weapon is further from the shooter use what is known as an “open sight”. This means that the rear sight is not a full ring, but instead a pair of dots or a groove, where the front sight is to be centred. Open sights are most used in pistols. Most shotguns are also equipped with a type of open sight or sometimes only a groove as aiming a shotgun is not meant to be as precise as aiming guns which fire a single projectile. [2]

Because iron sights are not able to be used effectively in the dark, many guns are also equipped with night sights. The night sights are usually built into the gun and can be flipped up in front of the regular sight to be used. The night sights are a type of open sight and are made with a light emitting material to be visible in the dark.

2.3.2 Optical sights

Optical sights are sights that make use of optics instead of metal like in iron sights. They have an aiming point or reticle built in and may be telescopic. While optical sights are more ergonomical and more accurate they are also expensive and require precise manufacturing. [2] [3]

A basic telescopic sight magnifies the target and gives the user a clear view of the area. This type of sight will have a basic reticle and a gradient to help the user adjust to bullet drop over distance. The sight also has an adjustment knob to focus the image over varied distances by moving the lenses. Not all optical sights are magnifying and, although it is rare, sights with a plain reticle with no magnification also exist. [2] [3]

Reflector sights have a semi-transparent mirror, which the shooter looks through. The mirror and the mounting are relatively large and give the shooter a clear view of the area they are aiming at. The mirror is concave and is shaped is such a way that light projected onto the mirror surface is reflected towards the shooter and projects an aiming point for the shooter. Some sights instead use a combination of a straight mirror and a collimating lens, which directs the light onto the mirror on a right angle. The shape of the illuminated point can be a dot as in “red dot sights” [4] or more complex for use in anti-air weapons for example [5]. Reflector sights are available with or without magnification and some sights use light sensitive lenses to clarify the sight image. Reflector sights need light to work and the most common light source is a battery powered LED. Alternatively, a tritium lamp may be used [6]. It works due to the tritium gas inside the lamp undergoing beta decay which allow the phosphorus coating on the lamp to emit light.

Laser sights do not need external optics to be used effectively and the aiming point is projected directly onto the target by the use of a laser attachment on the weapon. Visible wavelength lasers are most common, but for use in conjunction with night vision gear, infrared wavelength laser may be used. [3]

Collimator sights (also known as “occluded eye sights” or “OEG sights”) used in guns create a similar reticle as the aforementioned reflector sights, but instead of having a transparent window around the reticle, the collimator sight is opaque, and the shooter will use both eyes to look at the target. While using binocular vision, the shooter will perceive the reticle on the target [7]. Although collimator sights are rare in handguns, they are widely used in orienting mortars and other artillery and use ambient light during the day and tritium lamps in the dark, to illuminate the reticle. One example of a collimator sight in production is the Armson OEG -sight [8]. The sight uses a dark tube with a red optic fibre at the front end. During the day, the fibre is illuminated by ambient light and uses a tritium lamp in the dark. The Armson OEG produces a red dot, which is useful for rifles, but the same technology could be used to produce more elaborate patterns as well. The OEG style sights are quite rare, but some (For example the Armson OEG m16) are still manufactured as of 2024. The technology is less fragile when compared to other optical sights and can make use of transparent plastics instead of glass to protect the optic fibre. The fibre strands could be mounted in a pattern to create more elaborate reticles or ballistic patterns.

2.3.3 Peepsights and flip-up sights

Flip-up sights are commonly found in weapon systems in which absolute precision is not required or is unobtainable. A variety of grenade- and rocket launchers use a ladder type flip up sight, where height can easily be adjusted. A flip up sight is typically made of metal with an adjustable bar, for adjusting the aim, and is affixed to the weapon body. Some variations come instead with a clear plastic sheet on which are markings for aiming. These markings can be made with ink or paint that glows in the dark for nighttime operations. One example of this type of flip-up sight is a removable sight from the US army’s LAW M72 rocket launcher [9].

Although regular iron sights may also be grouped as peep sights, this refers to simpler sights consisting of a single point of reference. Peepsights are simple tubes, slits, or grooves, which help aim a weapon system. Peepsights have been used widely in directional explosives, where absolute precision is not required. The US developed M18A1 Claymore anti-personnel mine is an example of such device [10]. It was available with either a slit type sight in shape of a rectangle to suit the projectile spread area, or a “knife-edge” sight, which is basically a hole in the shape of a half circle. Although peep sights are cheap to produce and easy to use, they can be very inaccurate due to the lack of visual cues provided and dependant on the user’s ability to aim the device. For example, angle and distance from the sight can affect the perceived orientation and perceived effective area of the device. The accuracy can be improved by training the system operators, but ultimately the amount of information available to the operator is limited, especially in low light conditions.

2.4 Cost of existing sight systems

As excepted, as the novelty and complexity of sights rises, the prices hike up as well. Ranging from simple groove style sights which are practically free to manufacture to intricate telescopic sights, utilizing multiple expensive, precision -manufactured lenses. This section outlines the approximate costs of different technologies used in sights. All the price estimates are taken from retail prices available for private individuals to purchase and may not correlate to manufacturing prices or prices for corporate purchases.

Telescopic sights are by far the most expensive and often telescopic sights in rifles cost more than the rifle itself. The reason for the high price is the required use of lenses and other components with high precision. Usually telescopic sights are adjustable and include indicate patterns with reticles, which have a high manufacturing cost. A typical, good quality, telescopic sight will cost two to three thousand euros, with the most expensive ones costing more than six thousand euros.

Reflector sights are typically cheaper than telescopic sights costing less than a thousand euros with the more expensive models costing a little over a thousand euros. The main determining factor of the cost of reflector sights is the reticle shape. Simple dots or crosses are cheaper to produce, but more complex ballistic patterns and grids for adjusting for wind and distance will cost more. Elaborate reflector sights in anti-air applications for example will have complex ballistic patterns and will cost up to a few thousand euros while a typical red dot sight will range from three- to eight hundred euros. The use of a tritium lamp instead of a battery powered LED, does not affect the price in a notable amount and sights with tritium lamps have the same price range as other reflector sights. Cheaper red dot sights are available for use in air rifles and airsoft guns. Collimator sights are slightly cheaper ranging roughly from two to six hundred euros. Collimator sights for handguns are considerably rarer when compared to reflector sights, but some examples are still manufactured.

Iron sights as well as peep- and flip-up -sights are considerably less expensive to manufacture and are more durable, than optic sights utilizing glass reflectors and lenses. The price of iron sights is not usually specified as the sights come as stock in a gun. Spare parts are available and usually cost less than a hundred euros all together. This however is not a good comparison as spare parts tend to be a lot more expensive than the manufacturing expense. One platform for which iron sights are commonly sold as an extra is the AR-15 rifle and the iron sights for the AR-15 usually cost around fifty to a hundred euros, with more expensive variants ranging up to two hundred and fifty euros. Peep sights are even cheaper to produce with the primary cost being the starting cost for beginning the manufacturing process. The materials for this type of sight are cheap and do not utilize expensive technology. Flip-up sights can be more varied and complex when compared to peep sights but use cheap materials and do not require expensive and precise manufacturing techniques. Flip up sights can have varied reticles and ballistic patterns, although not as precise as reflector sights. Flip up sights have a few moving parts but are still much cheaper when compared to iron sights.

2.5 Low light conditions

Operating in low light conditions is vital for readiness and defensive security. Because half of the time is spent in the dark, must operational readiness in low light conditions be guaranteed. For sighting systems, low light conditions set some limitations. Most infantry weapons using iron sights will also be equipped with a night sight, usually a type of flip up sight [2]. The flip up sight in infantry weapons is less accurate but has been deemed to be sufficient enough to be installed in certain weapon platforms. Reflector sights work in the same way in all light conditions, but as the reflector sight works by projecting light towards the shooters eye, the light may obstruct targets in the dark. Reflector sights using red light have been deemed to be less obstructive as red light causes less pupil dilation, preserving more dark vision capabilities. The previous points also apply to collimator sights. Laser sights work well in the dark as it becomes very clear where the laser sight is pointing, sometimes even without having to look through the sight. The use of numerous laser sights in a small area brings its own problems as determining which point belongs to who can be hard to do.

One drawback of reflector- and laser sights is that they do produce light which is possible to be noticed by others. Telescopic sights, iron sights and peep- and flip up sights produce no light on their own, which makes the use of them in the dark more difficult. As these types of sights produce no light, it becomes difficult to aim a device using them in low light conditions. This drawback can be countered by equipping the operator with external night vision gear, which can be used in conjunction with iron sights etc. without any changes to the weapon platform or the sighting system. One requirement of the use of these, is the requirement that the night vision goggles fit between the shooter and the sight to be used.

3 Product development theory

In this chapter I explore product development theory, highlight the importance of product development processes, explore current trends and tools for implementing product development projects. The Cambridge dictionary defines product development as:
”The process of creating or improving a product or service and managing it during all stages from design through marketing.” [11]
Firstly, the reason why having a product development plan in place is important, is that the process is rarely if ever done by just one person. When there are clear goals, and the steps to get there, it is much easier for a team to work on the project simultaneously and sometimes even overlapping with other parts of the project. Even when the product development project is divided into parts (such as is the case with the topic of this thesis), it is beneficial to have common goals and share knowledge between different parts of the project and across different teams and branches of the company, marketing, and manufacturing for example.

Traditionally the product development process, known as the “waterfall model” [12] has been quite linear, as seen in the chart below. This linearity causes some inefficiencies as going backwards or starting the next step before the previous one is not done in project using this model. Similar to newer product development process models, at each step, feedback is collected, and the goal of each step is to produce something useful to the project.

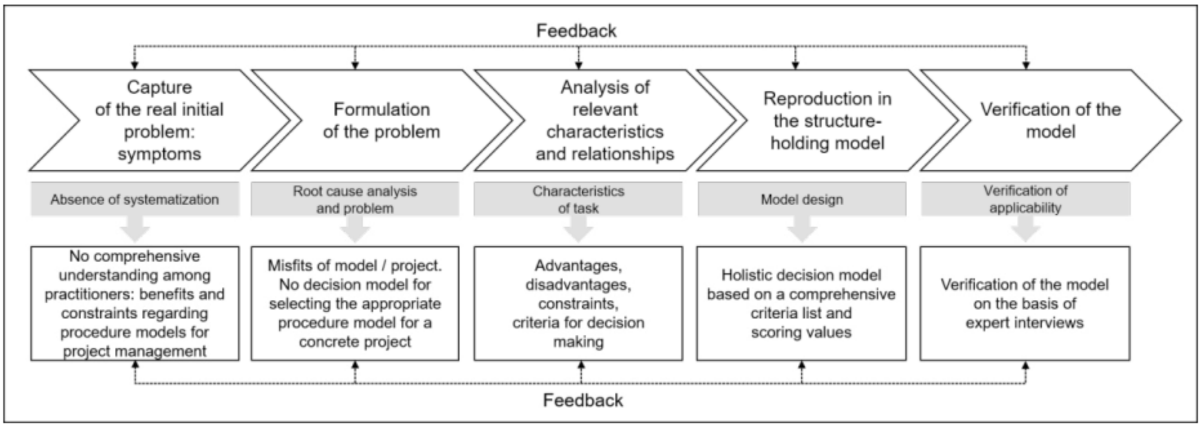

Figure 1: Waterfall model of product development by Theo Thersig et Al, licenced under CC-BY-NC-ND

While using the waterfall model in a product development process might be slower, it is often a more reliable option compared to more agile and complex methodologies. The waterfall model requires less effort from management and regular meetings with different branches happen less often, which in turn requires less organising between the branches. If a product development process focuses on a single aspect of a product or a single part, it may be more resource efficient to stick to a simpler model and focus on doing every part well independently.

By making the process more agile and iterative and allowing backtracking, the process can better accommodate unseen challenges that rise in the middle of the process, which would have caused a delay in the linear process. An iterative process is a process which is designed to be gone through multiple times and the framework for the process is designed to allow backtracking. In product development, this means that after any of the steps it is possible to go back to any other to improve the design, for example if some deficiency is realised during a prototype test, it is possible to go back and change the concept, rather than creating a workaround for the issue. The chart for an iterative product development process can be found below. By working on multiple steps simultaneously, the product development process has the potential to be faster and more efficient but requires sufficient information flow between all parts of the project. More about completing the process and the tools will be discussed in the chapter 3.2.

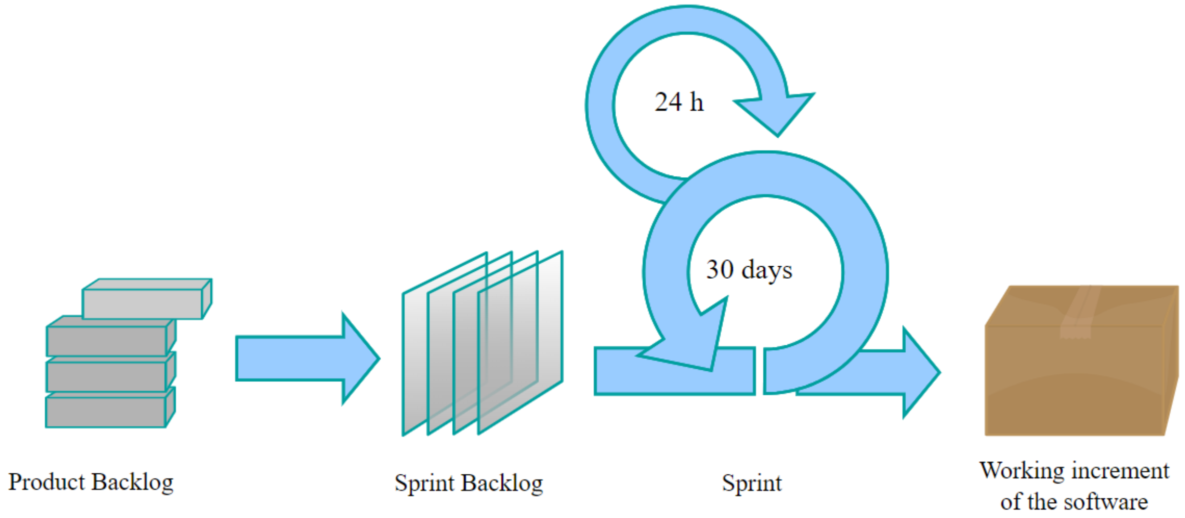

Figure 2: "Scrum process" by Lakeworks is licensed under CC BY-SA 4.0.

3.1 Trends in product development

In a study from 2021, M. Iqbal and A. Suzianti of Universitas Indonesia compiled trends of new product development processes in small and medium sized enterprises (SME) [13]. The literature review studies documents from 1996 to 2019 with most of the articles being from years 2010 to 2019. Most of the studies included concerned Europe, but other continents were represented in smaller parts as well. Trends emerging from the study can be used to design the product development process to maximise the possibility of its success and avoid before unseen pitfalls. The trends around the studied processes revolve around limited resources of the SMEs, involvement of management, informality and possibility for an agile product development process.

The study [13] also points out some techniques utilised by larger companies but often found missing in smaller ones. One of the elements often found missing was the existence of milestones in a project. When a project is laid out in full and only the end goal is commonly understood and accepted, tracking progress can become difficult and thus, allocating resources cannot be optimised. With milestones in place, the product development or design team has a clear goal to work towards in a shorter stint. After a milestone is (or is not) reached, the previous stint can be looked at by project management and resources can be allocated accordingly. [14] Clear milestones also help communicate ideas and goals between the different parties involved and so it becomes easier to suggest changes in either the design or the process. One trend that emerged from the study was the prevalence of changing priorities within the companies. Because this may affect the end goal for the product. Having milestones in place helps guide the project in the right direction. If and when the project priorities change, it is important for management to take initiative to make sure that everyone involved in the project knows what is wanted of them and the project. Because the change in desired product functions often require a change in the concept of the product itself, the agility of the product development process is necessary. [13] [12]

SMEs tend to keep closer relations with their clients, when compared to larger companies. This allows for including the clients straight into the product development process. The involvement might contain communication with the client to map out the clients wishes for the evolvement of the product or even including employees from both companies in the product development team for the duration of the whole project. The involvement of the customer in all parts of the project can prevent backtracking as communication about the direction the development is going can be more effective. Testing the product in as many steps is beneficial as it gives insight into actually using the product. Even early prototypes can highlight obvious deficiencies in operation, which were not found out in design. As resources for product development projects in SMEs are not endless, often smaller companies cannot do everything themselves. With knowledge in only a specific field it is often not viable to try to do the whole project inside the company, but instead seek help with associate companies. Because an associate company might hold valuable information about manufacturing, material engineering or industrial design for example, working in a tight relationship with a company during a product development process may help streamline the project as boundaries for the possibilities of the design will be highlighted through the expertise of the associates. Knowledge about manufacturing requirements can also prevent features from being overlooked and help prevent backtracking if the design turns out to be not viable to manufacture, and further streamline the project. [13] [12]

Product development projects in SMEs tend to be more autonomous, when compared to larger companies. With an autonomous project, the possibility of speed and agility for the process is higher. The advantage of an autonomous product development process is that the product development team can focus on the project intensively without outside interference allowing for better communication and faster iterations of the design, leading to a more optimised design. As the changes to the product design will not always have to be approved by management or a marketing team, it is much faster to redesign a product as deficiencies are spotted. While the possibility of being fast and agile, having an autonomous project might be counterproductive and produce designs which are very different than what is wanted of the product. If a design turns out to be completely different than anticipated, new parameters for the design and a lot of backtracking might be required which takes up extra time. Because the risk of developing unwanted designs exists, tight communication between the project management and other departments within the company and associates is mandatory. With a constant stream of information, the project manager can help steer the team in the right direction and react to changing conditions and new information quickly. [13] [11]

In software development an emerging trend has been the outsourcing of the development project. This means an employment of an external software development team. The team consists of the project leader and developers, who come from the external service provider and the product owner from the employing company. The team will gather information of the product from its users and the product owner and the project manager will be the link between the company's manager. Because the development team comes from outside the organisation, they have no experience in using the software and can assess the product more objectively. Observing how the software is without any previous experience can highlight issues with the product the experienced users have learned to bypass or just learned to live with. As grievances with software become mundane to experienced users, many possibilities for improvements can be missed. A person with outside perspective can spot many possibilities for improvement the experienced users had come to think of as "quirks of the system" or just had learned to deal with and not considered to be possible to improve. [14]

While outsourcing is currently common only in software development [15], It is possible to implement it into a traditional product development project as well [14]. Because employees of a company are more susceptible to having a bias toward the company's own product, having an unaffiliated party, might prove helpful in figuring out the aspects in the product that need improvement, the employees had not even considered. The company hierarchy might also hinder critical thinking, and information coming from management or more established employees are taken with face value instead of analysing the information. With physical products more input from inside the company is required, as manufacturing, marketing and design departments will have the most knowledge on their own sector and understanding the whole process is important in developing the product further. An external product development team can also relieve pressure from the employees, especially in smaller companies by bringing more manpower to the project. [14] [15]

Scalability is another emerging trend and is based on the principle of exerting just as much effort as a step in a development process requires. The methodology saves time and money in steps where overachieving is common and does not produce added value for the whole process. For example, an early prototyping test rarely requires manufacturing with tight tolerances or the use of expensive materials and a model made from readily available materials to test some function or gather other information, is sufficient. With product development projects growing in complexity, experts from multiple sectors are required to for a project to succeed. Individual talent is becoming less important and being replaced by having efficient teams and a good process structure. With most of the development process taking place in a teamworking environment, well-functioning communication has become more important and more time is being taken up by concept decisions. This decision-making process can be helped by active communication, clear instructions from project management and keeping clients in the loop. These factors help steer the development process in the right direction through the whole process and help achieve a better outcome for them. [16]

The scalability level is a type of measure for the requirements for engineering and manufacturing plans, introduced by Carolina Gracia Grijota et. al. in 31st CIRP Design Conference [16]. The scalability level help make decisions about the level of instructions given to manufacturing for fabricating a product. There are three scalability levels with the level of detail increasing with the levels. The information not given to manufacturing will be made by the manufacturing designer to best suit the current situation the manufacturing department has. At level 1, basic dimensions, material choices and finishing of the product will be given and a 2D sketch of the model is supplied, but manufacturing techniques and tolerances are not specified. At level 2, a full 3D model of the product is supplied by the design team as well as manufacturing requirements, a bill of materials, a product file for tolerances, surface finish etc. A timetable for manufacturing can also be supplied. A scalability level of 3, is similar to a traditional way of working. The manufacturer has little say in design of the product and all the information about the product will be supplied by the design team, including an exhaustive bill of materials, a tolerance analysis, validation plan of prototype and detailed sketches and models as well as the resources from the lower levels [16]. The possibility for a product development team manager to set the bar for the amount of information required, helps designers focus on what is important and cuts down on useless information being produced and thus make the process faster and more efficient. It is also easier to move forward on the process when the amount of information is not too much to handle. [16]

3.2 Process modelling tools

Additive manufacturing has been around for decades, but in recent years cheap 3d-printers utilizing various techniques have become available for the public for a relatively low cost. Ranging for a few hundred euros up to hundreds of thousands of euros, the variety in 3D-printers is huge. Because additive manufacturing is a relatively slow manufacturing method and the quality of printed parts is not yet comparable to traditional methods, excluding the best and most expensive machines, manufacturing products using additive manufacturing is slow and expensive. Where additive manufacturing has the edge, is the versatility and possibility to create complex geometries with relative ease. This is a feature that makes additive manufacturing a valuable fabrication technique for prototyping in a product development process, where the number of fabricated parts is small [17]. The possibility for rapid prototyping can help the product development to progress faster as multiple variations of a design can be tested quickly [18]. Having a physical model of a design helps illustrate the features it has and is easier to communicate between the project team. With a physical object or an assembly, the operation of the product and the overall effect on the base product can be seen clearly, in a way that only 3D modelling cannot illustrate, and specific features that need to be changed or can be further developed can be illustrated. It is also interesting to the clients to see and hold prototypes of the product and see how the development evolves.

Because test parts don’t always need to be structurally as sound, or as visually pleasing, as the intended final product but can instead be used as a proof of concept or a test piece for space management etc. the shortcomings of additive manufacturing can be overlooked. With multiple material choices and manufacturing techniques, everything from resin to metal and even concrete can be used as a material for fabrication. A product development team armed with n access to multiple additive manufacturing techniques can build prototype products and assemblies with multiple materials in a short period of time. And even complicated product development projects can be made a lot faster and more efficient. After the initial investment in a capable CAD-software, 3D-printers for the required techniques and quality and sufficient training in utilizing both, the advantages for future product development projects cannot be denied. [18]

As the product development cycles become shorter and the need for customer focus grows [19], the need for an agile product development process cannot be dismissed. As opposed to a traditional, plan-based development process an agile product development process works in shorter sections, often called sprints. At the beginning of the development process, core questions and requirements are documented, and the most important ones are identified to be worked on in the following sprint. The goal of the sprint is to address previously identified questions and to come up with follow up questions for the next sprint. At the beginning of the new sprint the most important questions are identified to be worked on the next sprint. The questions which will be answered in a sprint are selected on the principle of selecting design parameters which reduce the uncertainty of the product the most. With specific goals for the sprint, the product can be developed in small increments and the development process is iterated until enough development has been done and the product can be brought to the market. This principle of not developing a product more than is required is known as “minimal viable product” or “MVP” [19]. Many commercially available solutions for agile product development projects exist with SCRUM being one of the most widely used.

SCRUM is a technique created by Ken Schwaber and Jeff Sutherland in the early 1990s [14], originally to be used in the development projects of information systems, but it has applications for traditional product development projects as well. In their 2020 SCRUM guide, Schwaber and Sutherland present SCRUM as a framework within various tools and techniques should be used [14]. They state that for SCRUM to work properly, the whole process must be transparent. As the project team is given autonomy, frequent inspection must be possible to ensure the project is moving towards the right direction. The autonomy in the project also means, each team member must be allowed to take initiative and be capable of self-management. A possibility to enact a change without direct orders from upper management gives the SCRUM team a possibility for high agility and quickly changing plans. This is the reason why frequent inspections from management are also required. As stated before project using SCRUM works in sprints no longer than one month in length. A sprint is the standard time window for developments to be made and during a sprint, goals and research questions remain unchanged to increase predictability. After a sprint, a new sprint immediately starts with tweaked or changed goals to accommodate new information that has been discovered. The product backlog (A product backlog is created at the start of the project and it contains a list of what is required to develop a product in the project. The product backlog basically tells the product development team what is needed of them. [14]) is refined and the goals for a new sprint are determined.

Ideally [14] the SCRUM process consists of regularly held events at the same time each time to reduce complexity. Such events include:

i. Sprint planning; The first event in a new sprint, in which the goals, the value of the sprint, specific assignments and the tools and methodologies to be used, are discussed.
ii. Daily scrum; A quick, 15 minute daily meeting to inspect progress and help management address the right issues.
iii. Sprint review; Full sprint inspection at the end of a sprint to determine changes for the next sprint and to update goals etc.
iv. Sprint retrospective; The last event in a sprint in which the whole team inspects the last sprint to evaluate the tools used and plan for improvements for the next sprint.

Another technique for developing a product is GeMoCURE, the name of which comes from the words: Generalization, Modularization, Customizations and Reconfiguration [20], and focuses on the development of a product family utilizing modularization and the use of existing technology [21]. It makes a point of reusing existing company assets and proven technology and to effectively use those technologies, an exhaustive portfolio of the company's existing products and the technologies used within should be made. From withing the depository of assets, new variants and product families can be developed. As a sidenote, the inventors of this methodology also state, that having a methodology is more effective than the instinct of designers [20], although utilizing both; an effective methodology and the skills of designers will generate the best outcome. A methodology can produce great functionality, but with many products exterior style plays a large part in appealing to customers and is one reason why designers are needed [22] even if effective product development methodologies are put into practice.

After the product portfolio is completed, the next step in the GeMoCURE process is generalization. This step breaks down the existing products into structures and functions [20]. A function can then be analyzed further to figure out the specific components used to achieve the function in the product. Generalization is done to learn which components and features can be made into a module and used in another product and to see how a function would change by switching components in the module. This gathering of information can be used later to tune the functions of a product to better suit a customer's needs. Structures serve as a building platform for the modules which carry out functions. After the existing functions and structures are figured out, modularization can start. The idea behind modularization is to design and build modules that will carry out a single function. The aim of modularization is to use as many existing parts as possible to minimize the need for new manufacturing processes. Existing parts are also a proven technology and often don't need a new designing process. For modularization to be effective, the module interface must be designed in a way that every module interface is able to work with any other module interface or else, variation can be limited by certain modules not working with each other. If mutually dysfunctional interfaces are made, an extensive development process might not be able to be avoided. Instead, an investment into a standardized interface will be beneficial for making variations for future customer requirements.

Before the modules can be used, a base for the product family must be defined, onto which the modules can be added. In the GeMoCURE methodology, product features are categorized into three categories: common features, differentiation enable features (DE-features) and auxiliary features. Common features are the base for a product family and serve as the platform for adding modules. By using the Hailstorm product family as an example (although currently quite little customization is available). The detonator is the only common feature in this product family and works similarly in every variation. The main body of the device is a DE-feature and comes in three variants. These two modules comprise the main functionality of the device and onto this platform auxiliary features may be added. Auxiliary features will not change the main functionality of the product, but instead provide another function, a sighting system for example would an auxiliary feature. Currently, three different mounts are available; a tripod, a folding stand and a hook for mounting on a tree and are also auxiliary features. From these features a customer will choose the one best suited for them. Once all available modules have been identified, they can be arranged into a general product function structure (GPFS) to create a layout of all the available variants of a product.

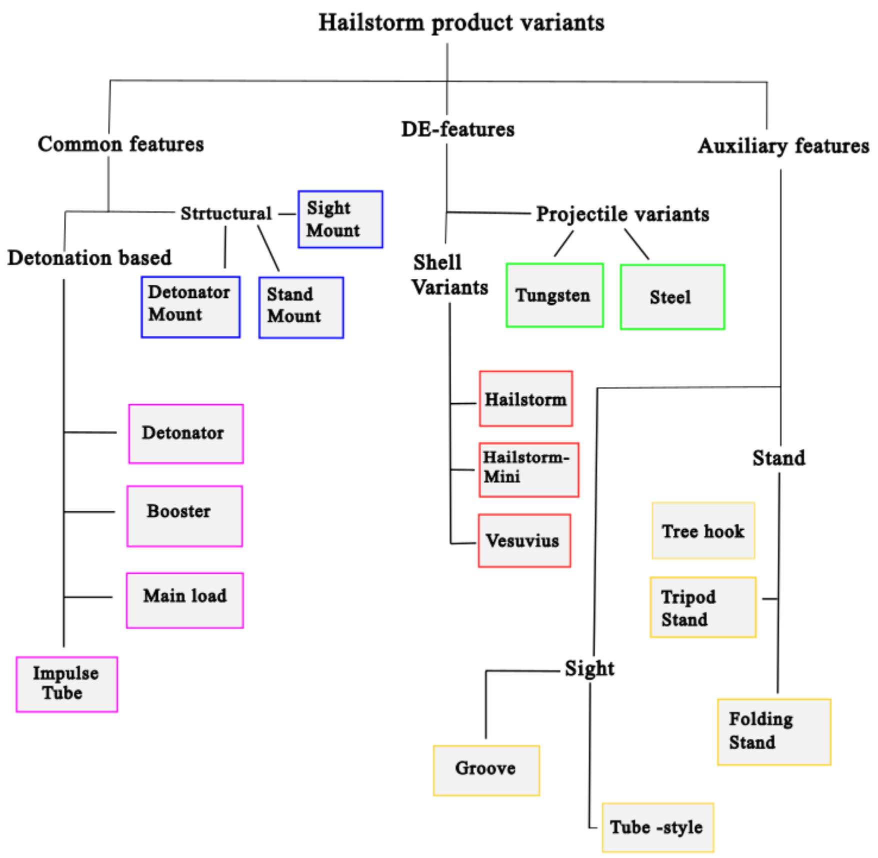

Figure 3: "General product feature diagram", which differs slightly from the similar "General product function diagram" in that it showcases the isolated features of a product family, the Hailstorm -product family in this case. This chart is not fully accurate, as all variants are not compatible with each other.

After recognizing what the existing assets are and designing modules using as much of the existing technology as possible, the customization part of the project can start, often initiated by collecting information of a customer's wishes and requirements for a product and its variability. The end goal of the customization part of the project is to create a product family from the common platform identified in an earlier step. If a customer asks for a feature that does not exist in the backlog, a development project for a new module is done or a combination of existing modules are adapted to complete the new requirement. To do this, the first step should be to identify the fundamental function to fulfill the request. By clearly defining the function needed it is much easier to see if existing components can be used to deliver said function [20]. From these existing and new modules, the composition of the final product is created for a customer. After this, the last step of the process can start. Generalization has the end goal of generating optimized configurations for modules to be used in multiple product families with similar functions [21].

For more complicated systems, it might be difficult to determine the composition of modules. To determine module composition a “module identification matrix" (MIM) and a “dependency structure matrix” (DSM) can be used (*Figure 4*). In the DSM, every component is plotted on a grid on both axis and a mark is made on the grid on each point where the components in the corresponding column and row have a dependency. This same grid is then plotted again and areas with a high number of marks are separated and outlined to create a suggestion for a module [20] [21].

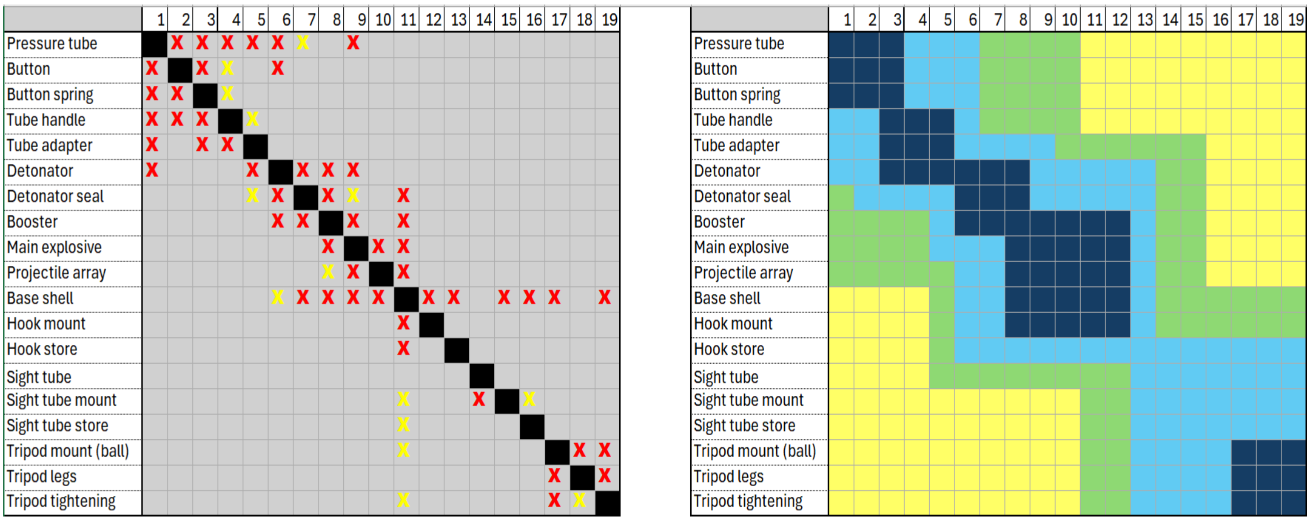

Figure 4: A dependency structure matrix (left) and Module identification matrix (right). Components of a product are plotted on the x- and y-axis. A red X marks a strong dependency while a yellow X marks a weaker dependency. The same data is then plotted and recognized as possible modules.

By working out dependencies individually, even a complicated system can be deconstructed with relative ease and existing groupings of components can be identified to be made into separate modules and used in other products. The DSM and MIM diagrams can also be made using software and The DSM and MIM diagrams can also be made using software and the guide [20] proposes the use of a “Seed” based clustering algorithm for making the DSM. To do this, each component is given a “seed” from which the software can identify the dependencies of the components and then propose generated modules. With complicated systems with large amounts of components, the use of software is warranted as the DSM-chart can be massive, but for simpler products with relatively few parts, the use of such software is rather excessive and can be done manually using less resources. With a manual approach to clustering the components, a thorough analysis or the product and a deep understanding of its function is required [20] [21].

4 Concept development

In this part of the thesis, I will produce and showcase a concept for a new add-on sight for the Hailstorm products as well as the mounting system to be built into the shell of the product. The recommendation will be made based on the availability of sight technologies, explored in section 2, and the data collected from the client survey as well as from employees of OY Forcit Ab. In this section I will also briefly outline the answers of the client survey conducted. Due to the nature of the information, the specific clients will not be disclosed in this thesis.

The concept development was done by utilising techniques for product development projects outlined in section 3. The existing product has been divided into modules, one of which is the sighting system and the goal of this project is to develop a new replacement for the existing module, while keeping the base product unchanged. As stated before, modularisation keeps the scope of the development project more focused and allows for faster development of specific functions of the product [20]. Before the new concept was conceived. Clients were asked about the wishes for the direction of development for the new sight, in a client survey. The goal of this thesis was to come up with a new sight concept which could be utilised for further development. This thesis can be looked as the first iteration of a new product development process and the baseline from which the next development cycle will start [14] [21].

4.1 Client survey

As talked about in section 3 of this thesis, including clients in the product development process can aid the project. [13] The survey consisted of questions regarding the environment in which the Hailstorm products are to be used, common problems with the existing product and the equipment of the operators of the product. Answers for the questions were gathered by e-mail or from an interview over Microsoft Teams.

4.1.1 Survey questions

To compile the wishes and requirements for a new sight, a client survey was conducted to make sure the development process of the new sight could be set in motion on the right track, according to the client’s needs. Before more thorough interviews were conducted, the clients were sent an inquiry by e-mail with a brief introduction to the project and generic questions relating to the use of the Hailstorm products. The questions posed were as follows:

i. In what kind of situations does the existing sight struggle in?
ii. What necessary features are missing from the existing sight?

iii. What are the conditions the Hailstorm products will be used in (Weather conditions, night-time use, snow or dust)?
iv. In what kind of environment will the Hailstorm products be used in (urban built-up areas, open areas, wooded areas with lots of vegetation)?
v. Could an operator carry a detachable sight, which could be mounted onto a Hailstorm device and removed again after orienting the device? This would allow the use of a wider range of technologies as a more expensive sight could be kept for repeated use in sighting the Hailstorm products.
vi. What kind of equipment will a person using the Hailstorm products have and how many of the Hailstorm devices will a single operator carry (will the operator have night vision gear for example)?
vii. Roughly how much can a single Hailstorm device cost?

Answers to these questions were used to roughly outline the performance requirements and the style in which the sight and mount could be developed and helped narrow down the types of sights to be used to best suit the wishes of clients. Along with the client requirements, there exist some manufacturing requirements as well. The external shell of the Hailstorm devices is made of injection moulded plastic and a mount for a sight could be either built into the mould or glued on after the manufacturing of the shell. As the shell is plastic, it is also desirable to make the mount using the same material, even if it is to be glued on. If a removable sight is to be used, the counterpart of the mount should not have as strict requirements as the number of the removable sights to be manufactured is smaller. If a sight from an external company is used, the counterpart of the mount should be made in a way which allows it to be attached to the sight.

4.1.2 Results of the client survey and sight features

In my opinion the most prevalent requirement from the client survey was that the sight must work in all environments and conditions. Clients were in favour of a removable sight, which must use a mounting system that can be operated with gloves on as it needs to be able to be used in cold climates. A removable sight was favoured, because of the enhanced performance achieved by the higher possible cost of a removable sight, allowing for the use of more elaborate technologies. In addition to the removable sight which will allow for fast, easy, and most importantly, accurate use of the device, the clients wanted a simpler and cheaper sight which would come as stock with every device and can be used if the removable sight is not able to be used. For both of these sights, it is important that an impact area of the estimated projectile pattern is visible.

To best accommodate wishes and restrictions from both the clients and manufacturing, I suggest the development of a flip-up sight for the base sight, built into every device. The flip-up sight can be simple and cheap to manufacture, but they can still offer good usability as they require very little space and can be made to show the full impact area of the device. For better control over the flip-up sight, two separate sights should be included. One closer to the user will have a transparent plate, marked on which is the impact area and a centre point. The plate further from the user will include a point, which is to be lined up with the point on the first plate to control the direction effectively as especially the vertical direction is critical to use the device effectively. In addition to the flip up sight, a rail should be added to the Hailstorm -devices shell onto which, a removable sight can be slotted. The rail and the sight mount should be designed in a way that the sight cannot come detached on its own, that is, the mount should be “locked” onto the rail, until it is intentionally removed. I will showcase one concept of this type of rail later in this section. As the sight is to be used in varying terrain and weather conditions, it is imperative that the sight stays secure in strong winds or in a slope. The rail and mount should also be designed in a way that there is no room for the mount to rotate on the rail, causing inaccuracy. On top of the mount, a more elaborate sight can be added, and such sight can be one that is commercially available. As it is favourable for the sight to show the full impact area, an accurate representation on the impact pattern limits the options quite a lot. Depending on the number of projected sales, it could also be possible to have a sight tailor made to show the appropriate impact pattern.

In addition to a reflector sight, the use of an OEG sight could be feasible as the technology used is simpler and cheaper to manufacture when compared to reflector sights. Because OEG sights are not commonly used in infantry weapons, a suitable variant would need to be developed and manufactured from scratch. Because the technology used in an OEG sight is simpler than the technology used in a reflector sight, building a sight with an appropriate impact pattern should be cheaper than a reflector sight. As OEG sights don’t rely on mirrors and delicate electronics, the sight is more rugged and durable, which might be an advantage especially in a detachable sight. The reasons listed above are the reason I recommend the use of an OEG sight, with a reflector sight as a strong 2nd option. Note that laser sights are not optimal as aiming onto an empty are should also be possible. One last thing that is to be considered if the removable sight option is chosen, is that the sight will need to be stored in a proper carry-on bag or a designated pocket for both ease of use and for protection of somewhat fragile sight components in field conditions. [4] [8]

The system I propose is shown in pictures below. The rail is to be built straight into the shell of the Hailstorm platform and a slide onto which the actual sight is to be fixed on, will attach onto the rail with spring loaded clips. The clips are large and simple enough to be operated with gloves on. The simplicity also reduces the risk of dirt or frost buildup affecting the performance of the sight. Although not illustrated on the pictures, the flipup sight with the rectangle should include a transparent plate, onto which the impact pattern is to be painted.

4.2 Rail and sight mount design

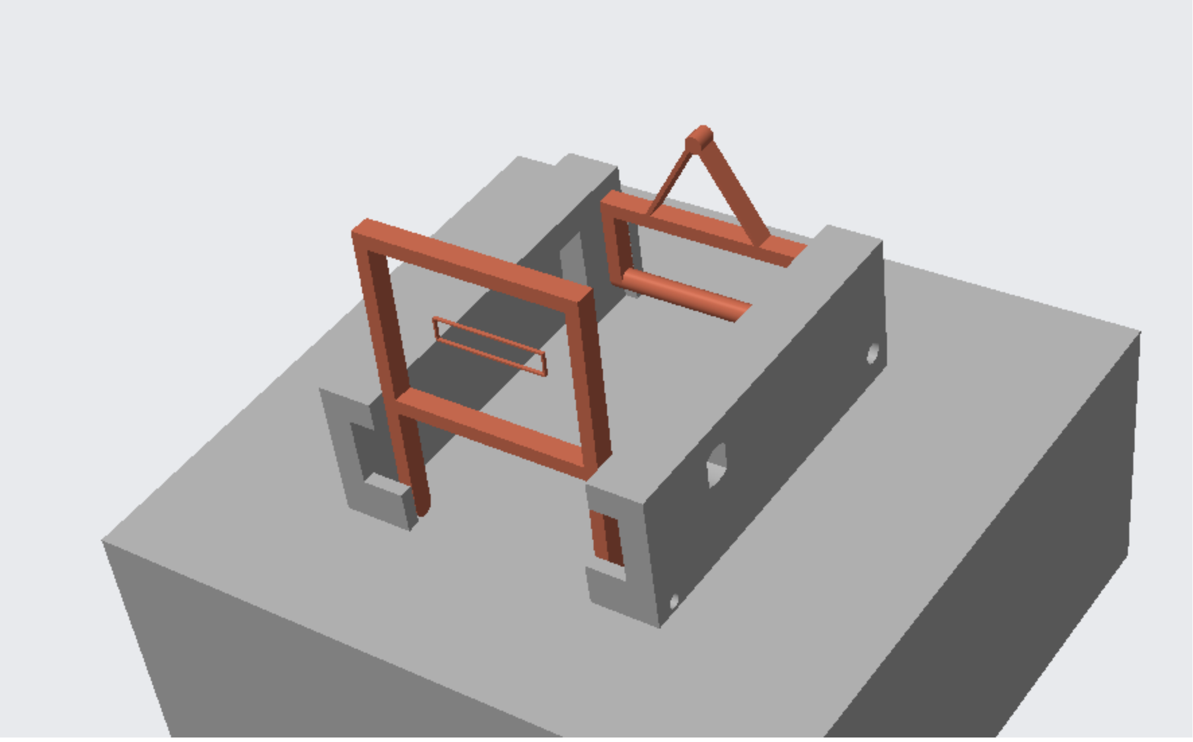

Figure 5: When the device is ready to be aimed, both parts are turned to an upright position against stopper pieces.

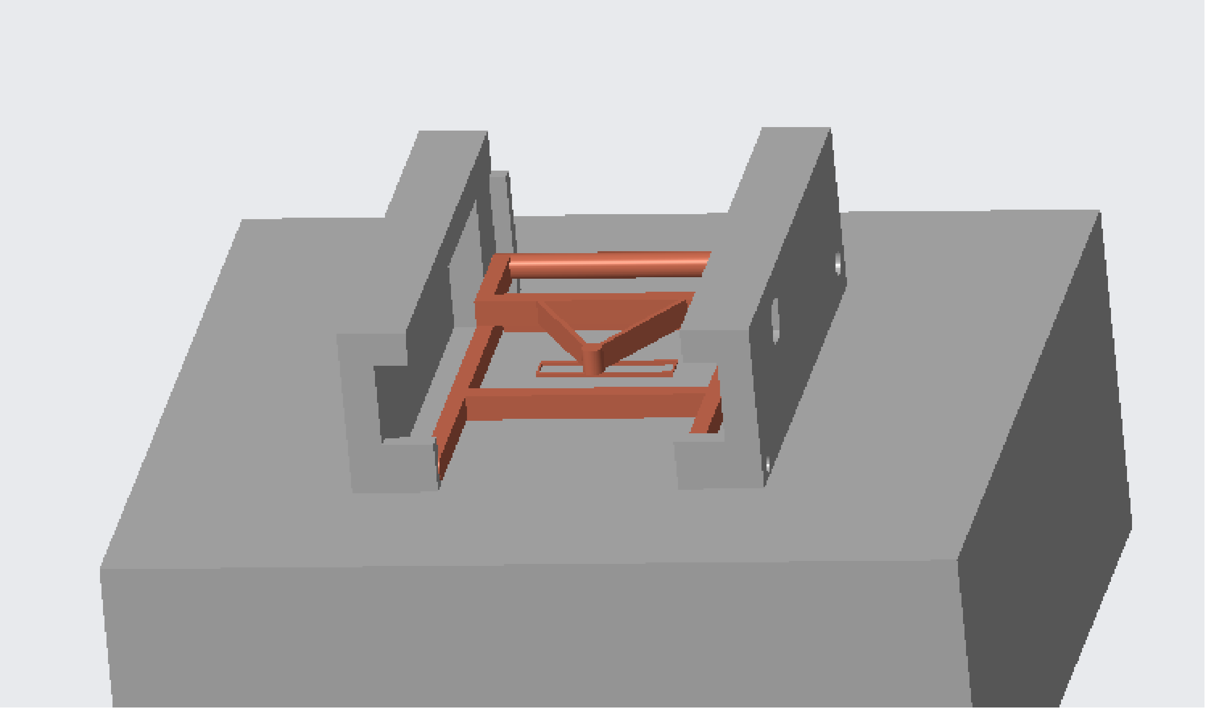

Figure 6: While not aiming, the parts can be folded on top of each other to take up less space and to protect the flip up sight. In this position the removable attachment is also able to be fitted on top of the flip up sight ad slides onto the rail.

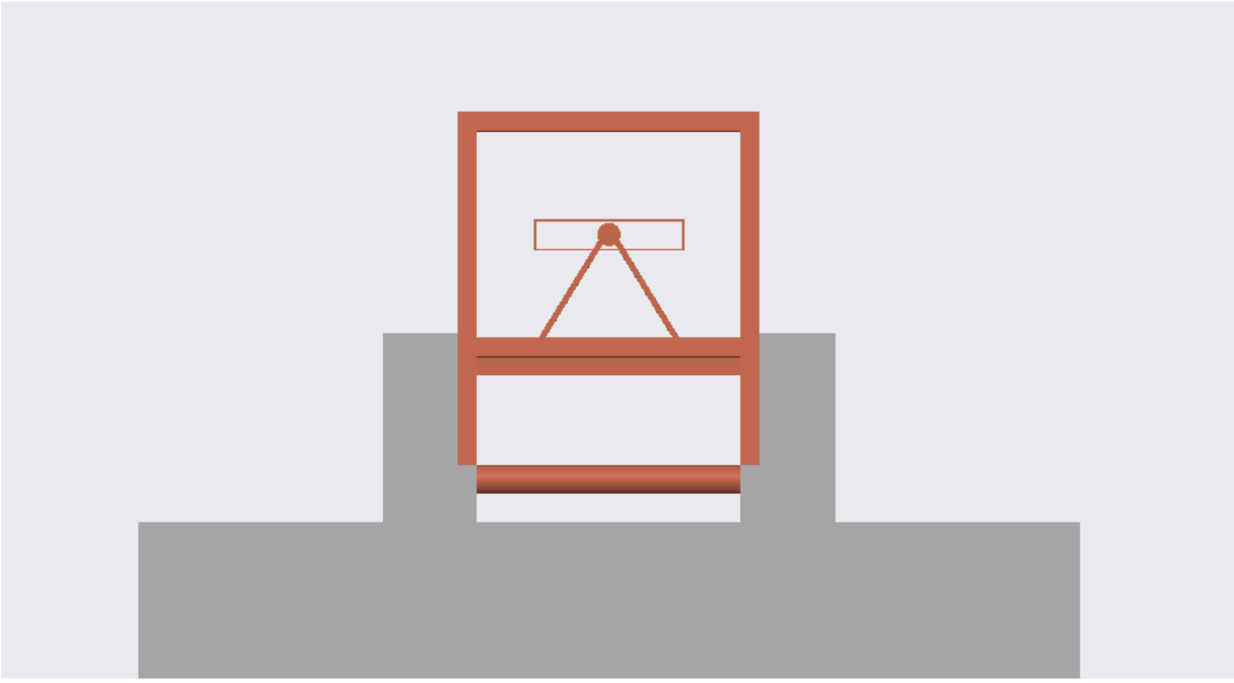

Figure 7: The sight picture when looking through the flip up sight. The dot on the front sight is to be lined up with the rectangle on the rear sight. This allows for height- and width control while aiming. The rectangle shows an approximate impact pattern.

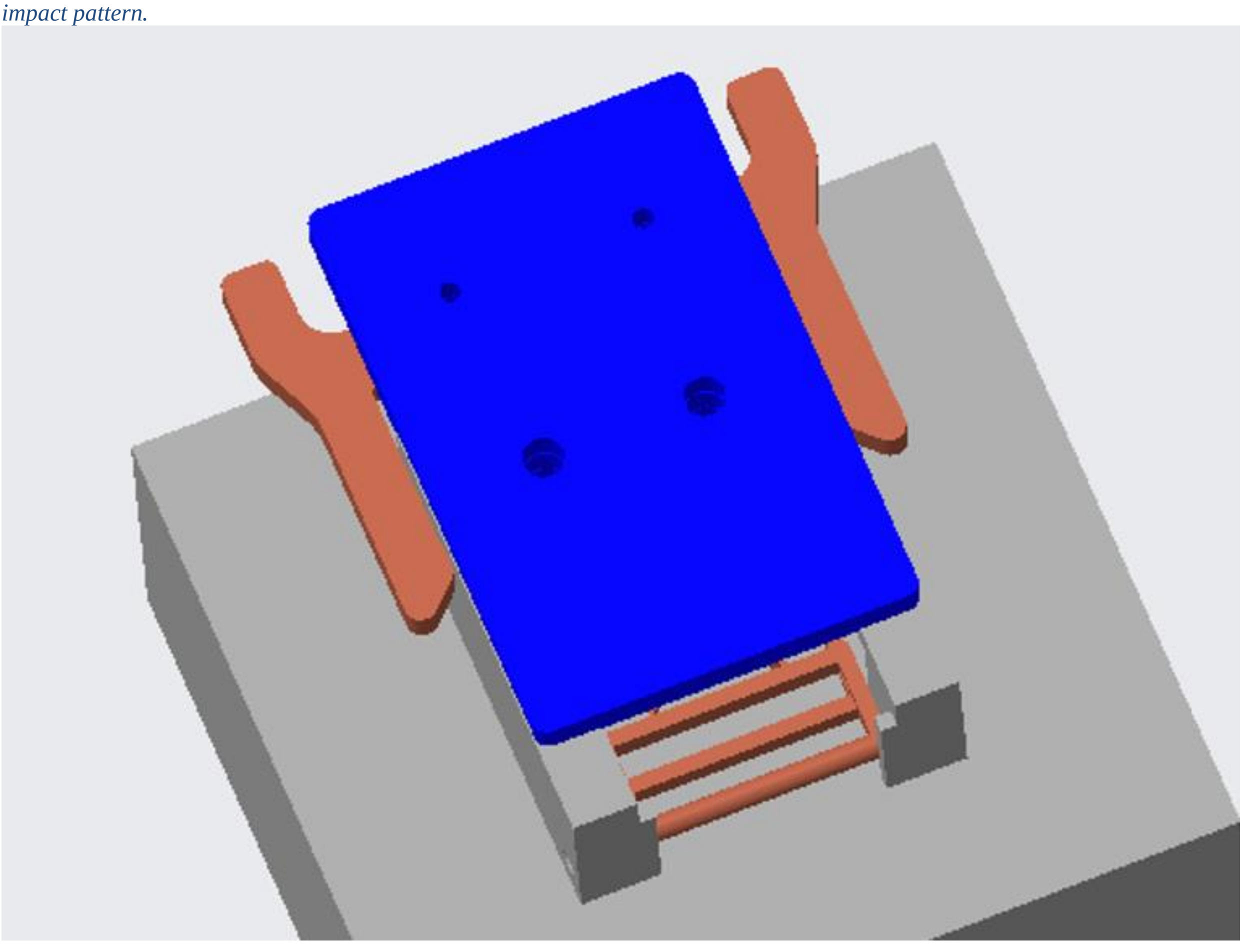

Figure 8: The sight mount fitted onto the rail with the flip up sight folded down.

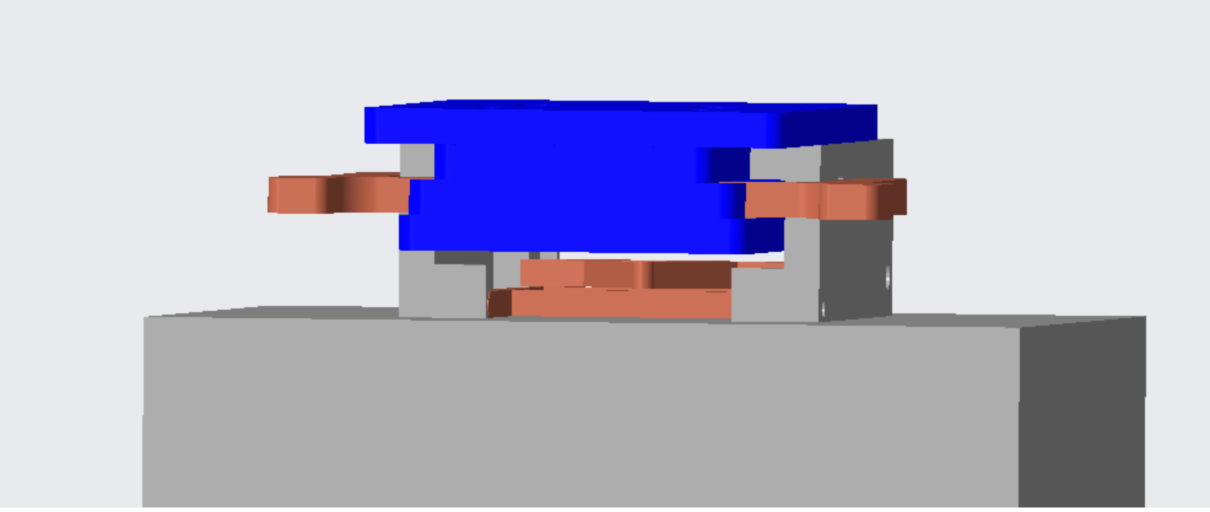

Figure 9:Sight mount viewed from behind. The groove on the mount is just large enough to fit onto the rail, eliminating wiggling, making the sight more accurate.

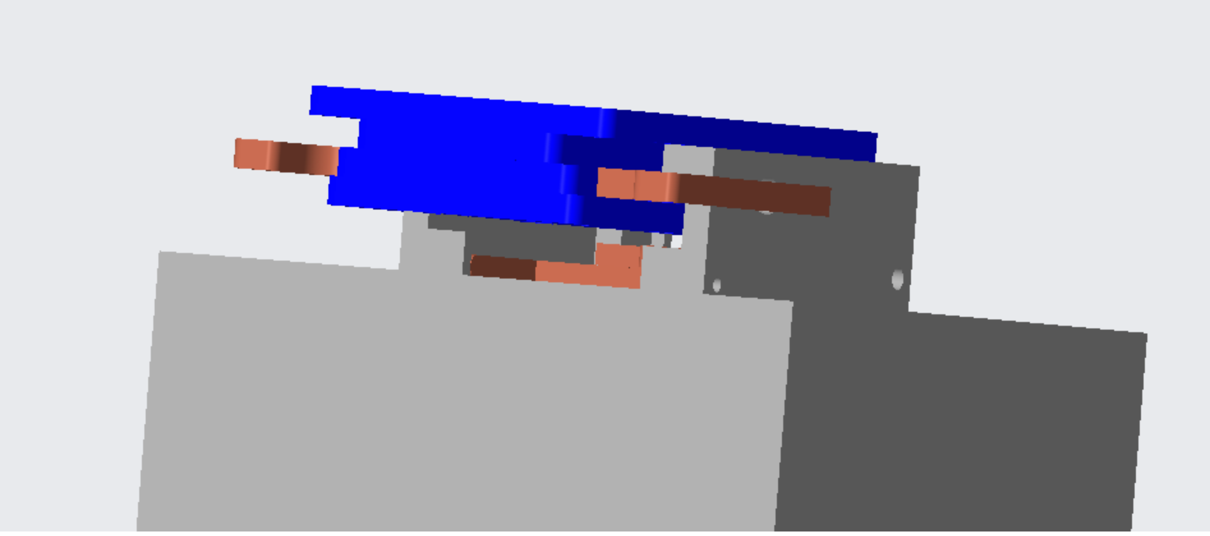

Figure 10: The clips on the side are spring loaded and clamp into holes on the sides of the rail. The rail allows the mount to slide just far enough to allow for the clips to lock in place.

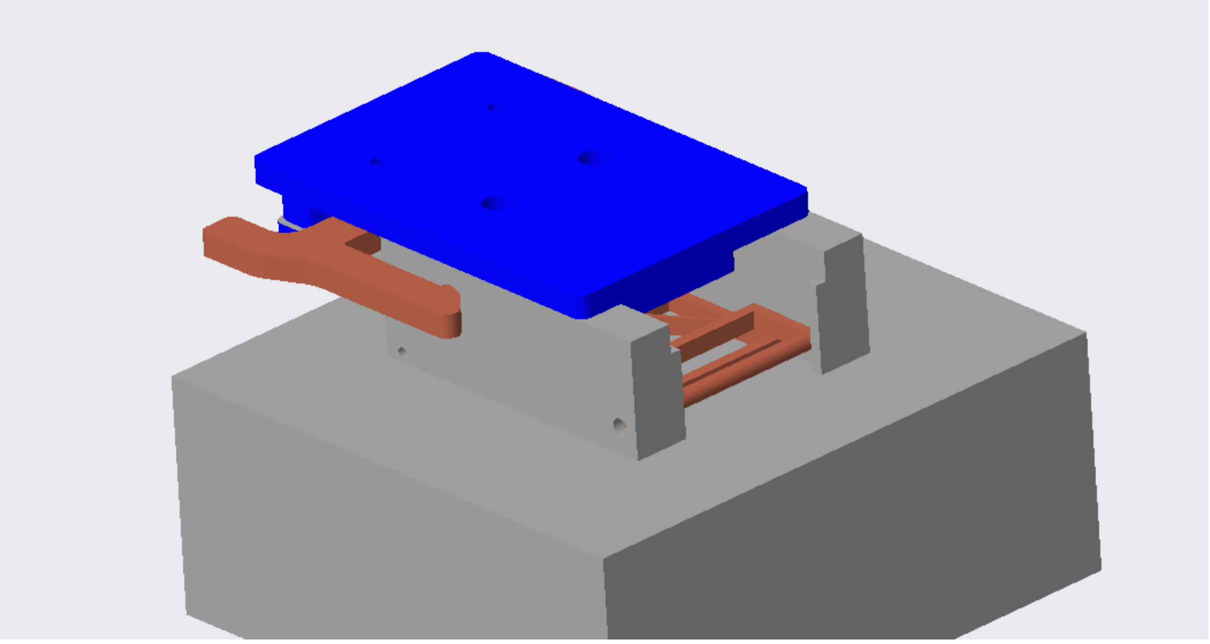

Figure 11: The clip viewed from another angle. The mount is not held in place by force or anything else, apart from the clips and so, detaching the mount is fast and easy, even with large gloves on. The tighter the tolerance with the clip and the barrier which stops the mount from sliding forwards, the less the mount is allowed to move.

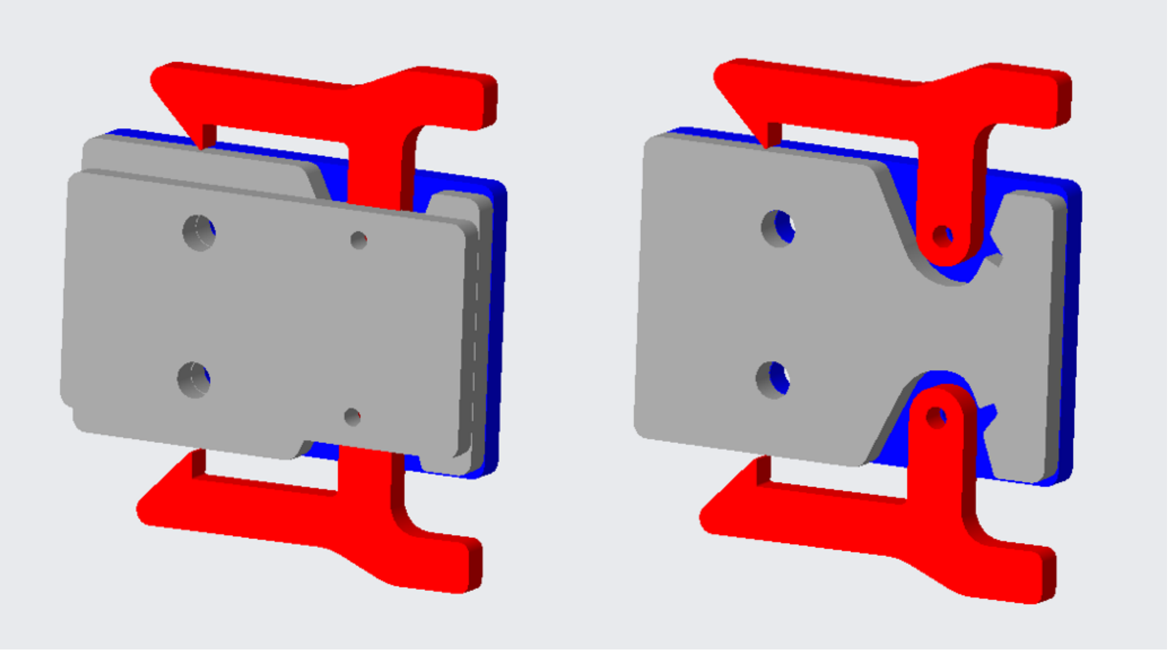

Figure 12: In this model, the mount is made up of plates. A spring is to be placed so that the clip will continuously push against the side of the mount to keep the sight in place and allowing for easier storage as the inside of the clip might get stuck easily otherwise. A yet wider plate (as seen on pictures above) is to be attached on top of the narrowest plate to create a groove to make a fitting for the rail.

5 Summary

This thesis was made for OY Forcit Ab's defence branch. The tasks given were to benchmark existing sight technologies and evaluate their effectiveness, and to come up with a new sight concept according to the requirements of clients. A literature review of emerging trends in product development and of product development methodologies was conducted and lastly a new sight concept was conceived, based on the answers of a client survey.

The sighting technologies currently in use fall into two categories. Iron sights are simple, consisting of only a few mechanical components, usually with two beads or a combination of an aperture plate and a bead. By aligning the bead near the operator's eyes to the bead near the muzzle of the gun, the gun can be aimed accurately. While iron sights don't allow for absolute precision on far away targets, they are cheap to produce, reliable and rugged, without fragile optical components. Iron sights are deemed satisfactory in for example shotguns and pistols, whose range is relatively short. Optical sights rely on optical components and allow for a wide range of different styles of sights. Some sights are telescopic and so are well suited for long range rifles, while others produce a ballistic pattern on the sight. These reflector sights work by reflecting light towards the shooter with a concave mirror. Reflector sights may produce different images ranging from a simple dot to elaborate grids and ballistic patterns.

Yet simpler than iron sights, flip up and peep sights offer rough accuracy, but often are far cheaper to produce and are used in weapons systems in which absolute accuracy is either not required or impossible to achieve. Less common sight technologies include laser sights, which employ a laser pointer to illuminate a dot straight onto the target and OEG -sights, which work by looking through the sight with both eyes and superimposing a reticle onto the target. OEG -sights are cheaper to produce compared to reflector sights and require less fragile components. One consideration when choosing a sight is the usability in the dark. Iron sights can be equipped with glow in the dark capsule or paint or be used together with night vision goggles.

Traditionally, a product development process has followed a waterfall model in which an earlier step is completed fully before moving forward. In the present day, with faster changing market and the desire for more customizability of products, agile product development methodologies are invaluable. With an agile product development process, backtracking is much easier, and sometimes even expected in what is known as an iterative product development process. Backtracking is essential to allow to guide the process in the correct direction. Keeping the client well informed through the entire process often reduces the need for backtracking as the product development team will have a clearer picture of what is wanted of the product. One way to offer more customizability for the customer is to create the product from separate modules. By changing individual modules, it is possible to include different features on the product. Having the product made up of modules also allows for more agile product development as only a single module can be considered in the product development process. If it is decided, that modularization is to be used, each module should be made with an universal module interface, that can be attached to any other module (or at least as many as possible) to allow further customization.

In small and medium enterprises (SME), product development projects have a high potential for agility and a part of this is the possibility of close relation to clients. SMEs tend to keep the projects less formal with higher independence, and while these aspects allow for higher agility in the process, without good management and clear goal for the process, the results can differ a lot from what is actually wanted outside the product development team. Iterative and continuous product development projects have also become more popular, especially in software development. In an iterative process, the project progresses in short sprints. Each sprint should have a clear goal the whole team works towards. With the sprint structure, less time can be spent managing the product development team and backtracking is easier again, allowing for more speed and agility. It has become more common to outsource product development projects almost completely with only a few contacts to the client company. Outsourcing of such projects can have advantages over doing them in house. With an impartial team of product development professionals, unseen flaws of designs can be spotted and unbiased observations made. On the contrary, unfamiliar product platforms can cause troubles, especially if the product is complex. Overall the trend of product development project is moving onto an even quicker iteration time and larger possibilities for customization.

To conceive a new sight concept, a client survey was conducted. From the answers of clients, requirements for the sight were identified. The concept I propose consists of two separate sights. A flip up sight, attached onto the external shell of the Hailstorm device. The attachment is built into a rail, onto which a removable sight can be attached. The sight needs to be removable without tools, even with thick gloves on, and simultaneously stay in place. To meet the criteria, a mount with spring loaded clips was designed, on top of which a more elaborate sight may be attached. The sight on top of the mount could be either a reflector sight with a dot or a rectangular impact pattern, or an OEG -style sight with similar pattern. In my opinion the latter offers great advantages, even though it needs to be designed itself. The advantages come from lower production cost, higher durability, and accuracy on par with a reflector sight.

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