DTS 01

Drilling Targeting Systems

Next Generation Aerospace Assembly

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Term Project 2018

MFA Advanced Product Design

Atlas Copco

UMEÅ INSTITUTE OF DESIGN
UMEÅ UNIVERSITY

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Abstract

The aim of the project is to examine the Aerospace assembly and to discover the problems here, a more healthy and comfortable work environment for the operators and to produce innovative and sustainable solutions for the sector.

Aircraft production is rapidly increasing worldwide and the sector has become unable to meet this demand. Therefore, aircraft manufacturers and suppliers are looking for new solutions on production and assembly, which will accelerate and make more precise the production process.

Thanks to the solutions DTS 01. It will speed up the workflow, provide more comfortable working conditions and reduce the need to the extremely skilled operator. DTS reduce human error and it enhances accuracy rate in the assembling progress.

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INTRODUCTION 01

Term Project brief

Next Generation

Aerospace Assembly

Traditionally during this first term project, we appled a more theoretical approach to identifying potential products. We were dealing with products and solutions for a special user group, this year it was the users of Atlas Copco's different product solutions within their portfolio for aerospace assembly.

We were using our abilities for new thinking and innovation, and exploring the users' emotional responses and their professional and personal needs.

Who is **Airbus?**

Airbus is a European aerospace corporation. It designs, manufactures and sells civil and military aerospace products worldwide and manufactures in multiple countries both inside and outside of the European Union.

The company has three divisions: Commercial Aircraft, Defence and Space, and Helicopters, the third being the largest in its industry in terms of revenues and turbine helicopter deliveries.

Stakeholder: **Atlas Copco**

The Atlas Copco Group is a global industrial group of companies headquartered in Nacka, Sweden. In 2017, global revenues totaled SEK 86 billion, and by the end of that year the company employed about 34,000 people. The company manufactures products at about 100 production sites in more than 20 countries. As of 2016, the United States is the company's largest single market, followed by China.

Atlas Copco companies develop, manufacture, service, and rent industrial tools, air compressors (of which it is the world's leading producer), construction and assembly systems.

INITIAL RESEARCH 02

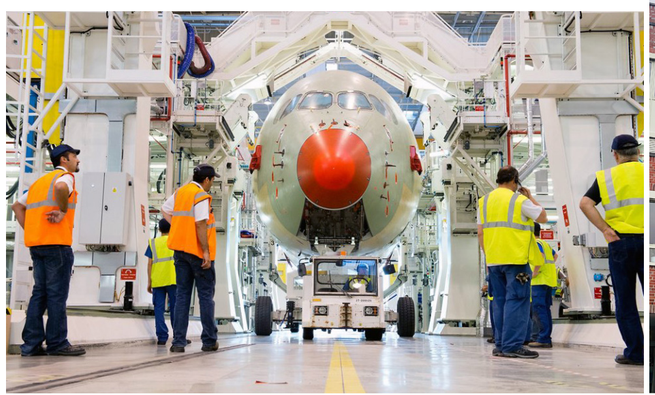
Field Trip

In order to get in touch with the tools themselves as well as to gather hands on insights from professionals, we went on a research trip during the first week of the projects.The journey began in Airbus main production site in Germany, lead us to the harbour city of Hamburg where we got the chance to see the complete process of aerospace assembly.

Then, to examine the products more closely and get detailed information, we headed to Stockholm where the head office of Atlas Copco was located. Here we had the chance to increase our knowledge by experiencing the products.

Our goal was to find a user and expert insights and to identify relevant design opportunities which we can transform into concepts and valuable products for coming material handling generations.

We had the chance to gather information through infield observations, user interviews, factory tours and trying to tools at Stockholm.



Hamburg
Visit Airbus

Workshop

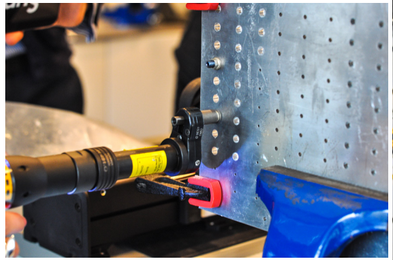
Thorsten Roye
ME Expert for Fastening Systems

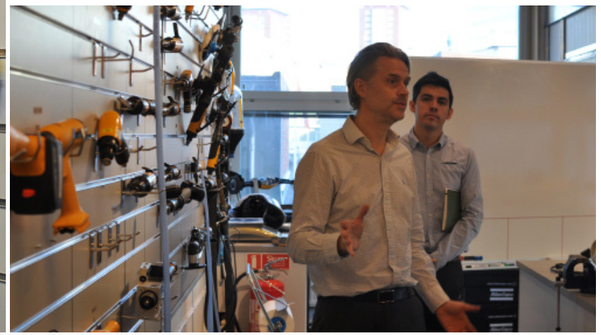
Hands On

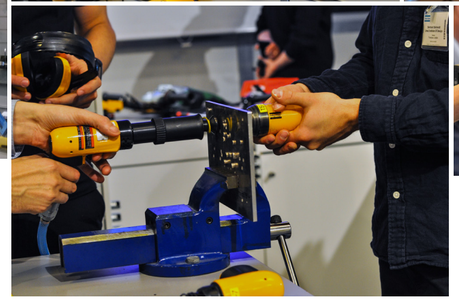
Tools, fasteners & competitor tools

Questions
Aerospace / Atlas Copco

Per Törnberg
Lars Burkhardt
Francisco Lindoro







Stockholm
Visit Atlas Copco

Company Introduction

Presentations

Aerospace - Per Törnberg
Ergonomic - Frida Graf

Hands-on Tools' test

Umeå

BACK TO SCHOOL

After we completed our time on the field, we came back to school to dive into creative process based on the information collected. We went through the process listed below.

Field trip analysis

Visual Problem and Opportunity Mapping

Brainstorming / Concept Generation

Rapid Concept Exercise

Role-Play Scenario

Field Trip **Analysis**

As a group of 3 students, we summarized the information gathered during the field research and analyzed it in a way that it concludes our insights and observations. At the end of the field research analysis, each group presents the outcomes of this process which further leads to creating pathways to follow in the upcoming design process.

A next step involved creating a visual persona diagram, describing a workers day visually with all its possible troubles and tasks.

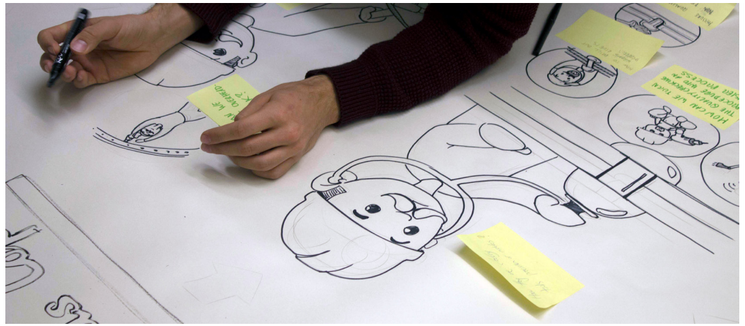
Visual

Problem and Opportunity

Mapping

Visual problem and opportunity mapping was put together after our research analysis. This method was used to spark our creativity and prepare us for the upcoming brainstorming session. The intention behind this method is to give us a detailed overview of a workday in the life of a operators in the aircraft assembly.

This task helped us to understand the workflow better and how the people are interacting with their work environment. At the end of this task we presented it to each other in a storytelling exercise.

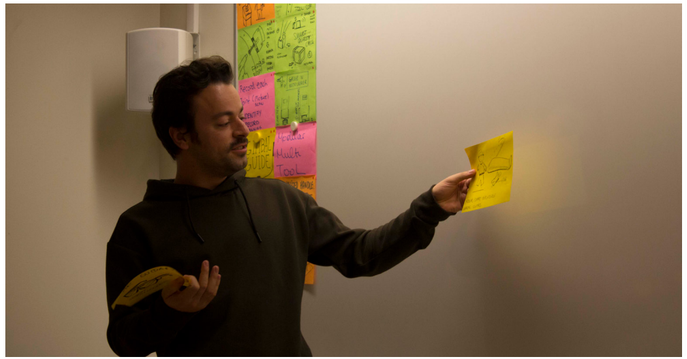


Concept Generation

Brainstorming

After the visual problem and opportunity map, we tried to figure out problem areas and possible solution based on all information collected so far.

This involved several short and intensive class sessions generating a broad range of ideas. From here, problem areas were collectively narrowed down and potential solutions brainstormed.



Role-Play Scenario

After the concept generation exercise we quickly analyzed each concept presented within our groups,before collectively deciding what idea would be most beneficial to ‘act-out’ in a role playing scenario.

This method proved to be extremely effective as it immediately identifield several issues the operator might face, as well establish a hierarchy of needs or determine what aspect of the design outweighed others. It was also presenting as a performance was a great opportunity to that enabled us to better understand the problem.

Research **Debrief**

At the end of an intensive workshop, we have presented the areas of personal interest for our projects to the Atlas copco. We had an opportunity to ask our questions to company. The feedback they gave us before determining our design direction was very useful and valuable.

Thibaut Papaix, Aerospace Assembly
Ola Stray, Manager Industrial Design
Atlas Copco

RESEARCH CONCLUSION 03

Design Opportunities

Areas of Interest

1. Organizing and carrying tools
2. Tool communication and interface
3. Collaborate robotics
4. Extreme ergonomics
5. Smarter quality check of the holes and bolts
6. Improved work environment
7. Reduce amount of templates
8. How can we make the work less monotonous to reduce the human errors
9. How to improve the quality check and collection of data
10. How to be flexible in limited space
11. Improve the human-machine process
12. Tool adapts to the user and the job
13. Guidance to less educated worker through complex tasks

Areas of Interest

Problem Description

'The International Air Transport Association expects 7.8 billion passengers to travel in 2036, a near doubling of the 4 billion air travelers expected to fly this year.' (IATA)

Aircraft production is increasing rapidly worldwide, but a large percentage of the aircraft production line is manual, so producers have difficulty in meeting the demands. During the field trip, I observed that several works were done by two or more workers.

The human factor leads to slower progress and errors. Moreover, the work cannot be precise enough. Given future demand growth in the aircraft sector, this will become a major problem in the future.

As a result of my observations, the positioning and drilling operations which are of high importance during the wing joining process are made by mostly manual and with many workers. At this stage, major time is lost and directly affects the production process.

My goal is to create a product solution which helps to relieve this process in order to make a fast,smart and high precise workflow.

Goals and Wishes

Goals

I would like to focus on the following topics:

- Provide a solution that will be improve the workflow in aerospace assembly
- A near future solution (2025)
- Storytelling
- Roadmap or infographics to visualize the opportunity scenarios
- Exploratory prototyping
- Quick photoshop renders
- Realistic visualizations and animations
- Physical model making

Wishes

- Advanced prototyping
- Incorporating new design methods to myself
- Improve animation skills
- Explore the aerospace assembly industry

IDEATION 04

Drilling in Aerospace Assembly

First, deeper research has been conducted into the area of interest. The problem was examined in detail and a strong infrastructure was created for the concept phase.

While researching, any interesting ideas and thoughts were noted down. These initial findings became the backbone for more structured brainstorming and idea generation.
From here, defined directions were established and concepts developed based around drilling in aerospace assembly.

What is drilling in aerospace assembly?


Process
Work sequence
Structure rigidity
Jigs, Supports
Position of tacking elements
Tacking element type
Clamping force
Number of tacking elements
Level of automation
Cleaning
Use of tripod
Pre- and secondary drilling
Jigs, supports
Product design
Drilling process
Accessability
One step drilling
Tools, machines
Work sequence
People
Motivation
Training
Time Pressure
Instructions
Quality awareness
Equipment
Maintenance & tool exchange
Calibration
Measurement Equipment
Accuracy, precision
Vibrations
Drilling machine
Speed
Feed
Geometry
Tolerance
Cutter
Wear
Sharpness
Lubrication
Hole Quality
Position
Surface roughness
Diameter
Normality
Countersink
Thickness deviation
Part deformation during assembly
Tolerances single parts & pre-assemblies
Machining tolerances
Accuracy of pilot holes & pre-holes
Positioning accuracy (absolute & relative)
Operator/ Machine
Use of tripod
Drilling normality
Use of normality assurance system
Temporary fastener head
Referencing accuracy
Operator/ Machine
Temporary fasterners
Positioning jig
Repositioning parts after disassembly
Tolerance Chain
Open hall doors
Temperature
Light
Air pressure for machines
Environment
Hardness
Alloy
Material
Variation in thickness
Cutter
Wear
Coating
Material

‘People don’t want to buy a quarter-inch drill, they want a quarter-inch hole.’

Theodore Levitt
Economist and professor at Harvard Business School

Drilling in aerospace assembly is one of the most important stages. Because the quality of the hole will affect all subsequent steps. Therefore, the more accurate the drilling is, the better the quality of the aircraft. The drilling process consists of 5 stages.

Drilling processes in aerospace

Drilling	Reaming	Countersinking	Boring	One-shot Drilling

Drilling is done in 3 different ways.

Robotic systems

25%

High throughput and production efficiency
Lower manufacturing cost
No operator dependency

Positive feed drill

40%

Areas which can’t be fully automated.
Generally for holes above ¼ and deeper stacks.
Irregular shapes and cramped spaces.
Limited operator dependency

Hand held drill

35%

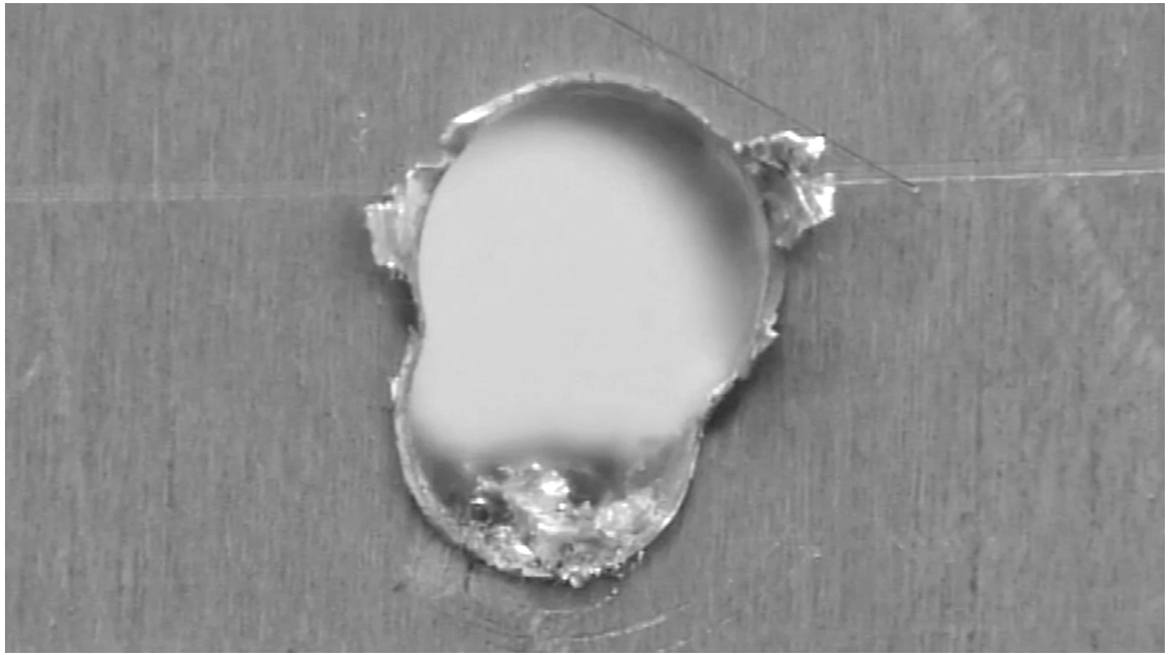
Areas which can’t be automated.
Mainly for small holes and thin stacks.
Irregular shapes and cramped spaces.
High operator dependency.

Problem Analysis

Finding location of buried fastener holes

Tolerance analysis of interest is the risk for so called “snowman” holes.

This phenomenon describes double holes that can occurduring drilling back from the outside (secondary drilling) due to normality deviations or hole mismatch because of jig tolerances after re-connection of the fuselage or if non-transferred pilot holes in the couplings.

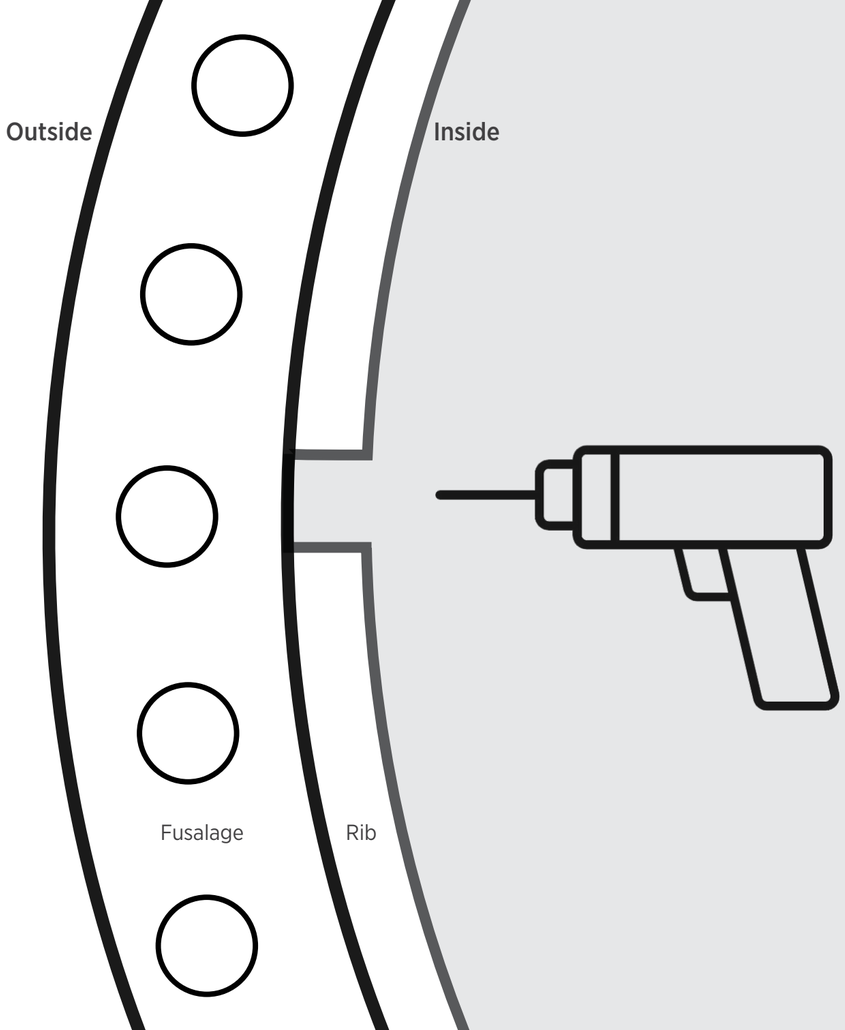


What is buried fastener holes ?

Buried fastener holes occur during the assembly of the rib with prehole and skin with no prehole.

To assemble the rib and skin, back drilling is done from the inside of the fuselage.This transfers the prehole from the rib to the skin.

The process is done manually. Requires alignment Time consuming and requires highly skilled operator.



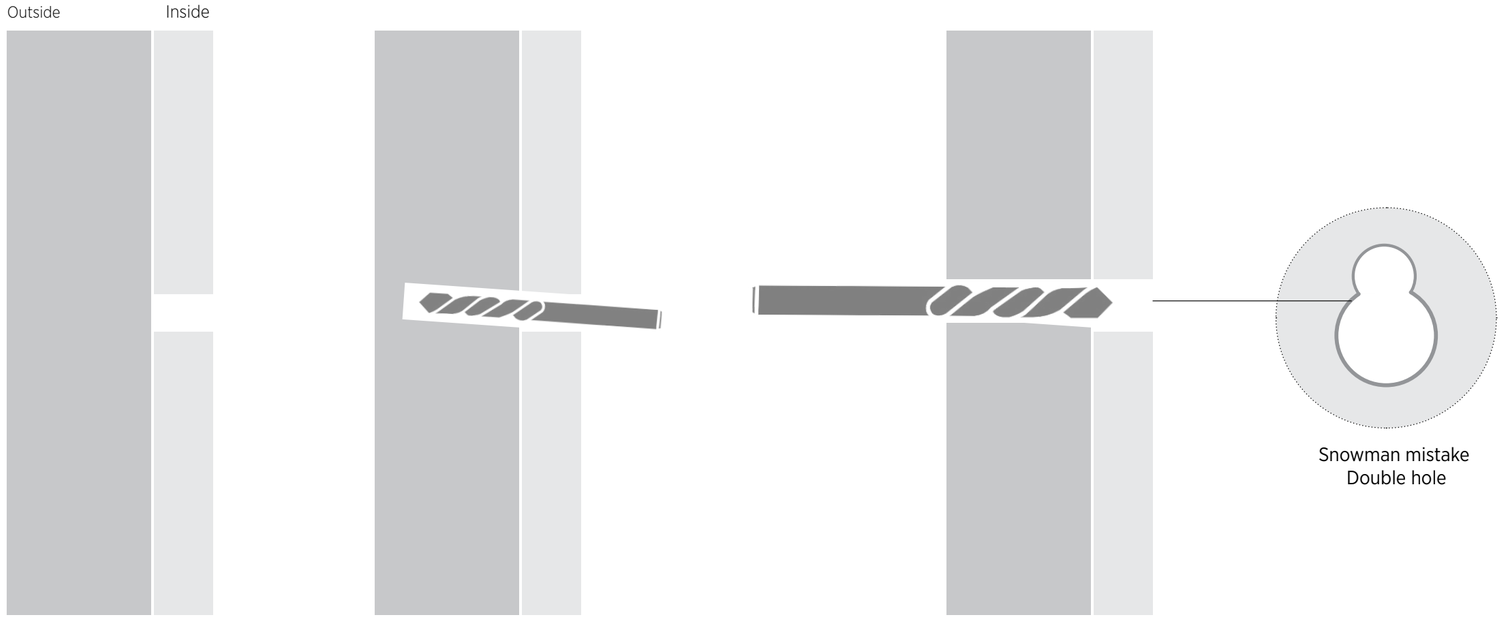
Back Drilling

Snowman Risk

Another tolerance analysis of interest is the risk for so called “snowman” holes. This phenomenon describes double holes that can occur.

- During drilling back from the outside (secondary drilling) due to normality deviations or hole mismatch because of jig tolerances after re-connection of the skin.

- If non-transferred pilot holes in the couplings and the drilled hole through skin and coupling (one step drilling into full material) do not match properly due to hole mismatch after re-connection, pilot hole position variations according to the tolerances specified in the design and the robot’s positional accuracy of the fuselage.



Prehole in rib

Back drilling through prehole

Redrilling from outside

Very difficult to drill from inside.

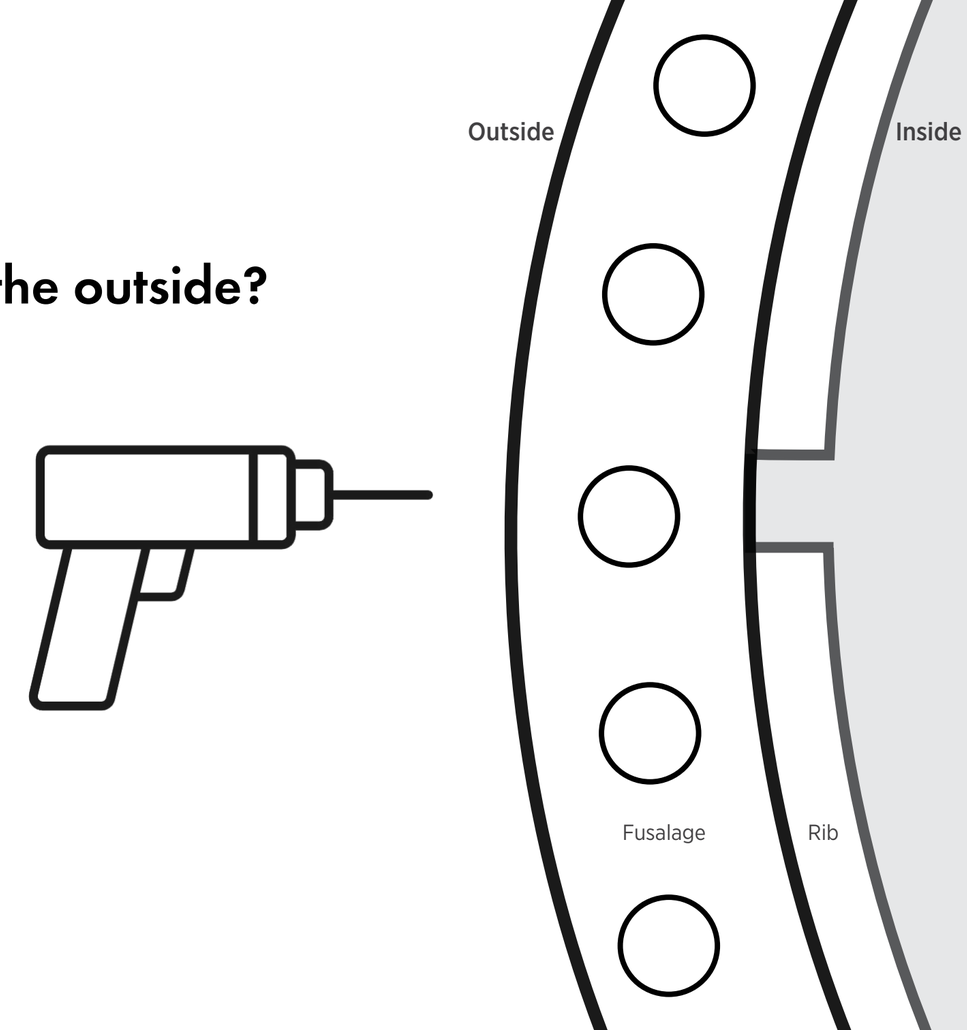
As a result, it is very difficult due to the limited space, awkward positions, darkness, heavy - big tools, lying on uneven surfaces that will puncture holes from the inside.

For this reason, I started to look for solutions that could do the job one-shots from outside.

Pain Points

- Limited space
- Awkward Positions
- Darkness
- Heavy - Big tools
- Lying on uneven surfaces

What if we can do the back drilling from the outside?



Drill position targeting systems

HALOSENSOR (AVX Electronics)

I found the halo system when I was looking for solutions to one-shot drill from the just outside. This product is a solution that opens the hole only from the outside because it is very difficult to open the hole from the inside as seen on the previous page.

The Halosensor, is using for the problem of accurately finding a pilot hole or feature through the skin in aircraft structure.

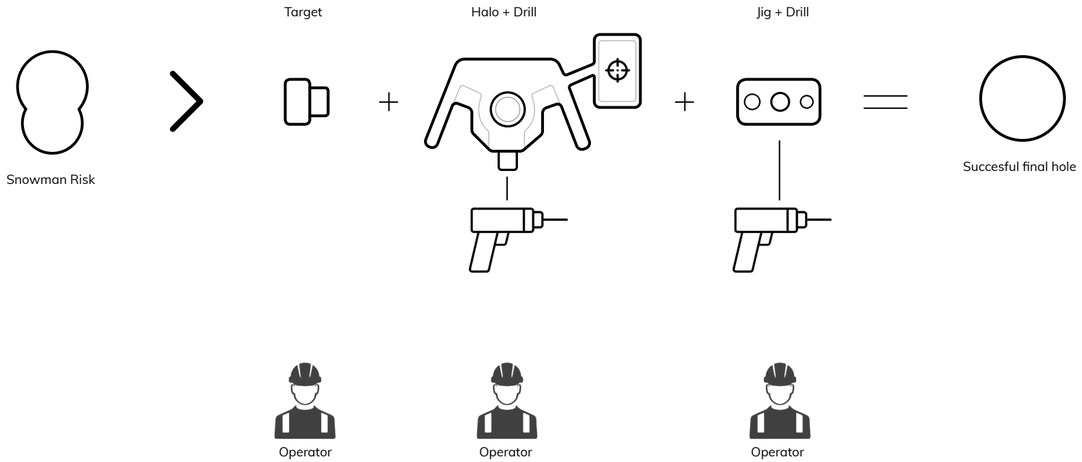
In detail this product developed as an answer to the problem of accurately finding a pilot hole or feature through skin in aircraft structure assembly. It works through aluminium, carbon composite, titanium or any other non-ferrous materials but some grades of stainless steel can also be located using special targets.

Finding the internal pilot hole from the outside skin gives accuracy advantages over traditional back drilling methods and eliminates the costly pipped hole or oval hole issues that have plagued the industry for many years.

Problem

Halo Workflow

Solution

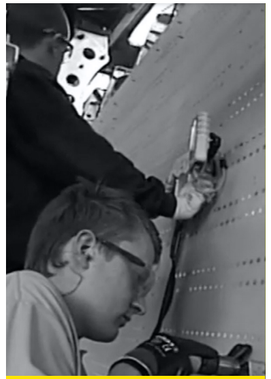


Painpoints

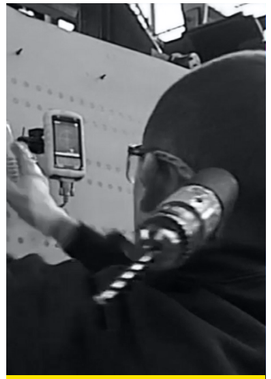
Although the product is a solution for back drilling, there are many pain points as you can see in the workflow.

- Inefficient worker supply
- Time-consuming
- More efficiency
- Holding the sensor
- Operator has to find the exact position
- Extra tools
- 4 steps for one hole
- Risk of material damage

Amount of operators



Hardware units



Product volume

How could we improve the finding of buried fasteners holes and delivery of the prehole from rib to skin

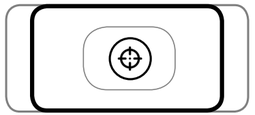
Concept

Problem

Solution

Snowman Risk

Target + Pre-Drill + Jig + Final Drill



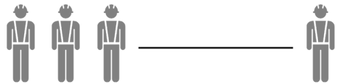
All in one

Succesful final hole

Operator

Moduler and Smart

Reduce the Amount of Steps



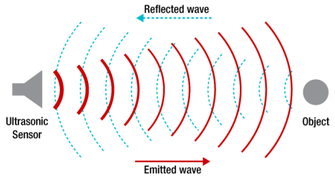
Increased accuracy

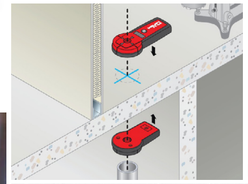
Easy and fast workflow

Technology Research

Ultrasonic testing is an NDT technology for detecting test piece discontinuities which may not be visible to the human eye. These defects can include cracks, corrosion, inclusions, porosity outside of specified tolerances, and voids.

Ultrasonic testing devices pass ultrasonic sound waves into the test piece and measure the waves that reflect back to the device. The profile of the reflection is interpreted by software and the human operator to determine if the test piece is within spec.





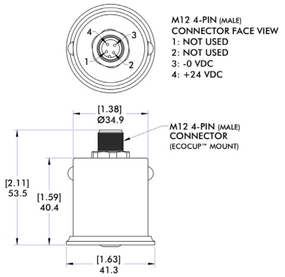
Inbuilt drill drill tech

The size of ultrasonic technology today.

Modular drill heads

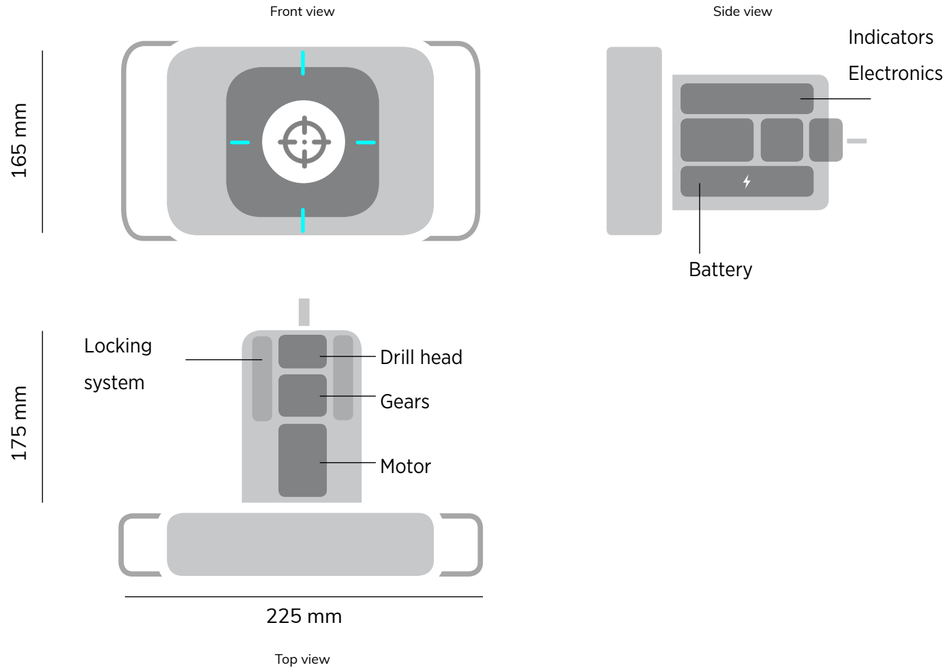
Perpendicular Guidance

Electric Vacuum Technology

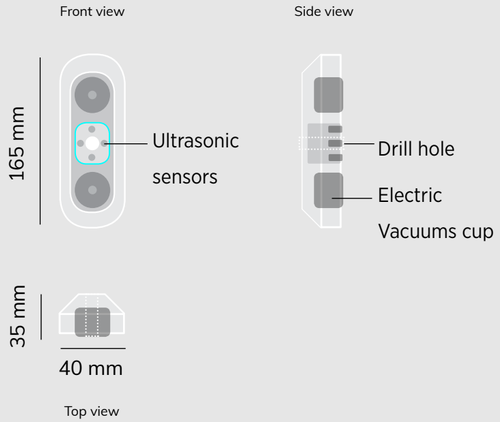


Technical package

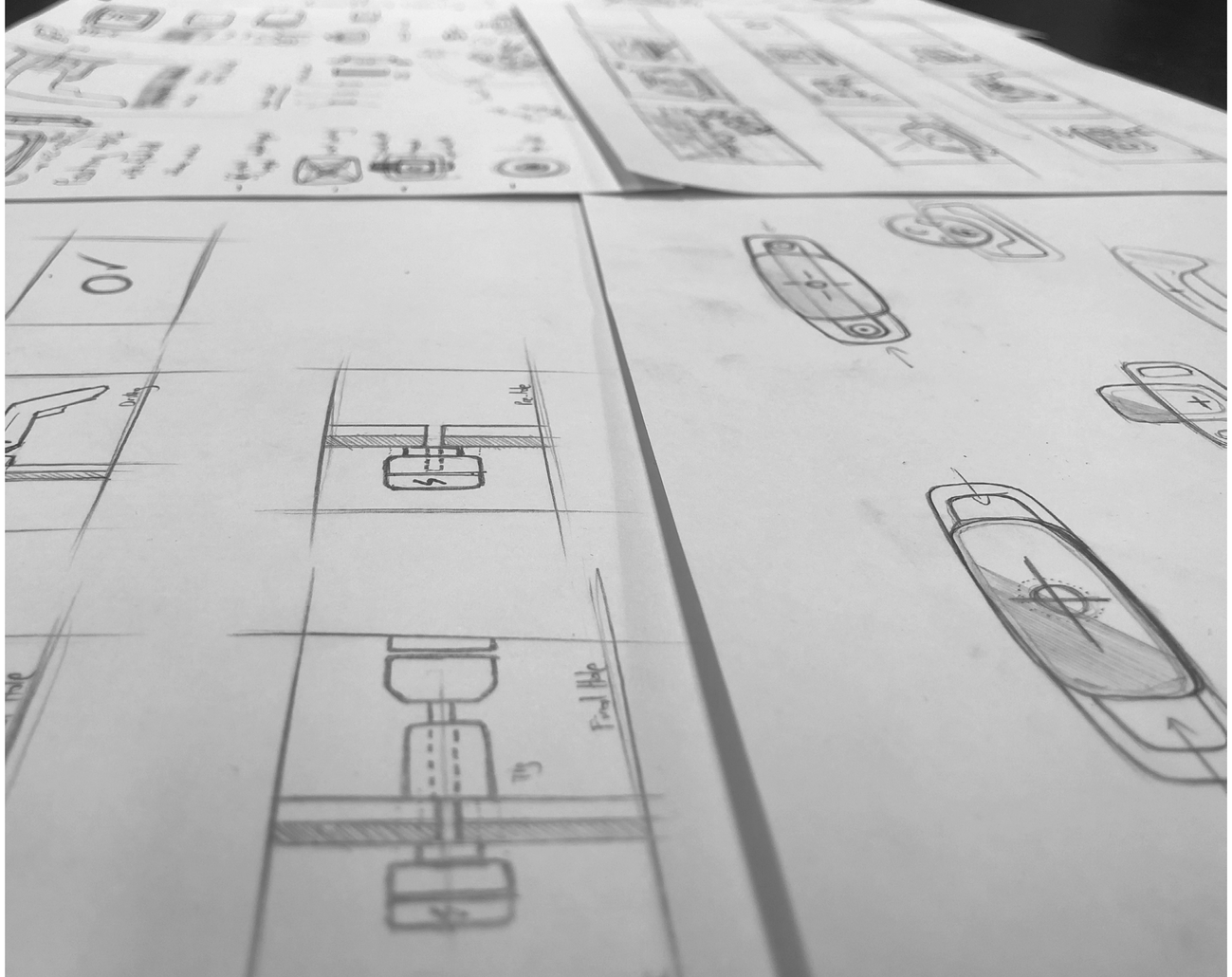
Drill Unit



Targeting Unit



CONCEPT 05
Creative Process



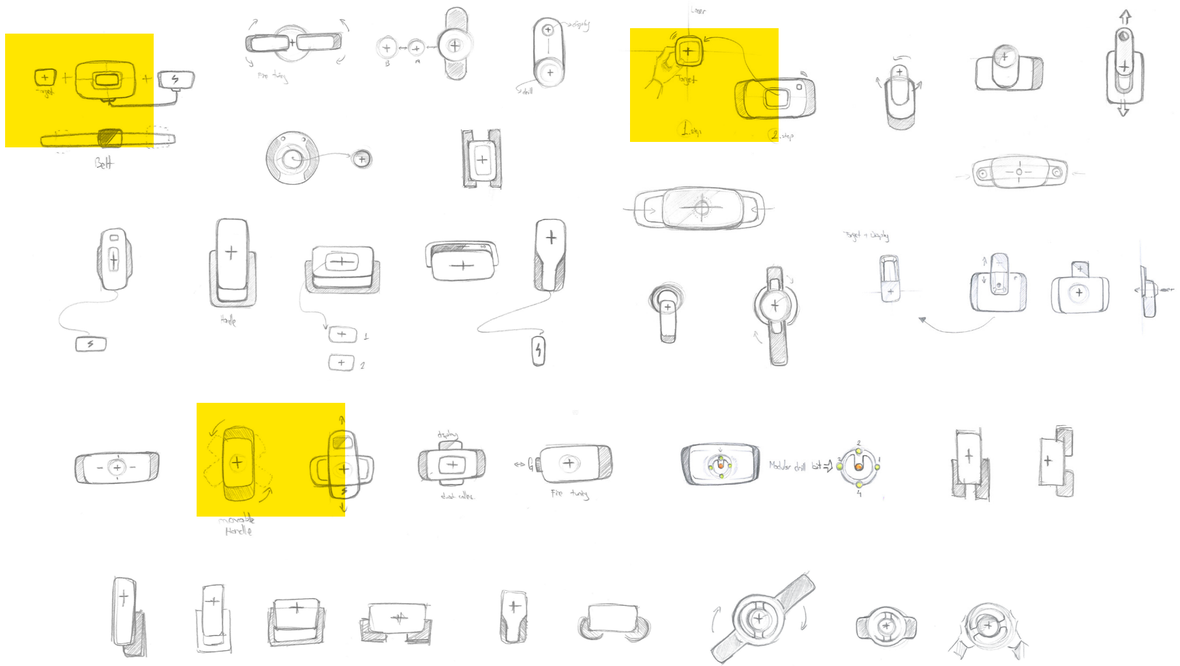
DTS 01
Drilling Targeting Systems

The main purpose here is to create a new tool which combines the three steps of finding the correct position. It should also become modular and smarter to help the operator to find the precise location faster and easy.

Benefits

- Increased accuracy
- Less human errors
- Less time consuming
- Better ergonomics
- Better guidance
- Less Tools
- Less operator

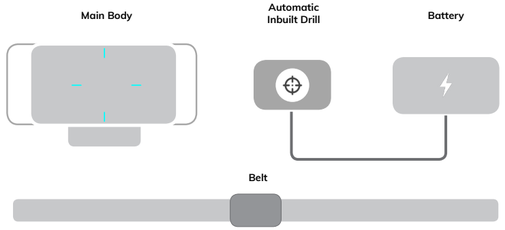
Concept **Sketches**



The concept is basically the separation of the 2 main modules, first lightening the target part and making it easier to scan and find the hole. Then use the automatic main drilling module to open the hole.

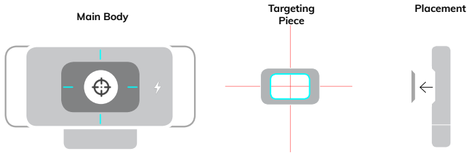
Technical Package 1

In the first proposal, heavy sections can be separated and carry on the belt so the main module can be lightened for scanning.



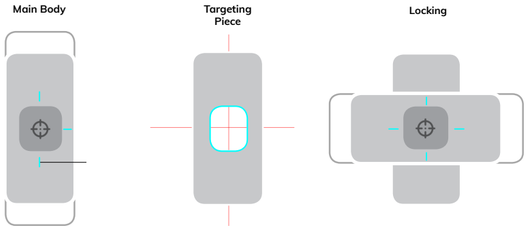
Technical Package 2

In the second opinion only the targeting part is separated from the main body for scanning. After the blind hole is found, it is locked on the surface and then the drilling unit place on targeting piece and the hole is opened.



Technical Package 3

In the third concept, the targeting part is divided larger and part of the main body.In addition, the male-female lock is considered for locking.



Separating products

Quick Mock-ups

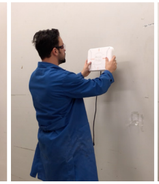
Role-play - Ergonomics - Weight test

At this stage, it is aimed to determine the right ergonomics and form. Many ergonomics and weight tests were conducted via quick mockups.

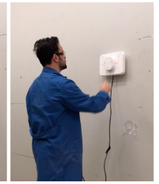
It was also role play was very useful in the development of ideas because many mistakes and needs were noticed during the acting. So I got new information that could improve ideas.


Placing products on the belt


Going to the workspace

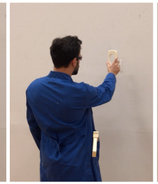

Buried hole scanning


Attached the drill to the main body


Pressing the button for drilling

1 2 3


Taking targeting unit from the pocket


Buried hole scanning


Locking the targeting unit to the surface


Locking the drilling unit on the target unit


Taking targeting unit with drill unit.

1 2 3


Taking target piece from a box

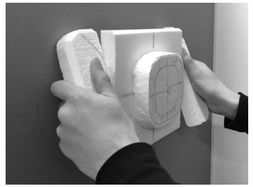

Buried hole scanning and surface locking

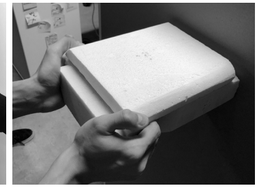

Taking main body from a box

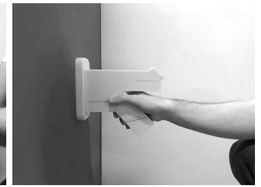

Locking on the target piece.


Pressing the button for drilling

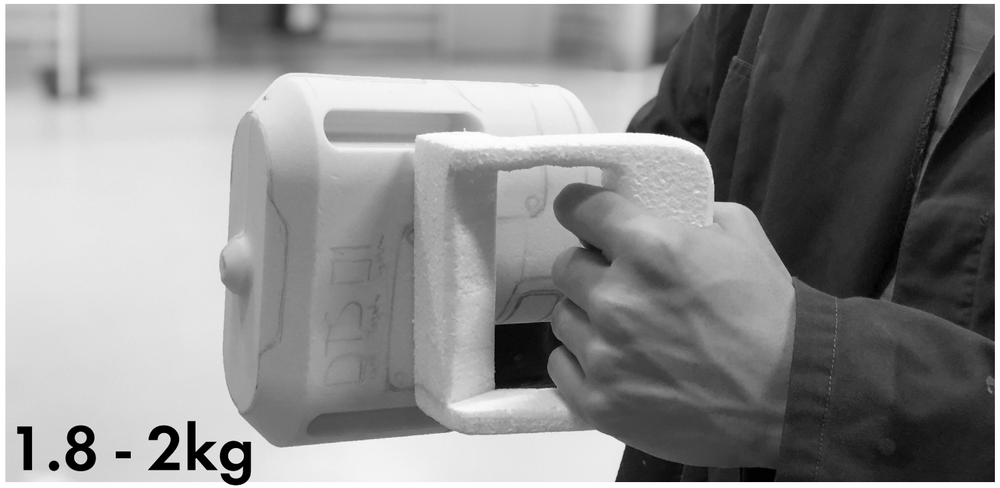
1 2 3







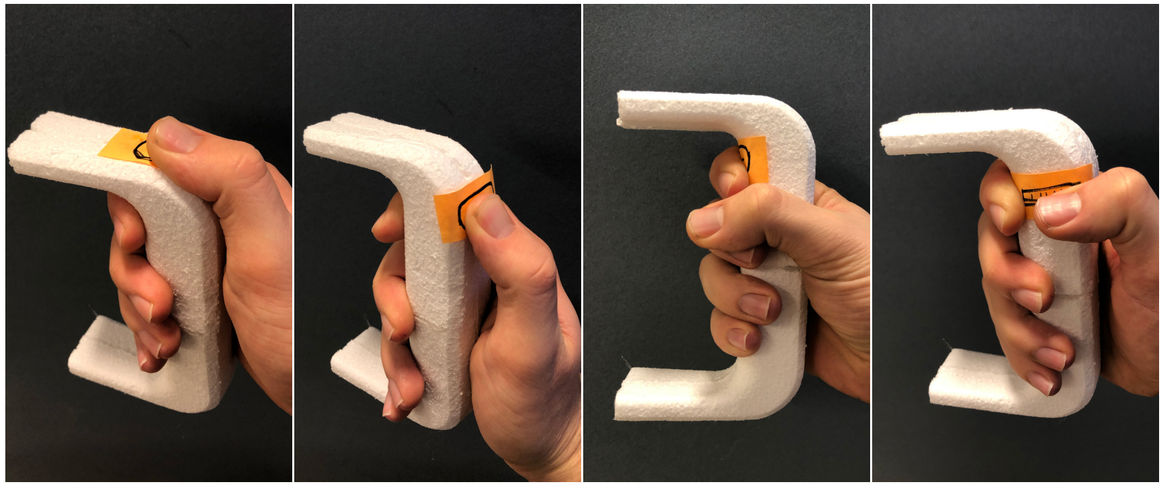
Weight Mock-up



Approx. 1.8 - 2kg

I discovered the position of the center of product and the position of the handles by putting metal pieces into the foam model I made. I also come to the conclusion that the product must have 2 handles and close to the center of gravity as much as possible.

Interaction Mock-up



I experimented on the handle to see the interaction with the on-off button.

Critical questions

Thorsten Roye (Airbus)

At the end of all the tests, I had some questions especially in my role play and the answers to the questions would shape the final design.

That's why I contacted with Thorsten Roye (Airbus) and found the answers to my questions and finalized my concept by adding them to my initial concept.

How often use back drilling?

In the wing box assembly approximately 50%

What are the hole size pre-hole and final hole? (rib-Fusalage)

3,3mm, than 4,8 or 5,6mm

What is the thickness of fusalage?

1,6mm-10mm

Final Concept

Should be light
Fast work flow

- %50 of the assembly

Should be Flexible and Moduler

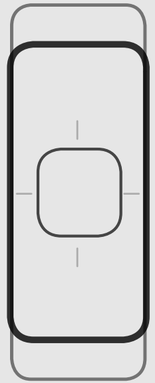
- Curve surfaces
- Different size of drill bits
- Different angles

Drilling takes 2-5 second max

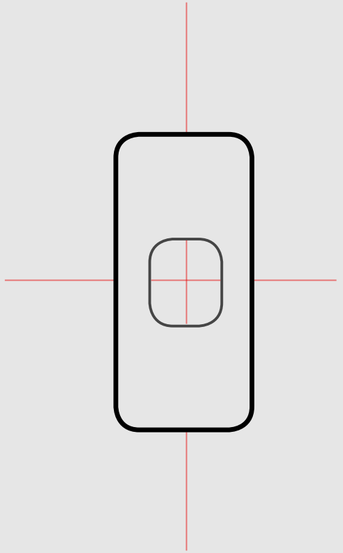
- Drill does not need to be locked on surface

+

Technical package 3



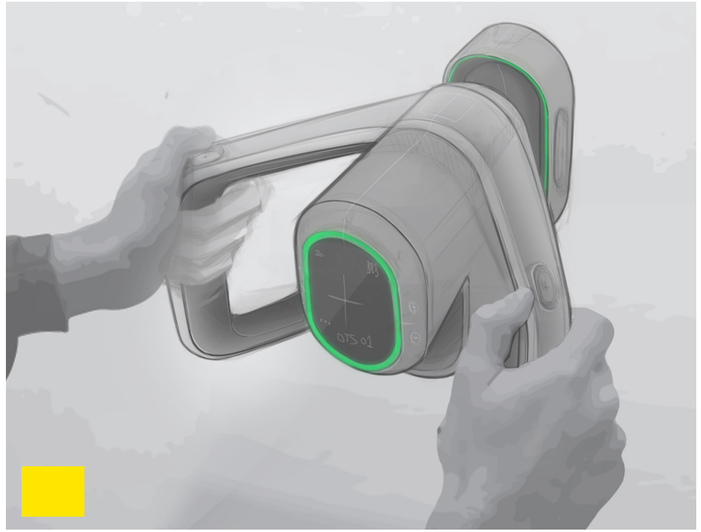
Autonomous Drill

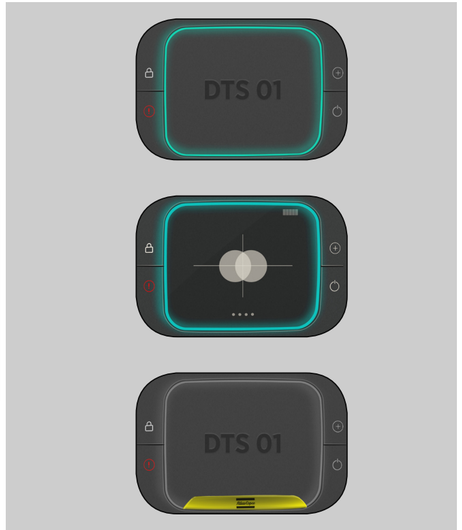


Targeting Piece

Quick Renderings

Form Development





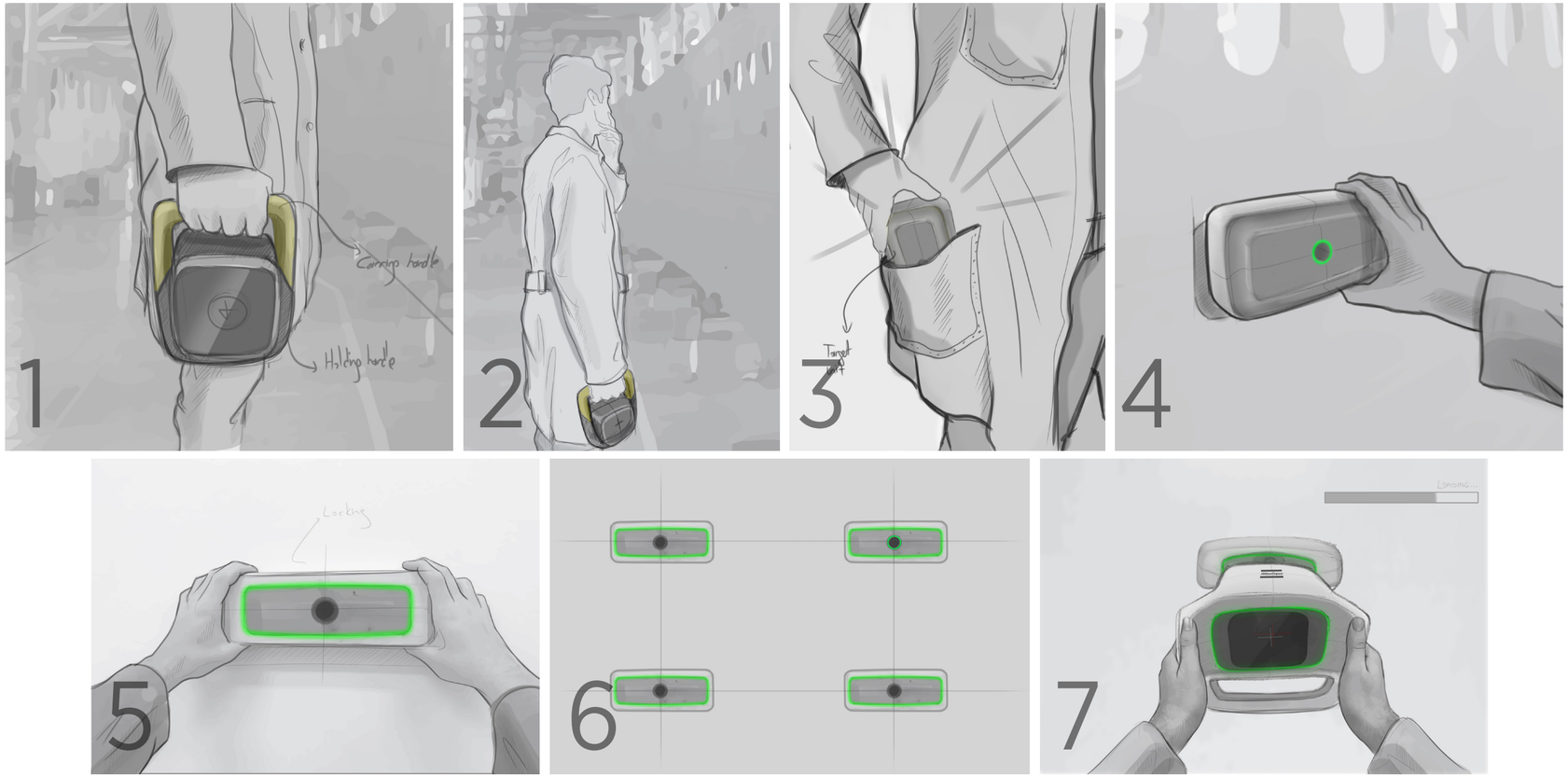
Interface and display

Storyboard

Final Direction

1 Going to the workspace

2 Detecting approximately the area
3 Taking targeting unit from the pocket
4 Buried hole scanning
5 Locking the targeting unit to the surface
6 The other operator can lock the targeting units on the surface and only the drilling operation remains.Thus, the process can be made faster.
7 Holding the drilling unit and pressing button for drilling.



Design Language

Minimalistic

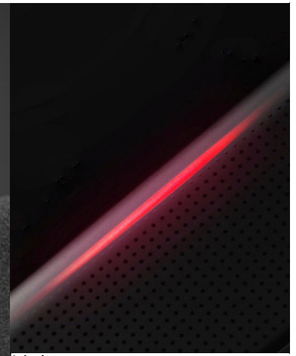
Transparency

Powerful

Soft

Innovation

Accuracy

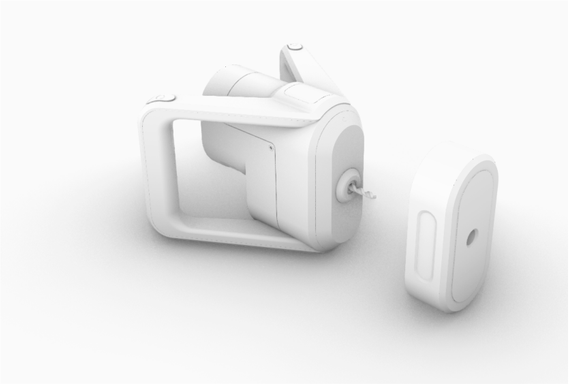


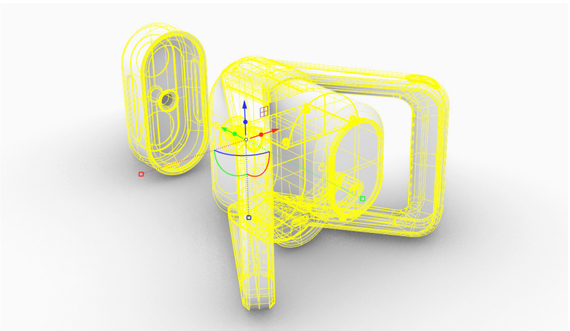
Lights

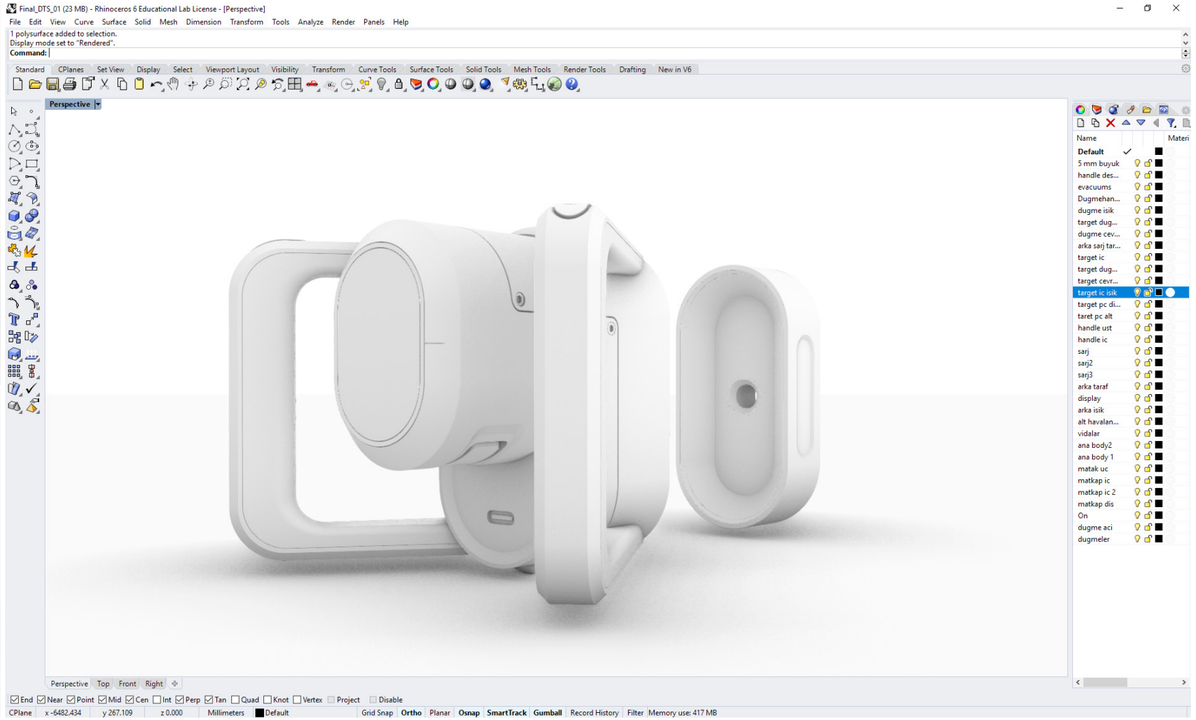
CAD Development

I started the CAD work at an early stage to test out mechanical principles. It also helped me a lot with working sizes to understand the product.

Cad software Rhino was used to translate the latest mock-up into a 3D digital environment.

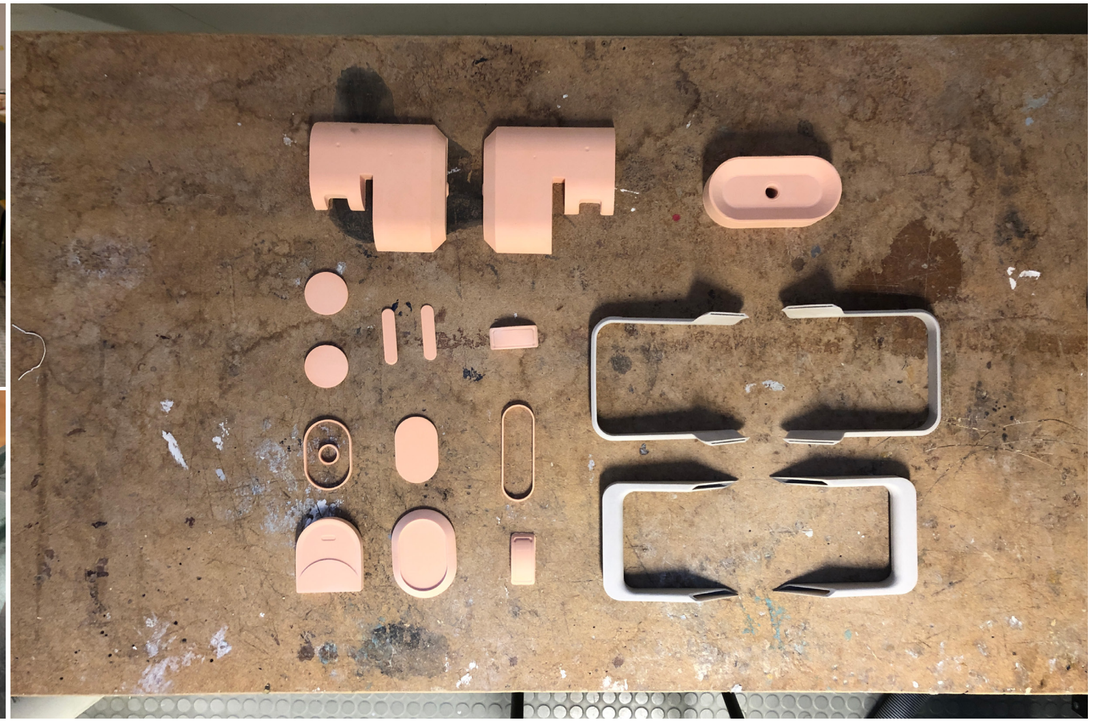






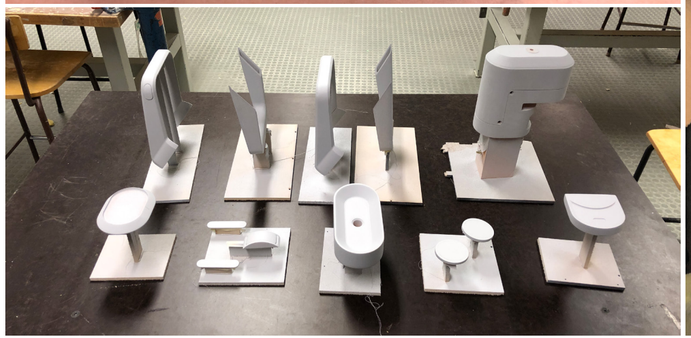
Model Making

Once the design was finalized a presentation model was printed-milled and assembled for exhibiting. Colors, branding and finishing were matched with our collaborating partners Atlas Copco ‘s current range.



Model Making

This model served as a valuable tool when explaining the concept to others during the exhibition.



DESIGN 06

DTS

Drilling Targeting Systems

DTS 01

Drilling and Location Targeting Systems

Next Generation Aerospace Assembly

DTS is the new innovation aimed to solve the problem in the aerospace assembling. More specifically it focuses on fuselage and ribs connection. My concept purpose to speed up the workflow and reduce the need to the extremely skilled operator. DTS reduce human error and it enhances accuracy rate in the assembling progress.

DTS 01

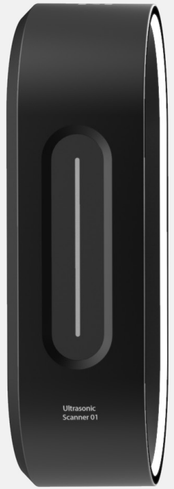
BENEFITS

- Increased accuracy
- Less time consuming
- Better ergonomics
- More efficiency
- Torque adjustment
- No need for Skilled operators
- No material damage
- Less amount of operators

Design consists of two main parts targeting and drilling unit.

The targeting part is small and lightweight, making it easy for the operator to scan and find the buried hole.

Targeting unit



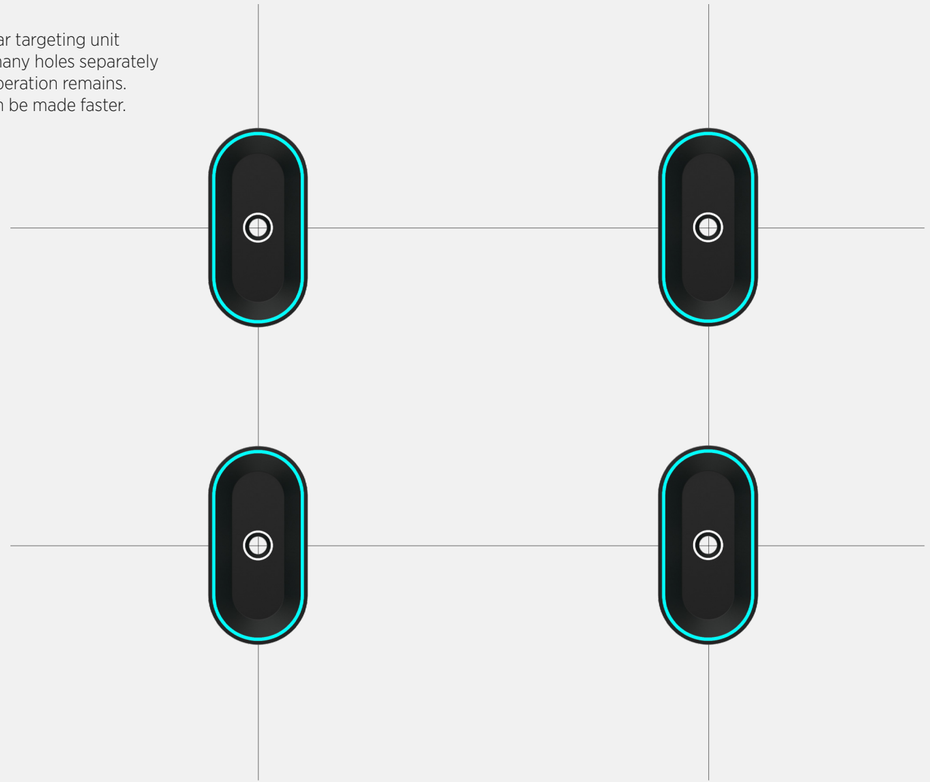
Drilling unit

DTS 01 Targeting Unit

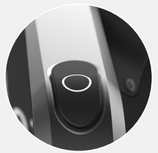
Ultrasonic targeting unit pass ultrasonic sound waves into the fuselage and measure the waves that reflect back to the device. This determines the position of the buried hole.

Multiple target units.

In addition, the modular targeting unit can be pre-locked in many holes separately and only the drilling operation remains. Thus, the workflow can be made faster.



DTS 01 Drilling Unit



Drilling start button

Emergency stop !

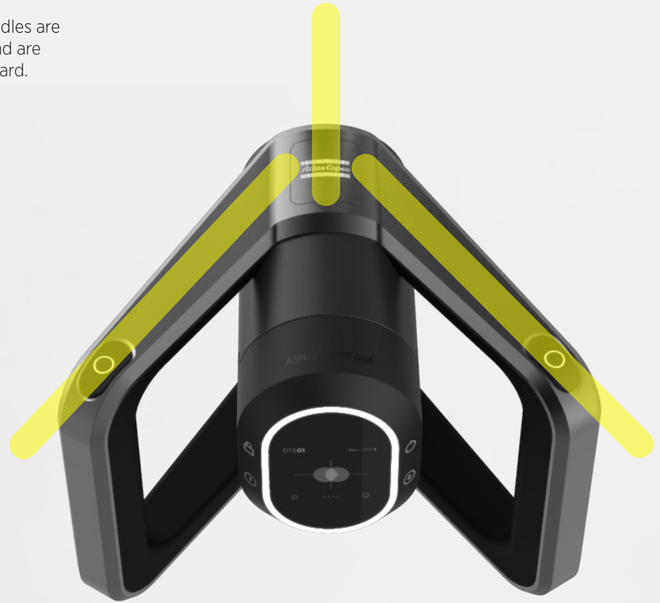
When light turns from white to red it means an emergency.

Display

Charge input

Ergonomics

The angle and position of the handles are located in the center of gravity and are positioned to guide the user forward.

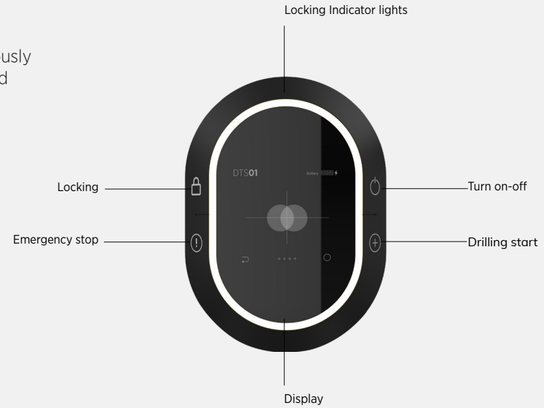


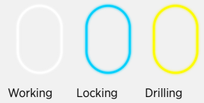
In addition, the soft inner form of the handle and rubber on the inner surface provide a more robust and non-slip grip.

DTS 01 Drilling Unit

Display

The process can be monitored continuously via display and can be directly interfered when any problem is seen.





Drilling !

Locking !

Ready to drill !

DTS 01

Drilling and Location Targeting Systems

Next Generation Aerospace Assembly

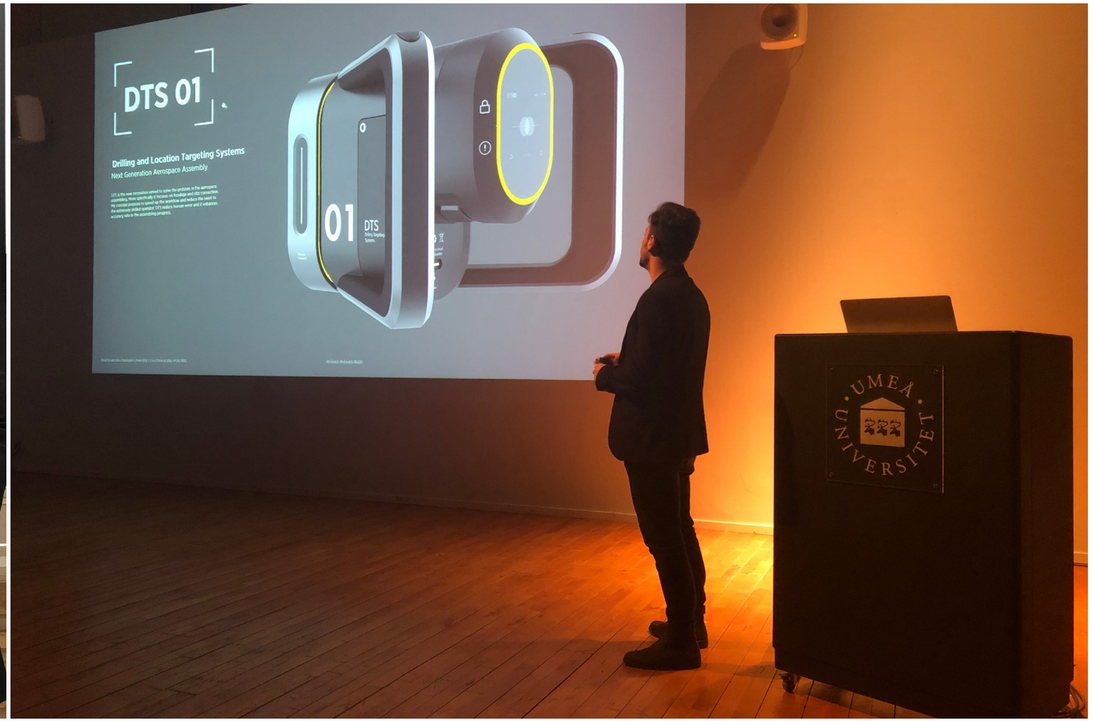
DTS is the new innovation aimed to solve the problem in the aerospace assembling. More specifically it focuses on fuselage and ribs connection. My concept purpose to speed up the workflow and reduce the need to the extremely skilled operator. DTS reduce human error and it enhances accuracy rate in the assembling progress.

Atlas Copco

CONCLUSION 07

Presentation

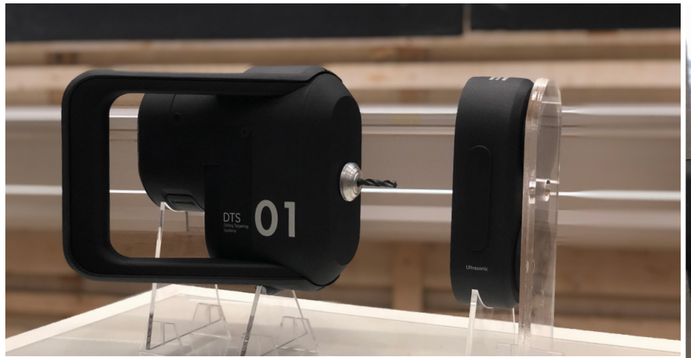
The final presentation was held at the Umeå Institute of Design on the 24th of January 2019. Representatives from Atlas Copco gave feedback on the concepts that we had developed during this 10 week project.



Reflections

I was very excited at the beginning of the project because the aerospace assembly was a very interesting topic for both design and personal curiosity. It was also difficult because the aircraft assembly was completely new to us and we had to learn a lot of information about the subject in a short time before jump into ideation, but then things went fine and I was very happy at the end of the project and learned a lot.

I think I added a lot to myself during this project. Especially in a short time, such as the aerospace assembly to discover new areas and developing ideas. At the beginning of the project I reached almost all of my goals and wishes. At the end of the project, It was nice to get positive feedback from the Atlas Copco team both as a visual form and as a concept.



The model in scale 1:1

Ola Stray
Head of Industrial Design & UX
at Atlas Copco

Thorsten Roye
ME Expert for Fastening Systems at
Airbus

REFERENCES

If a picture is not listed it was either taken or produced by study collague of mine or myself.

Pictures

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TIME TABLE

Week-by-Week