Sensur av hovedoppgaver
Høgskolen i Buskerud
Avdeling for Teknologi

HØGSKOLEN i Buskerud

Prosjektnummer: 2011-8
For studieåret: 2010/2011
Emnekode: SFHO-3200

Prosjektnavn
JSM Air Intake Cover & Wing Support System Release Mechanism
Utført i samarbeid med: Kongsberg Defence Systems

Ekstern veileder: Trond Henning Sleveland

Sammendrag: Dette prosjektet omhandler å ta frem ett eller flere konsepter for fastholding og utløsing av deksel, basert på krav og retningslinjer gitt av KDS.

Stikkord:
- Release Mechanism
- Missile
- Concept

Tilgjengelig:DELVIS

Prosjekt deltagere og karakter:

Navn	Karakter
Marius Tøien	
Morten Brodahl	
Øystein Ellefsen	
Raymond Evje	
Lars Meskestad	

Dato: 30. mai 2011

Jørn Breivoll	Olaf Hallan Graven	Ivar T. Hoelsæther	Trond H. Sleveland
Intern Veileder	Intern Sensor	Ekstern Sensor	Ekstern Veileder

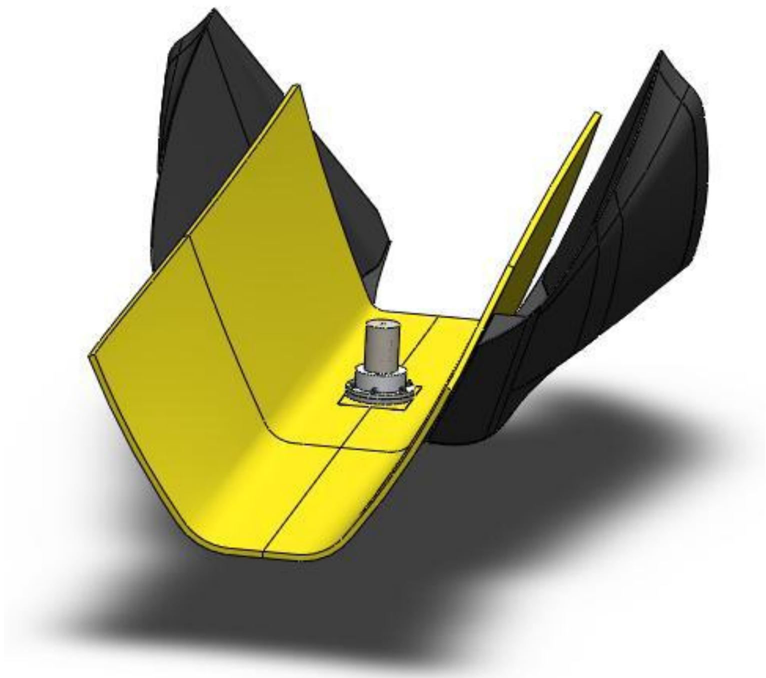
KDS/ GROUP 8

Project Report

JSM Air Intake Cover & Wing Support System Release Mechanism

Øystein Ellefsen, Morten Brodahl, Marius Tøien, Raymond Evje and Lars Meskestad

30.05.2011



Contents

KDS/ GROUP 8

PRELIMINARY STUDY

JSM Air Intake Cover & Wing Support System Release Mechanism

Lars Meskestad , Morten Brodahl , Raymond Evje , Øystein Ellefsen and Marius Tøien

15.03.2011

This document contains planned progress, info regarding our employer, description of the project assignment and a risk analysis of the project

Contents

1. Introduction

1.1 Abbreviations

MB	Morten Brodahl
ØE	Øystein Ellefsen
MT	Marius Tøien
LM	Lars Meskestad
RE	Raymond Evje
KDS	Kongsberg Defence Systems
KDA	Kongsberg Defence and Aerospace
HiBu	Høgskolen I Buskerud

Table 1: Abbreviations

1.2 Purpose of Document

This document is meant to evaluate if this assignment suits us as a project group. It also contains information about future work on this project.

1.3 Document Version

Document version	Date	Activities	Author
1.0	04.11.2010	First draft	Group
1.1	18.11.2010	Changed project model	MT
1.2	18.11.2010	Revised Gantt diagram	LM /ØE
2.0	18.11.2010	Second draft	Group
2.1	15.03.2011	Update Document due to updated template	MB
3.0	15.03.2011	Third Draft	MB

Table 2: Document Versions

1.4 Related Documents

Document Name	Description
Project Plan	Overview of the project

Table 3: Related Documents

2. Background

2.1 Group members

The group consists of five machine engineering students from Høgskolen i Buskerud. All members are about to complete their final year in their bachelor studies. All group members have the same education with slight differences in some subjects.

Lars Meskestad (Project leader)
Age: 26
E-mail: lars.meskestad@gmail.com
Phone number: 93424867

Marius Tøien
Age: 24
E-mail: marius.toien@gmail.com
Phone number: 97086587

Raymond Evje
Age: 24
E-mail: raymond.evje@gmail.com
Phone number: 99746320

Øystein Ellefsen
Age: 26
E-mail: ellef84@hotmail.com
Phone number: 93210071

Morten Brodahl
Age: 27
E-mail: morten.brodahl@gmail.com
Phone number: 46501350

2.2 About Kongsberg Defence Systems

Picture 1: Kongsberg Group Logo

Kongsberg Defence Systems (KDS) is a part of the Kongsberg Group, previously known as Kongsberg Våpenfabrikk (KV). KV was founded in 1814; the same year as Norway was given they're constitution. Kongsberg Våpenfabrikk played an important role in Kongsberg's development after World War II. Between the years of 1960 and 1987 the company went from focusing on mechanical production in offshore, aircrafts and space related systems. 1987 was also the year KDS (formally known as Kongsberg Defence & Aerospace) was founded. KDS are best known for their Penguin Missile which has been in use since the early 70s.

Today, KDS is Norway's premier supplier of defence systems and space related systems to the Norwegian Armed forces. Their systems and products cover a wide range within surveillance, communications solutions and missiles [1].

2.3 Project goals

2.3.1 The primary goal:

Find concepts for the release mechanism of the air intake cover in terms of functionality, efficiency and results.

2.3.2 Secondary goals:

- More insight when it comes to the specifications of the release mechanism and some of its surrounding components.
- Collecting data from different suppliers to know what kind of release mechanisms the market has to offer, and then immerse ourselves in the specifications.
- Perform calculations and simulations on the range of components we want to apply. Consider if the components meet our requirements.
- Testability

2.3.3 Effect goals:

Through this project the effect that the organization will achieve is; free labor, new ideas and maybe produce a prototype. In addition to these effects KDS might recruit future employees.

2.3.4 Project extent

- The project will run parallel to the organizations product.
- The project is not about the design of the cover.
- The concept will not replace an old system.

2.3.5 Consequences for the organization

The organization will have to offer us time with a supervisor to provide us with the information we need to reach our goals.

3. Challenges and needs

- Joint Strike Missile (JSM) will be positioned underneath the wing of and in the bomb bay on the F-35 Joint Strike Fighter.
- When the missile is carried under the wing during transit, the missile is largely affected by the environment.
- As a consequence to this, the air-intakes are required to be covered during this phase.
- In-flight testing reveals that the wings are subjected to a great amount of stress which induces the need to relieve forces acting on the wing-folding mechanism.
- As a result there has been produced a cover that solves these challenges.

3.1 The Cover

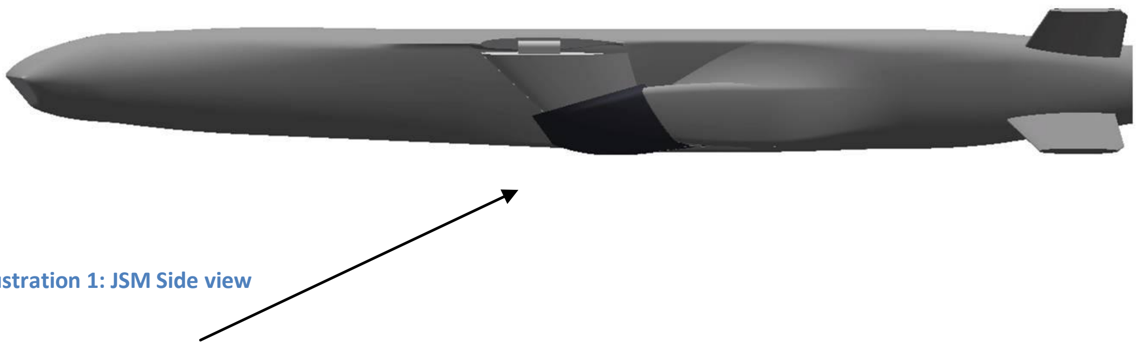


Illustration 1: JSM Side view

- The cover is held in place by a front fixing, a rear axis rotation point and the geometric outline of the air-inlets.

- When released, the cover will rotate about the rear rotation point and then separate from the missile.

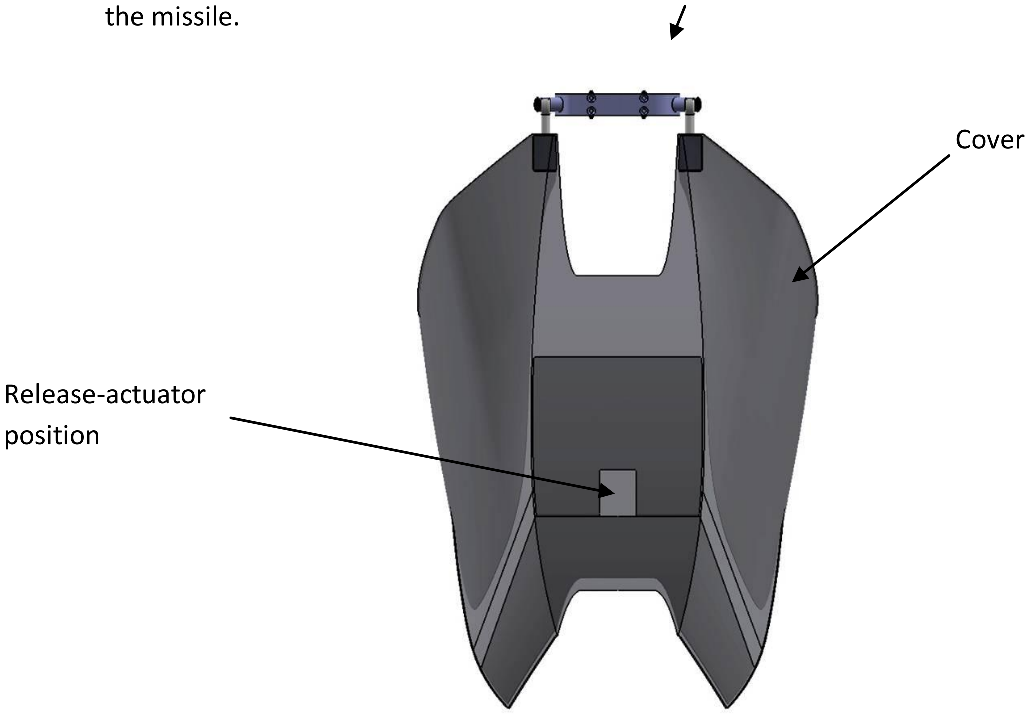


Illustration2: Cover

3.2 The Concept: The Release Actuator

3.2.1 Actuators

There are several ways to release an object and several ways to trigger the releaser. Amongst the most common, are:

- Pyrotechnical - Pin puller
- Electromechanical - Solenoid
- Thermal - Shape memory alloy

3.2.2 Project description

To produce one or more concepts on fixing and releasing the cover as described, based on the requirements and guidelines set by KDS (Kongsberg Defense Systems).

3.2.3 Key-points:

- Aerodynamic loads
- Volume
- Activation
- Low signature
- Effect
- Environment
- Assembly
- Testability

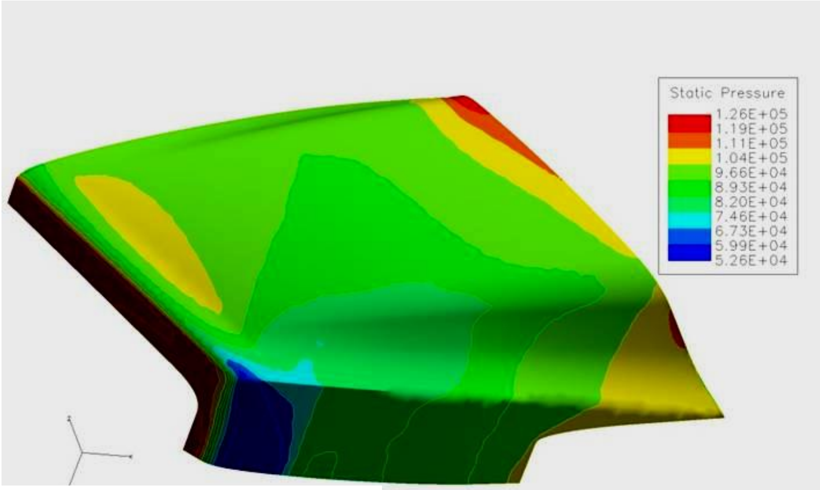


Illustration 3: Static pressure of cover

The releaser has to follow a set of criteria which involves key-points mentioned above. The ideas concerning the release of the cover are conceptual but might produce a preferable solution. It is to be said that the company is interested in new ideas in which are not influenced by existing solutions and thereby give the project a great span of ingenuity.

4. Stakeholders and regulating framework

4.1 Stakeholders

Main stakeholders in this project are:

- KDS
- Project group
- HiBU

The project will be driven by the project group which is also responsible for the final product.
The final product will be evaluated by an external sensor along with supervisors from both HiBU and KDS.

4.1.1 Success criteria

The stakeholders have different opinions of what defines a successful project. These are listed as follows:

KDS:
Create conceptual solutions taken as far as possible. A working prototype is preferable along with sufficient documentation to verify our working methods and the process.

HiBU:
Sufficient documentation on how we have solved the problem and how we have worked during the project is the basis of evaluation.

Project group:
Provide KDS with concepts and hopefully a prototype. Document everything from start to finish. If these are met, the project is considered well executed.

Stakeholder	Success criteria	Contribution to project
KDS	- Concepts - Prototype - Documentation	- External supervisor - Knowledge - Input data - Requirements
HiBU	- Documentation	- Internal supervisor - Knowledge
Project group	- Well executed project	- Responsibility

Table 4: Summary

4.2 Regulating framework

In our Bachelor thesis, the main framework will be the deadlines set by HiBU. These are:

- First presentation:
  - Early January

- Second presentation:
  - Before eastern holiday

- Deadline for all written material and third and last presentation
  - End of May

We will also set deadlines in our project plan, but these can be adjusted and are not listed here. The exact dates will be added in a later document version.

5. Project organization

We have yet to decide the individual roles of the project group. We have decided that Lars Meskestad is our group leader and will have the responsibility to be our contact outwards, this means setting up meetings with internal and external supervisor etc. He will also have the superior responsibility of the project progress.

We have chosen to use an evolutionary incremental model in our project, mainly because we do not have a known case to work on and will learn as we go. This will lead to a better understanding of our problem. We have to constantly make changes in the requirements, which mean we have to work in an iterative way to refine our concept(s). To ensure quality and reliability within our concepts we have decided to use Robust Engineering as our systems engineering method.

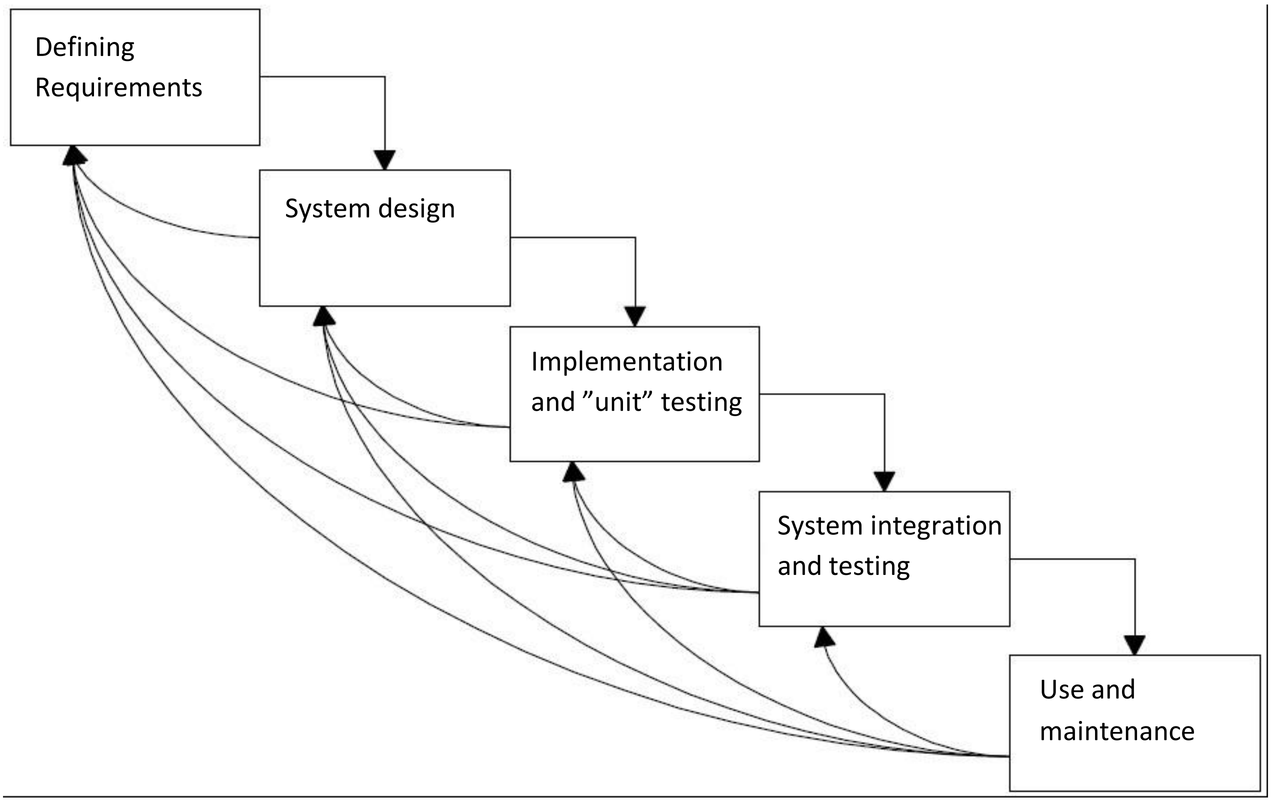


Illustration 4: Evolutionary Incremental model

5.1 Competence

This project requires competence outside our mechanical field, where we will rely on the expertise of KDS and self study. KDS has given us confirmation that we will receive any help needed.

5.2 Amount of work

Each student is expected to use approximately 650 hours on this project. About 100 of these are spent on administrative and planning purposes before project startup. Work on solutions and realization of the project plan will take place during spring semester.

6. Guidelines and standards

6.1 Documentation requirements:

- Summary of every meeting with supervisors has to be submitted to every participant within 24 hours after meeting.
- Saved copy of every version of the documents.
- Work schedule for every group member.
- Final project has to be submitted as a report and all written documents in all their versions shall be handed in on CD, within the end of May.
- Every electronic document must be in .otd or .pdf

Documents that needs approval from our supervisors, or documents that need updating will be updated continuously. Changes done will be noted in the "Document version" section of the document.

6.2 Presentation requirements:

- Contents of the presentation must be handed to supervisors 72 hours before presentation.
- First and second presentation has to last 20 minutes.
- Third presentation has to last 40 minutes.
- Project group has the responsibility of booking rooms and send out invitations to participants.

6.3 Standards:

We have not decided all the standards in the project, as we have not signed a contract with KDS yet. If this preliminary study is approved we will discuss standards regarding document formats and technical standards etc. This will be added in this document in a later version.

7. Risks and evaluation

7.1 Pros and cons

This is a short analysis describing the pros and cons considering starting the project or not.

7.1.1 If we do not start the project (cons):

- We need to look for an alternative project
- The new project might not be suitable for us
- We get less time to prepare the first presentation
- The employer needs to be informed that we are not going to start the project
- We must establish a new relationship with a new company

7.1.2 If we start the project (pros):

- We get an interesting assignment in an ongoing project
- We get an assignment relevant to our field of competence
- Contact the employer and inform them that we are starting the project
- We must sign a contract with the employer
- We will meet with the employer to discuss the demands and further cooperation with the company regarding the assignment
- Prepare the first presentation

7.2 Risk analysis

For a project of this size, there is an advantage in analyzing most of the known risks before starting it. Below we have listed and rated the risks and divided them into groups. All groups (General, Project Specific, Involuntary, and Voluntary) are highlighted and the risks are listed with grades from 1 to 4 with following descriptions.

7.2.1 General Risks

- The project group misunderstands/ misinterprets the requirements:
    - **Probability**: **2**
      A large amount of requirements increase complexity.
    - **Consequence**: **3**
      Creates unnecessary re-work and is very time-consuming.

- Difficulties in acquiring the right resources and competence to solve the problems:
    - **Probability**: **1**
      There are only machine engineering students in the group, but the project does not require a lot of competence in other fields than mechanics.
    - **Consequence**: **3**
      If the requirements suddenly changes and/or electronics or programming is required we need additional competence.

- Flaws on, or prototype delivered past due-date (If relevant, we have to plan this early in the project):
    - **Probability**: **2**
      If we order parts for a prototype and it fails to be produced before we are supposed to hand in the assignment, or it has significant flaws. Prototype is not a requirement.
    - **Consequence**: **3**
      If the prototype or test is not ready for the project hand-in, we waste a lot of time and valuable info.

- The requirements in the project changes several times:
    - **Probability**: **3**
      This happens in almost every project since all requirements are not revealed right away. Other problems might occur along the way. Minor changes and adjustments are usually easy to make.
    - **Consequence**: **2**
      Setbacks cause demoralization in the group.

- The project is not extensive enough:
    - **Probability**: **1**
      The employer has stated that the project is flexible as they want more than one solution and maybe some tests.
    - **Consequence**: **3**
      It will affect our final grade negatively.

7.2.2 Project Specific Risks

- Failure to correctly simulate influences on the design:
    - **Probability**: **2**
      The employer possesses all data related to the environment the system is subjected to. This is a complex calculation and thereby vulnerable to error.
    - **Consequence**: **3**
      The design will be faulty in design and will thereby lose robustness.

- Extensive complexity in design:
    - **Probability**: **2**
      With lack of experience we might avoid this, but easy design can be more difficult to create.
    - **Consequence**: **3**
      Greater possibility of incompatibility and general flaws. Greater degree of difficulty in creating robustness.

- Failure to meet one or more key-point requirements (p.10):
    - **Probability**: **3**
      Demanding requirements and high engineering complexity.
    - **Consequence**: **3**
      Takes up space designed for fuel. The bigger the design, the less fuel it can carry.

- Failure to create more than one concept:
    - **Probability**: **2**
      KDS wants several concepts to find the best suited one. Several concepts require a lot of comparing, evaluation, elimination, testing and brainstorming.
    - **Consequence**: **3**
      More difficult to meet all requirements in a single complete design. Results in a less satisfactory project.

7.2.3 Involuntary Risks

- One of the persons in the group gets sick and cannot participate in the project for an extended period of time in a critical phase:
    - **Probability**: 1
      Statistically this is unlikely.
    - **Consequence**: 3
      Depends on where we are in the project. In a critical phase, this might have great impact.

- Lost documentation due to data failure.
    - **Probability**: 1
      We will have copies of our documents in several separate locations.
    - **Consequence**: 4
      Demoralizing. Losing critical documents can result in project failure or vast re-work. Time-consuming.

- Lack of motivation:
    - **Probability**: 1
      We have agreed to help each other if this would occur and will implement socializing events to prevent this.
    - **Consequence**: 2
      Lack of motivation is demoralizing for other members of the group and may result in lower productivity.

7.2.4 Voluntary Risks

- We use untested technology.
    - **Probability**: 1
      We will most likely use technology that are already tested.
    - **Consequence**: 3
      The technology might not work.

- We set a time schedule that we cannot follow.
    - **Probability**: 4
      Most likely the time schedule needs to be rewritten several times as it is only a guideline for time consumption.
    - **Consequence**: 2
      More work in less time. Might result in failure to reach deadline in some areas.

7.3 Risk Assessment table

The following table shows a summary of all the risks, probabilities and consequences with a color-graded priority. The risks have been rated on a scale from 1-4 considering probability and consequence. By multiplying them, we get a risk factor which grades the priority of the risks. The color codes are represented as follows:

Priorities:

- **Green** = Low Risk: 1-3
- **Yellow** = Medium Risk: 4-7
- **Red** = High Risk: 8-16

Green

These are at low priority and will probably not occur. They have little or no consequence.

Yellow

These priorities we need to watch out for in our project, but they are not very critical. We have to monitor these to prevent them from happening or evolving into a red-zone.

Red

We are aware of these high risks and consequences and need to monitor them at all times. All of these are in the project-specific row, so they can be suppressed by setting a well defined requirements-specification.

	Risks	Probability	Consequence	Risk	Priority
General	The project group misunderstands/ misinterprets the requirements	2	3	6	
	Difficulties in acquiring the right resources and competence to solve the problem	1	3	3	
	Flaws on, or prototype delivered past due-date (If relevant we have to plan this at an early stage)	2	3	6	
	The requirements in the project changes several times	3	2	6	
	The project is not extensive enough	1	3	3	
Project Specific	Failure to correctly simulate influences on the design	2	3	6	
	Extensive complexity in design	2	3	6	
	Failure to meet one or more key-point requirements (p.10)	3	3	9	
	Failure to create more than one concept	2	3	6	

Involuntary	One of the persons in the group gets sick and cannot participate in the project for an extended period of time in a critical phase	1	3	3
	Lost documentation due to data failure	1	4	4
Voluntary	Lack of motivation	1	2	2
	We use untested technology.	1	3	3
	We set a time-schedule that we cannot follow	4	2	8

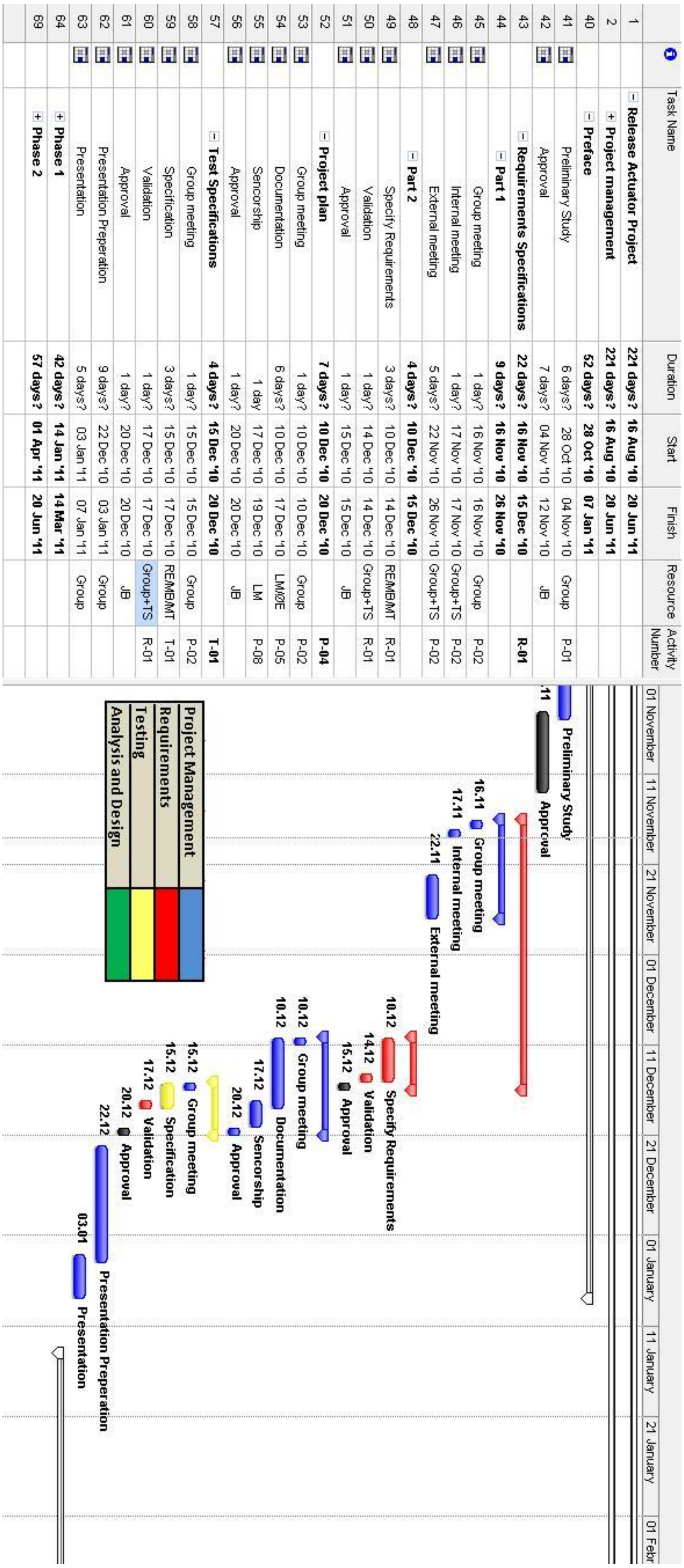
Table 5: Priorities of risks

8. Activities

Table 3 shows the categorization of our activities, which are illustrated in the Gantt-diagram (Diagram 1, p.16).

Workflow	Activity number	Activity
Project Management	P-00	
	P-01	Preliminary Study
	P-02	Meetings
	P-03	Presentation
	P-04	Project Plan
	P-05	Documentation
	P-06	Economy
	P-07	Project Report
Requirements	R-00	
	R-01	Requirement Specification
Testing	T-00	
	T-01	Test Specification
	T-02	Simulation
	T-03	Physical Test
Analysis and Design	A-00	
	A-01	System Design
	A-02	Theoretical Calculation
	A-03	Modeling
	A-04	Prototyping

Table 6: Activities



	Task Name	Duration	Start	Finish	Resource	Activity Number
1	Release Actuator Project	221 days?	16 Aug '10	20 Jun '11		
2	Project management	221 days?	16 Aug '10	20 Jun '11		
40	Preface	52 days?	28 Oct '10	07 Jan '11		
41	Preliminary Study	6 days?	28 Oct '10	04 Nov '10	Group	P-01
42	Approval	7 days?	04 Nov '10	12 Nov '10	JB	
43	Requirements Specifications	22 days?	16 Nov '10	15 Dec '10		R-01
44	Part 1	9 days?	16 Nov '10	26 Nov '10		
45	Group meeting	1 day?	16 Nov '10	16 Nov '10	Group	P-02
46	Internal meeting	1 day?	17 Nov '10	17 Nov '10	Group+TS	P-02
47	External meeting	5 days?	22 Nov '10	26 Nov '10	Group+TS	P-02
48	Part 2	4 days?	10 Dec '10	15 Dec '10		
49	Specify Requirements	3 days?	10 Dec '10	14 Dec '10	REMBMT	R-01
50	Validation	1 day?	14 Dec '10	14 Dec '10	Group+TS	R-01
51	Approval	1 day?	15 Dec '10	15 Dec '10	JB	
52	Project plan	7 days?	10 Dec '10	20 Dec '10		P-04
53	Group meeting	1 day?	10 Dec '10	10 Dec '10	Group	P-02
54	Documentation	6 days?	10 Dec '10	17 Dec '10	LM/ØE	P-05
55	Sencorship	1 day	17 Dec '10	19 Dec '10	LM	P-08
56	Approval	1 day?	20 Dec '10	20 Dec '10	JB	
57	Test Specifications	4 days?	15 Dec '10	20 Dec '10		T-01
58	Group meeting	1 day?	15 Dec '10	15 Dec '10	Group	P-02
59	Specification	3 days?	15 Dec '10	17 Dec '10	REMBMT	T-01
60	Validation	1 day?	17 Dec '10	17 Dec '10	Group+TS	R-01
61	Approval	1 day?	20 Dec '10	20 Dec '10	JB	
62	Presentation Preperation	9 days?	22 Dec '10	03 Jan '11	Group	
63	Presentation	5 days?	03 Jan '11	07 Jan '11	Group	
64	Phase 1	42 days?	14 Jan '11	14 Mar '11		
69	Phase 2	57 days?	01 Apr '11	20 Jun '11		

Diagram 1: Preliminary project plan

9. References

[1] Kongsberg Group, about us, www.kongsberg.com/en/KDS/AboutUs.aspx (visited 01.11.2010)

KDS/ GROUP 8

Requirement Specification

JSM Air Intake Cover & Wing Support System Release Mechanism

Morten Brodahl, Raymond Evje, Lars Meskestad, Øystein Ellefsen and Marius Tøien

24.05.2011

This document contains system requirements for the Joint Strike Missile Air Intake Cover & Wing Support System Release Mechanism

Contents

1 Introduction

1.1 Abbreviations

KDS	Kongsberg Defense Systems
JSM	Joint Strike Missile
ID	Identification
Req	Requirement
MT	Marius Tøien
RE	Raymond Evje
MB	Morten Brodahl
LM	Lars Meskestad

Table 1: Abbreviations

1.1.1 Requirement- and Test-ID explanation

The requirement-IDs and test-IDs are divided into codes that are logical and easy to understand. They are divided into letters and numbers:

(NT)-nRM-X-m

(NT)-TST-X-m

- (NT)= Non-Testable. This is described in ch 1.7
- n= Main Requirement Group
    - F = Functional
    - N = Non-Functional
    - O = Other
- RM = Requirement
- TST= Test
- X = Requirement Sub-Group
- Requirement Sub-Group is divided into:
    - E = Environmental Requirements
    - D = Design
    - DOC = Document
- m(numeric) = Counter within the given requirement sub-group

1.2 Purpose of this document

The purpose of this document is to specify the system requirements that we will consistently follow throughout the project. The Requirement Specifications are set in collaboration with KDS. The Requirement Specifications will ensure that KDS and the project group come to an agreement when it comes to the requirements and constraints.

The requirements in this document will be a guideline and the foundation for further development in the project. If changes or updates of the Specification Requirements are performed, KDS and our internal supervisor must approve them. They will then be added to this document.

1.3 Document Version

Document version	Date	Activities	Author
0.1	13.12.2010	Document established, Created templates	RE,MT,MB
0.2	14.12.2010	Input from KDS, Requirements processed and added.	RE,MT,MB
0.3	15.12.2010	- KONGSBERG confidentiality legend added - Explanation to requirement specification ID added (Ch 1.6) - Test specification ID added (Ch 2.2)	RE,MT,MB
1.0	17.12.2010	First Draft	RE,MT,MB
1.1	20.12.2010	Censorship	LM
1.2	20.12.2010	- Corrected RM-D-{1.1, 2.1, 2.2, 3.1} to maintain “release mechanism” tracking - Insertion of “non-Functional”, “Functional” and “other” requirements (2.2.1, 2.2.2, 2.2.3) - Established RM-F-1, RM-F-2	MB
1.3	21.12.2010	Renamed Req ID and Test ID(Ch 2.2)	MT
2.0	03. 01.2011	Second Draft	RE,MT,MB
2.1	17. 02.2011	Added FRM-F-3 Re-defined NRM-E-6, NRM-E-7 from A to B priority Renamed FRM-F-1 “Release Mechanism” to “Release”	MB
2.2	14. 03.2011	Added FRM-F-4	MB
2.3	16.03.2011	Editing	MB,MT
2.4	17.03.2011	Ch 1.4 Related Documents Added. Ch 1.7 Suppressed Requirements. Edit ch 1.1.1. Edit requirements NRM E-1,2,3,4,6,7	MB,MT,RE,ØE
3.0	17.03.2011	Third Draft	MB
3.1	09.05.2011	Revise	MB
4.0	24.05.2011	Fourth Draft	LM

Table 2: Document history

1.4 Related Documents

Document Name	Description
Test Specification	Contains test layout of the individual tests
Concept Development Report	Contains reference to the requirements
Project Plan	Contains an overview of the project
Preliminary Study	Contains plans and risks regarding the requirements

Table 3: Related Documents

1.5 System Overview

The JSM Air Intake Cover & Wing support System has two main functions:

- Cover the air intake when missile is in captive carriage condition to prevent any kind of debris from reaching engine compressor face
- Detain the wing panels when the missile is in captive carriage condition

The release mechanism shall ensure removal of the cover prior to the wing unfolding when the missile is in free flight condition.

1.6 Priority rating

The requirements are rated in a scale from A to C:

A: Considered to be top priority. These requirements come mainly from the customer and are a critical factor for the completion of the project.

B: Are preferably reached. These requirements are not critical in terms of a successful project but are a valuable contribution for the overall completion of the project.

C: Are taken into consideration if the time allows it. These requirements are not critical in any way, but can be an improvement to the overall completion of the project.

1.7 Suppressed Requirements

Certain requirements in the requirement specification are suppressed regarding testing. They are still an important factor regarding production of the release mechanism, but will not affect the completion of the school project.

Aerospace requirements are complex and difficult to fulfill. We do not have the resources, time or qualifications to conduct tests on some of the particular requirements. Even though they are considered as top priority to our employer, we came to an agreement that the test specifications will be generated as close to complete as possible although they will not be conducted in other ways than simulation. This signifies that these test specifications can be simplified.

As mentioned introductorily in ch 1.1.1, the denomination of these requirements will be (NT)-NRM-X-m.

The suppressed requirements regarding testing is shown below in table 3:

Req. ID	Requirement name	Priority
NRM-E-1	Storage Temperatures	A
NRM-E-2	Operating Temperatures	A
NRM-E-3	Captive Carriage Air Pressure	A
NRM-E-4	Captive Carriage Pressure Rate of Change	A
NRM-E-6	Vibration Tolerance	B
NRM-E-7	Withstand Mechanically Induced Shock	B

Table 4: Suppressed Requirements

2 Requirements

2.1 Requirement summary

The requirements in table 4 below are a summary of the main system requirements. Some of them are given by KDS and some are prepared by the project group.

Req. ID	Requirement name	Priority
(NT)-NRM-E-1	Storage Temperatures	A
(NT)-NRM-E-2	Operating Temperatures	A
(NT)-NRM-E-3	Captive Carriage Air Pressure	A
(NT)-NRM-E-4	Captive Carriage Pressure Rate of Change	A
NRM-E-5	Static Load: Vertical Limit Load	A
(NT)-NRM-E-6	Vibration Tolerance	B
(NT)-NRM-E-7	Withstand Mechanically Induced Shock	B
NRM-D-1	Material Choice	B
NRM-D-2	Step and Gap Allowance	A
NRM-D-3	Surface Coating	A
NRM-D-4	Volume Allowance	A
NRM-D-5	No Part Separation	A
FRM-F-1	Release	A
FRM-F-2	Detainment	A
FRM-F-3	Seal	A
FRM-F-4	Rotating Axis	C
ORM-DOC-1	Decision Documentation	A

Table 5: Requirement summary

2.2 Requirement specifications

2.2.1 Non-Functional Requirements

2.2.1.1 Environmental requirements

Requirement ID	Issued by
(NT)-NRM-E-1	KDS
Requirement name	
Storage Temperature	
Description	
The release mechanism shall operate as intended after being stored within the following temperatures for duration of one year. - Minimum storage surrounding air temperature: -54°C - Maximum storage surrounding air temperature: cycles +32°C to +71°C	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)-TST-E-1	A

Table 6: (NT)-NRM-E-1

Requirement ID	Issued by
(NT)-NRM-E-2	KDS
Requirement name	
Operating Temperature	
Description	
The release mechanism shall operate during exposure to the following temperatures. - Minimum operating surrounding temperature is: -57°C - Maximum operating surrounding temperature is: +95°C	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)-TST-E-2	A

Table 7: (NT)-NRM-E-2

Requirement ID	Issued by
(NT)-NRM-E-3	KDS
Requirement name	
Captive Carriage Air Pressure	
Description	
The release mechanism shall operate during exposure to the following pressures - Minimum absolute low pressure: 18,7 kPa - Maximum absolute high pressure: 108,4 kPa	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)-TST-E-3	A

Table 8: (NT)-NRM-E-3

Requirement ID	Issued by
(NT)-NRM-E-4	KDS
Requirement name	
Captive Carriage Pressure Rate of Change	
Description	
The release mechanism shall withstand a pressure rate of change during captive carriage conditions as listed below - Maximum decreasing rate of change: -3,65 kPa/s - Maximum increasing rate of change: +4,83 kPa/s	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)-TST-E-4	A

Table 9: (NT)-NRM-E-4

Requirement ID	Issued by
NRM-E-5	KDS
Requirement name	
Static Load: Vertical Limit Load	
Description	
The release mechanism shall be able to support and release the cover when it is subjected to a vertical limit load of 1114N	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
TST-E-5	A

Table 10: NRM-E-5

Requirement ID	Issued by
(NT)-NRM-E-6	KDS
Requirement name	
Vibration Tolerance	
Description	
The release mechanism shall withstand the random vibrations described in table 23 appendix A-1.	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)- TST-E-6	B

Table 11: (NT)-NRM-E-6

Requirement ID	Issued by
(NT)-NRM-E-7	KDS
Requirement name	
Withstand Mechanically Induced Shock	
Description	
The release mechanism shall withstand the mechanically induced shock levels described in table 24 in appendix A-2	
Activity number	**Requirement type**
R01	Environmental
Test ID	**Priority**
(NT)-TST-E-7	B

Table 12: (NT)-NRM-E-7

2.2.1.2 Design Requirements

Requirement ID	Issued by
NRM-D-1	KDS
Requirement name	
Material Choice	
Description	
If no other materials of specific quality are needed, design material for the release mechanism shall be chosen from table 25 in appendix A-3	
Activity number	**Requirement type**
R01	Design
Test ID	**Priority**
TST-D-1	B

Table 13: NRM-D-1

Requirement ID	Issued by
NRM-D-2	KDS
Requirement name	
Step & Gap Allowance	
Description	
After release, the surface of the release mechanism shall not exceed steps or gaps within the tolerance of: - ±0,1mm for any step - 0,1 mm for any gap	
Activity number	**Requirement type**
R01	Design
Test ID	**Priority**
TST-D-2	A

Table 14: NRM-D-2

Requirement ID	Issued by
NRM-D-3	KDS
Requirement name	
Surface Coating	
Description	
The external surface of the ball-housing on the release mechanism shall have a 1mm thick surface coating.	
Activity number	**Requirement type**
R01	Design
Test ID	**Priority**
TST-D-3	A

Table 15: NRM-D-3

Requirement ID	Issued by
NRM-D-4	KDS
Requirement name	
Volume Allowance	
Description	
Maximum volume for the release mechanism is 160 cm^3	
Activity number	**Requirement type**
R01	Design
Test ID	**Priority**
TST-D-4	A

Table 16: NRM-D-4

Requirement ID	Issued by
NRM-D-5	KDS
Requirement name	
No Part Separation	
Description	
No objects shall part from the release mechanism or cover after activation of mechanism.	
Activity number	**Requirement type**
R01	Design
Test ID	**Priority**
TST-D-5	A

Table 17: NRM-D-5

2.2.2 Functional Requirements

Requirement ID	**Issued by**
FRM-F-1	KDS
Requirement name	
Release	
Description	
The release mechanism shall ensure release of the cover.	
Activity number	**Requirement type**
R01	Functional
Test ID	**Priority**
TST-F-1	A

Table 18: FRM-F-1

Requirement ID	**Issued by**
FRM-F-2	KDS
Requirement name	
Detainment	
Description	
The release mechanism shall detain the cover when the missile is in captive carriage.	
Activity number	**Requirement type**
R01	Functional
Test ID	**Priority**
TST-F-2	A

Table 19: FRM-F-2

Requirement ID	Issued by
FRM-F-3	Group
Requirement name	
Seal	
Description	
After release of the cover, the release mechanism shall seal the hole in the fuselage.	
Activity number	**Requirement type**
R01	Functional
Test ID	**Priority**
TST-F-3	A

Table 20: FRM-F-3

Requirement ID	Issued by
FRM-F-4	Group
Requirement name	
Rotating Axis	
Description	
The Release Mechanism shall be made in a way that it allows for rotating about an axis placed at the rear of the missile. Main points are: - Satisfying draft angle - Enough space between surfaces in the Release Mechanism	
Activity number	**Requirement type**
R01	Functional
Test ID	**Priority**
TST-F-4	C

Table 21: FRM-F-4

2.2.3 Other Requirements

2.2.3.1 Documentation

Requirement ID	**Issued by**
ORM-DOC-1	Project group
Requirement name	
Decision Documentation	
Description	
All decisions made throughout the project must be well documented so KDS can verify them for further use.	
Activity number	**Requirement type**
R01	Document
Test ID	**Priority**
TST-DOC-1	A

Table 22: ORM-DOC-1

Appendix A-1

	Units weighing less than 5 kg
[Hz]	PSD [g^2/Hz]
20	0,04
1000	0,04
2000	0,02
g_{rms}	**7,70**

Table 23: Random vibration levels

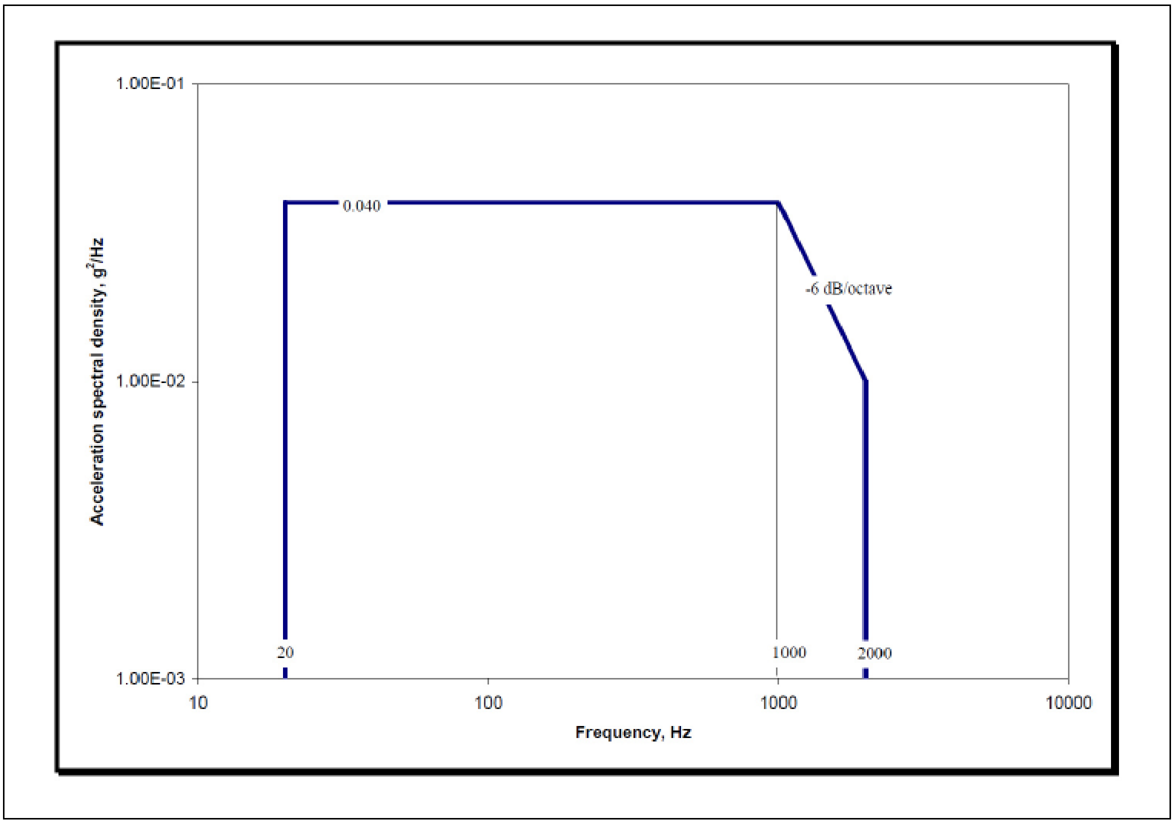


Figure 1: Random vibration spectrum, 1 hour per axis, 7.7 grms

Appendix A-2

	Units weighing less than 5 kg
Hz	g_{peak}
5	3,36
45	30
100	30

Table 24: Mechanically induced shock levels, all three axis

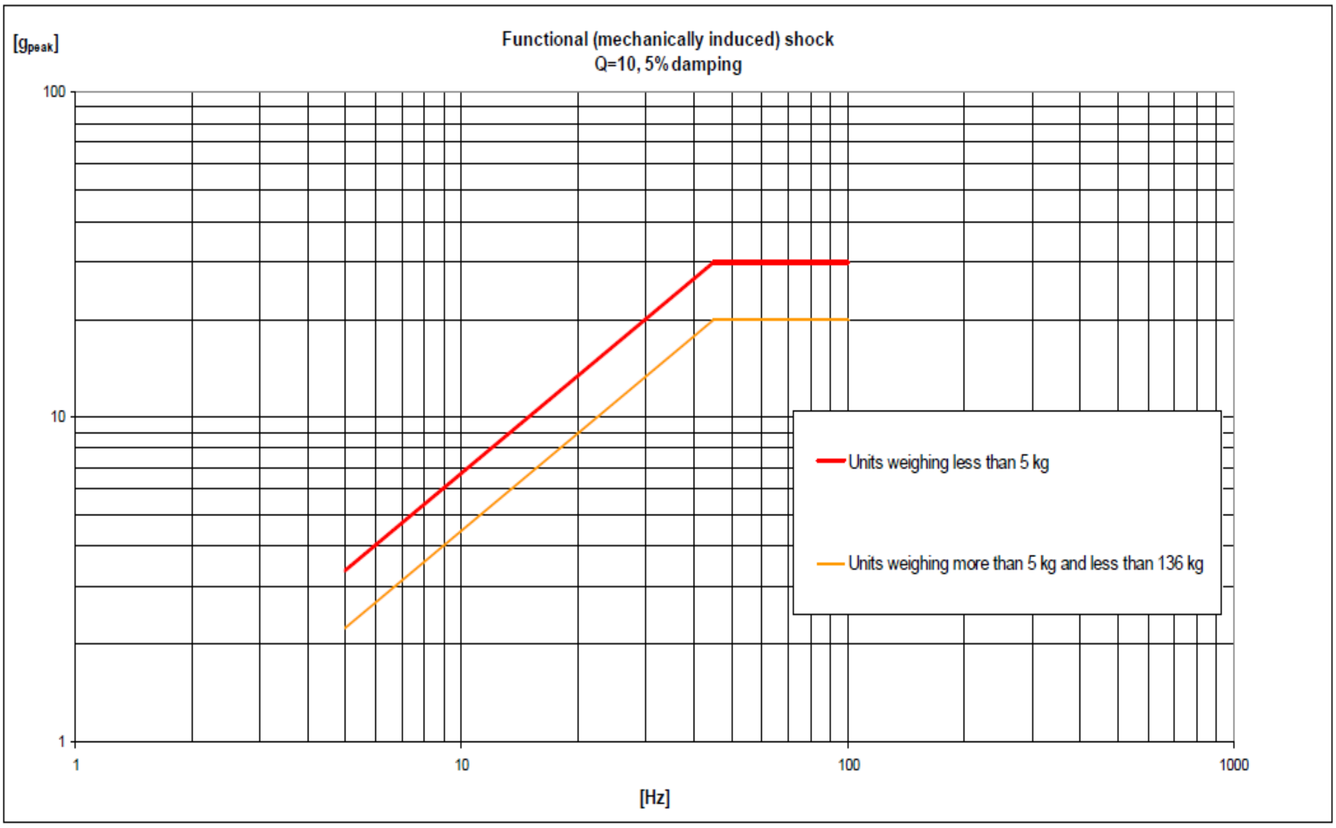


Figure 2: Mechanically induced shock levels

Appendix A-3

Material	Grade	Form	UTS (Ftu)	YS (Fty)	Elong.	Spec
Stainless	AISI 316		507 MPa (S)	240 MPa (S)	40 %	AMS 5524 Annealed
Stainless	AISI 316		862 MPa (A)	479 MPa (A)	25 %	AMS 5907 1/4H
Stainless	17-4PH-H 1150	Bar, Plate (15-100mm)	868 Mpa (A)	694 MPa (A)	16 %	AMS 5643 Bar, AMS 5604 Sheet, Plate
Stainless	17-4PH-H 900	Bar, Plate (15-100mm)	1319 Mpa (A)	1181 MPa (A)	10 %	AMS 5643 Bar, AMS 5604 Sheet, Plate
Stainless	17-4PH-H 1150	Forging, Tubing, Rings	938 Mpa (S)	729 MPa (S)	16 %	AMS 5643 Forging
Stainless	17-4PH-H 1000	Investment Casting	1042 Mpa (S)	903 MPa (S)	4 %	AMS 5343 Investment Casting
Stainless	13-8PH-H 1150	Round, Hex, Square, Flat Bar	938 Mpa (S)	625 MPa (S)	14 %	AMS 5629 Round, Hex, Square, Flat Bar
Stainless	13-8PH-H 950	Round, Hex, Square, Flat Bar	1507 Mpa (S)	1375 MPa (S)	10 %	AMS 5629 Round, Hex, Square, Flat Bar
Stainless	13-8PH-H 1150	Bar, Forging, Ring, Extrusion	938 Mpa (S)	625 MPa (S)	14 %	AMS 5934 Bar, Forging, Ring, Extrusion
Stainless	13-8PH-H 950	Bar, Forging, Ring, Extrusion	1528 Mpa (S)	1424 MPa (S)	10 %	AMS 5934 Bar, Forging, Ring, Extrusion
Stainless	Custom 465 H950	Bar	1667 Mpa (A)	1528 Mpa (A)	10 %	AMS 5936 Bar
Stainless	Custom 465 H1000	Bar	1528 Mpa (A)	1389 Mpa (A)	10 %	AMS 5936 Bar
Low Alloy Steel	AISI 4340	Bar, Forging, Tubing	1806 Mpa (S)	1507 Mpa (S)	10 %	AMS 6414 Bar, Forging, Tubing
Low Alloy Steel	300M (0.40C)	Bar, Forging, Tubing	1875 Mpa (S)	1528 Mpa (S)	8 %	AMS 6417 Bar, Forging, Tubing
Low Alloy Steel	300M (0.42C)	Bar, Forging, Tubing	1944 Mpa (S)	1597 Mpa (S)	7 %	AMS 6257, AMS 6419 Bar, Forging, Tubing
High-Alloy Steel	AerMet 100	Bar, Forging	1910 Mpa (A)	1632 Mpa (A)	10 %	AMS 6532 Bar, Forging, Aged at 900F
Alfa-Beta Ti Alloys	Ti-6Al-4V, Annealed	Plate 5-100mm	903 Mpa (A)	819 Mpa (A)	10 %	AMS 4911, Plate Annealed
Alfa-Beta Ti Alloys	Ti-6Al-4V, Solution Heat Treated and Aged	Sheet and Plate 5-50mm	1007 Mpa (S)	938 Mpa (S)	6 %	AMS 4904 Sheet and Plate
Alfa-Beta Ti Alloys	Ti-6Al-4V, Solution Heat Treated and Aged	Round, Square, Hex Bar 12-75mm	972 Mpa (S)	903 Mpa (S)	10 %	AMS 4965, AMS 6930 Round, Square, Hex Bar
Alfa-Beta Ti Alloys	Ti-6Al-4V, Alpha-Beta Processed and Annealed	Die Forging -150mm	903 Mpa (S)	833 Mpa (S)	8-10%	AMS 4928, AMS 4920 Die Forging
Alfa-Beta Ti Alloys	Ti-6Al-4V, HIP and Annealed	Investment Casting - 100mm	833 Mpa (A)	764 Mpa (A)	3 %	AMS 4992 Investment Casting
Aluminium Alloys	6061-T6,T62	Sheet	292 Mpa (A)	250 Mpa (A)	8-10%	AMS 4025, AMS 4027, AMS-QQ-A-250/11
Aluminium Alloys	6061-T651,T6	Plate up to 150mm	278 Mpa (S)	243 Mpa (S)	6 %	AMS 4025, AMS 4027, AMS-QQ-A-250/11
Aluminium Alloys	6061-T651,T6	Rolled, Drawn, or Cold Finished Bar, Rod and Special Shapes, Thickness up to 200mm	292 Mpa (S)	243 Mpa (S)	10 %	AMS 4117, AMS-QQ-A-225/8
Aluminium Alloys	7050-T7451	Plate up to 100mm	500 Mpa (A)	431 Mpa (A)	9 %	AMS 4050
Aluminium Alloys	7050-T7451	Plate 100-200mm	472 Mpa (A)	403 Mpa (A)	6 %	AMS 4050
Aluminium Alloy Casting	A356.0 T6P	Sand, Investment, permanent mould and composite casting	222 Mpa (S)	153 Mpa (S)	2 %	AMS 4218
Aluminium Alloy Casting	A357.0 T61P	Casting	264 Mpa (S)	208 Mpa (S)	2 %	AMS 4219
Aluminium Alloy Casting	F357.0 T6 (Low Beryllium)	Casting	264 Mpa (S)	208 Mpa (S)	2 %	AMS 4289

Table 25: List of preferred materials

KDS/ GROUP 8

Concept Generation Document

JSM Air Intake Cover & Wing Support System Release Mechanism

Marius Tøien, Morten Brodahl, Raymond Evje and Lars Meskestad

15.03.2011

This document contains a description of the process regarding the Concept Generation Phase

Contents

1 Introduction

1.1 Abbreviations

MT	Marius Tøien
MB	Morten Brodahl
LM	Lars Meskestad
RE	Raymond Evje

Table 1: Abbreviations

1.2 Purpose of this Document

This document is a plan for the brainstorming process in the project. The purpose of this plan is to ensure a thorough and tidy process that will result in better concept generation.

1.3 Document Version

Document version	Date	Activities	Author
0.1	21.12.2010	Established Document	MT
0.2	28.12.2010	Added ch5. Alter layout	MT, MB
0.3	01.01.2011	Editing	LM
1.0	03.01.2011	First Draft	MT, MB
1.1	15.03.2011	Editing for CD	RE
2.0	15.03.2011	Second Draft	RE

Table 2: Document history

1.4 Related Documents

Document Name	Description
Concept Generation report	This report has all the first draft concepts
Concept Development Report	This report will provide a more thorough introduction to the concepts

Table 3: Related Documents

2 Brain writing

2.1 Purpose

This is the first phase when developing concepts. This phase will generate the basic ideas to solve the problem. These ideas must then be filtered and evaluated. In this phase of the concept generation there is no room for negative remarks or thoughts, everything is allowed.

2.2 Procedure

We will start with a set of post-it notes and then write our ideas down in private. After a given period of time we will put the post-it notes on a wall and look at each other's ideas. A short filtration of ideas that are too similar will be performed before beginning a second round of concept generation were we are allowed to combine and/or build on previous ideas. The new ideas will be put on a separate part of the wall.

2.3 Documentation

We will write down all the ideas that have been created. Save the post-it notes and take pictures along the way.

3 Discussion and Evaluation

3.1 Purpose

In this phase we will discuss all the ideas in attempt to extract more concepts based on this discussion. When all new concepts are put on the wall we will discuss the ideas again. In this phase of the concept generation there is no room for negative remarks, only positive.

3.2 Procedure

Everyone gets a period of time to look at the post-its. We then discuss the ideas to uncover improvements or additions. The next step is to discuss all the ideas in plural so everyone understands what the creator means. Everyone will be given some time to evaluate the ideas individually.

3.3 Documentation

We will write down the new ideas, and take notes from the discussion, save the post-it notes and take pictures along the way. Record the discussion on a recording device to make sure that nothing is forgotten when we write the report.

4 Filtration

4.1 Purpose

In this phase we will start to be critical against the created ideas to remove the bad ones and those that cannot be executed, especially considering the requirements. Everyone is allowed to protect ideas that they like or aspects of them. The main function of this phase is to reduce the number of ideas.

4.2 Procedure

We start at the first section of the wall and discuss the ideas. The ideas that are obvious to fail will be discarded and ideas that are questionable will be marked and discussed again in a second round. After two rounds of discussion and discarding the group will rate the ideas with a scale of 1-5, where 5 is the best. Depending on the number of ideas at this stage we will go on to research phase. If there still are too many ideas, the filtration phase will be repeated.

4.3 Documentation

Ideas that are discarded will be documented with the proper arguments in a “discarded ideas archive”.

5 Research

5.1 Purpose

In this phase we will do an in-depth study on the individual ideas. This is to investigate the possibilities and restrictions of the ideas.

5.2 Procedure

We divide the ideas between the group members, 1-2 ideas per person. We then do an individual research on the idea and make a short presentation for the group. Based on these presentations we will discuss which ideas are suitable for further development. This will be done in collaboration with internal and external supervisors to get every parts opinion.

5.3 Documentation

All research shall be written down, and every chosen or discarded idea shall be documented.
A complete report on the concept generation process will be made, which includes the chosen as well as discarded ideas.

KDS/ GROUP 8

Concept Development Report

JSM Air Intake Cover & Wing Support System Release Mechanism

Øystein Ellefsen, Morten Brodahl, Raymond Evje, Marius Tøien and Lars Meskestad

15.03.2011

This document describes our progress in concept development. Which ideas we have chosen to exclude from further research, and which ideas we will look more into.

Contents

1 Introduction

1.1 Abbreviations

ØE	Øystein Ellefsen
MT	Marius Tøien
MB	Morten Brodahl
RE	Raymond Evje
LM	Lars Meskestad
KDS	Kongsberg Defence Systems

Table 1: Abbreviations

1.2 Purpose of this Document

This document describes our progress in the concept development phase. The end purpose of this document is to give basis for choice of five or less concepts for final evaluation.

1.3 Document Version

Document version	Date	Activities	Author
0.1	27.01.2011	Document Established	ØE
0.2	10.02.2011	Purpose of this document edited, Edited layout, Added Criteria's for evaluation	ØE
0.3	10.02.2011	Added drawings to the ideas, added text to 6.5	ØE
0.4	14.02.2011	Added text to Ch. 5.12, 3.2, 5.10, 5.1	MT
0.5	15.02.2011	Added text and drawings to idea 5.2, 5.3, 4.1, 4.2	ØE
0.6	15.02.2011	Added text and drawings to idea 5.1, 5.9, 4.3, 4.4, 4.5,	RE
0.7	15.02.2011	Added text and drawing to idea 4.1 and 5.5	ØE
0.8	16.02.2011	Inspecting document, spell-checking	RE
0.9	16.02.2011	Added Idea 3.1	ØE
0.91	16.02.2011	Added Idea 4.7, 5.8, 5.6	MB
0.11	17.02.2011	Added Evaluation table, 3.3, 5.1	LM
0.12	17.02.2011	Added 3.4, 5.5, 5.6	LM
0.13	17.02.2011	Added 5.12, 5.13, 5.14, 5.15	MT
0.14	17.02.2011	Edited Idea 4.1, 5.1, 5.2, 5.3, 6.2, 6.5 and 6.7	ØE
0.15	17.02.2011	Edited idea 6.6, 6.8 and 5.7	MB
0.16	17.02.2011	Edit idea 5.4, 5.5, 5.6, 6.1, 6.3, 6.9	RE
0.17	17.02.2011	Added 5.12-13-14-15	LM
0.18	21.02.2011	Added to 1.4, 1.5, table 3. Edited 2.1 and 2.2. Moved 5.13 and 5.14 to 3.1 and 3.2. Changed headline Ch. 2	LM
0.19	22.02.2011	Edited/corrected up to and including 4.2 (pg. 25)	LM
0.20	23.02.2011	Edited 4.8	RE
0.21	23.02.2011	Edited/corrected from pg.25 to final page. Added captions	LM
0.22	23.02.2011	Added Concept Property Matrix	ØE/RE
1.0	23.02.2011	First Draft	LM
1.1	10.03.2011	Changed Conclusions in ch 2. Added ch 2.5. Correction. Added captions to table 6 thru 28	MB/ MT
2.0	15.03.2011	Second Draft	MB

Table 2: Document Version

1.4 Related Documents

Document Name	Description
Concept Generation Report	Initial evaluation and filtration of the initial ideas.
Concept Generation Document	Plan for the Concept Generation process.

Table 3: Related Documents

1.5 Process

The Concept Development phase has resulted in 20+ Concepts. Some of them derived from the Concept Generation phase, but most of them are new. The concepts have been a result of iterative brainstorming, modeling and simulation. Most of the modeling has been conducted individually, but with cooperative evaluation to allow diverse design insight.

The Concepts are categorized in the following sequence:

- Concept ready for final evaluation
- Discarded Concepts from Concept Development
- Discarded Concepts from Concept Generation

1.6 Criteria for Evaluation

It is in the interest of this thesis to end with five or less concepts ready for final evaluation and choose one of these for prototyping. For this purpose we have set some criteria for the evaluation of the ideas we have worked on in the Concept Development phase.

1.6.1 Main criteria:

- All the functional requirements are fulfilled.
    - Hold - Detainment; FRM-F-2
    - Release - Release; FRM-F-1
    - Cover - Step and Gap Allowance; NRM-D-2
    - Seal gap in fuselage - Seal; FRM-F-3
- Volume allowance; NRM-D-4

1.6.2 Concept Property Matrix:

To compare the concepts it was necessary to grade a set of properties that was important in order to meet the requirements for this thesis. In the table below (table 3), there are seven properties where each has an individual multiplier to separate impact on the resultant value. The value “x” is a variable between 1 and 5, where higher is better. This value is based on an evaluation of the following:

Property	Description	Multiplier
Complexity	Number of parts, moving parts and their form factor	1.4 x
Assembly	Ease of assembly (move, orient and insert in order)	1.3 x
Movement	Jamming and wedging characteristics with respect to intended travel pattern	1.5 x
Size	The flexibility of size manipulation	1.0 x
Draft angel	Sensitivity to draft angle with respect to step and gap allowance	1.1 x
Functional Requirements	Cover all functional requirements	1.0 x
Force Needed	Force needed to release	1.5 x

Table 4: Concept Properties

(**! Note that the sizes of the models are not finalized as there have not been conducted accurate simulations regarding loads and forces.)**

	Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
Ball-bearing Clip-on	4	3	3	3	2	2	3	25,7
Ball-bearing-slider	3	2	3	3	4	1	4	25,7
Bolt Slider	2	2	2	3	3	4	3	23,2
Ball- Bearing Bolt-In With Alternative	4	5	5	4	5	3	5	39,6
Hinge-lock	3	2	3	5	5	5	4	32,8
Horizontal Slider	4	3	3	4	3	3	3	28,8
Ball-Bearing Closed Chamber Pin Puller	5	4	5	5	5	4	5	41,7
Lock box	3	3	3	2	4	3	3	26,5
Magnet	3	2	3	5	5	5	4	32,8
Pivot Clips	3	3	2	2	3	4	3	24,9
Rotating Slider	3	3	2	4	3	3	3	25,9
Rotational Lock	5	4	2	4	3	3	3	30
Rotator	4	4	3	4	5	5	5	37,3
Snap Lock	3	3	3	5	4	5	3	31,5
Strap In	3	2	2	3	3	1	1	18,6
The Clip-on	5	5	2	5	1	5	2	30,6
The Expander	4	3	2	3	3	5	3	28,3
Trapdoor	3	3	2	2	4	5	3	27
Diamond Bolt	5	5	3	3	3	1	3	29,8
U-Pin Slider	2	3	3	2	3	4	3	25
Rotating Stoppers	4	4	3	4	5	5	5	37,3
Cork Screw Bolt-In	5	5	3	3	3	1	3	29,8
V-Bracket Push Rod	3	4	2	2	4	5	4	29,8

Table 5: Concept Property Matrix

We can see from the finalized matrix that there are 4 ideas we want to develop further. These four ideas will be presented to several engineers from KDS early in March. This will be the final evaluation of the concepts, and the outcome of this presentation will be to end with one concept for optimization and prototyping.

2 Concepts Ready for Final Evaluation

2.1 Rotator

2.1.1 CAD Model

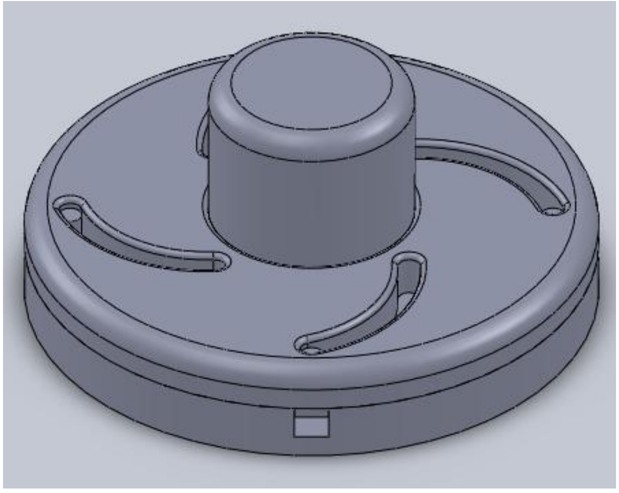


Figure 1

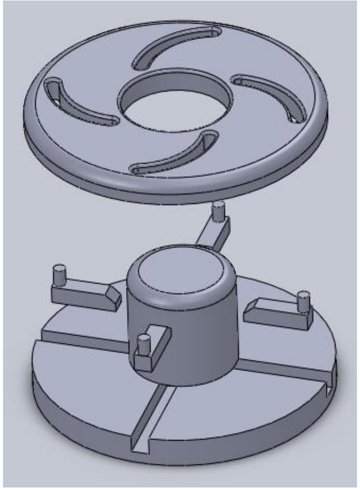


Figure 2

2.1.2 Description

The mechanism consists of two disks and four sliding pins. The bottom disk has four slots to guide the sliding pins. The top disk has four trails which are curved in order to convert rotation of the disk into linear movement of the pins. A pin puller (actuator) is retaining rotation of the cover and the trails will keep the pins fixed. To release, the actuator allows rotation of the disk. The pins retract and release the cover. Inside the dome in the center of the bottom disk there is a spring-loaded piston which will cover the gap once the cover is released.

2.1.3 Evaluation

The mechanism consists of few parts and is easy to assemble in a top-down fashion. There are moderate possibilities of jamming due to guide-trails and close-contact surfaces. The mechanism can be compact due to the distribution of forces. The pins are designed to let the vertical force from the cover help them retract. Draft angel is not an issue as the hole can be larger than the pin protruding from the cover. The mechanism fulfills all the functional requirements of hold, release and cover in a good way.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
4	4	3	4	5	5	5	37,3

Table 6: Section of matrix in ch 1.6.2

2.1.4 Conclusion

Due to high overall scores, this idea will be further evaluated. It requires low-force to release, which indicates the need of a smaller actuator. In addition it has low complexity and space requirement.

2.2 Rotating Stoppers

2.2.1 CAD Model

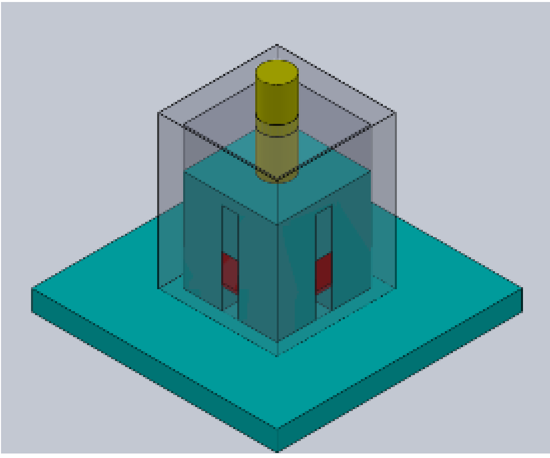


Figure 3

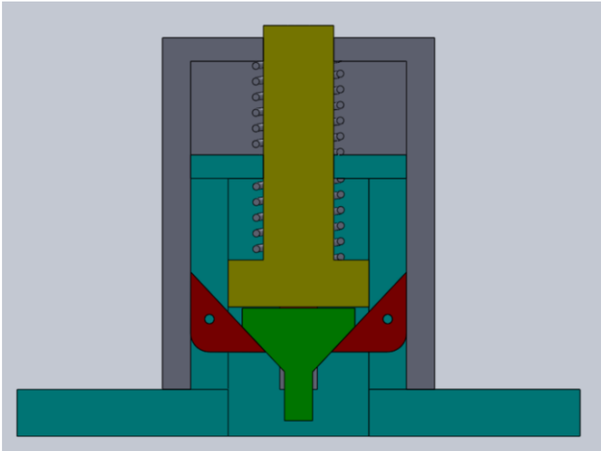


Figure 4

2.2.2 Description

This idea was generated after a small brainstorming internally in the group. The cover is held in place by four stoppers (red). An outer box (grey) prevents rotation of the stoppers. When actuated, a pin is pulled from the piston (yellow) and the spring forces are released. The top spring will lift the box allowing the stoppers to rotate and release the cover. The piston will simultaneous be pushed downwards to seal the gap. In this mechanism the force required for release is small and the vertical force from the environment will work with the direction of release. Actuator position is not given at this point.

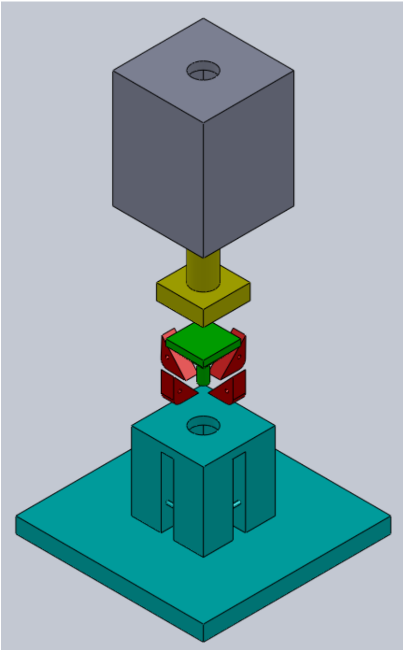


Figure 5

2.2.3 Evaluation

This concept consists of few parts and is considered to be a simple system. Because of the springs and multidirectional movements it does not get full score on complexity. This system can also be assembled mainly outside the fuselage and then be fixed into place. When releasing there are some insecurity regarding the rotating stoppers that may cause jamming. This mechanism can be made quite small, and are flexible regarding changes in the size. Release force required will be low because an actuator will release the vertical load. Draft angel will only be a design issue. Overall this idea is considered to have good solutions to all the functional requirements.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
4	4	3	4	5	5	5	37,3

Table 7: Section of matrix in ch 1.6.2

2.2.4 Conclusion

This concept will be further evaluated.

2.3 Ball-Bearing Bolt-in with alternative

2.3.1 CAD Model

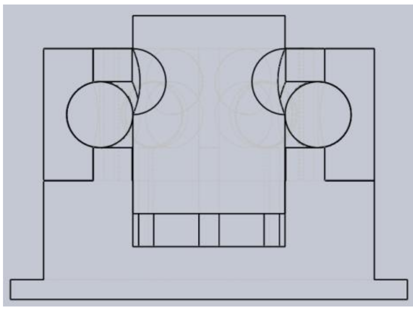


Figure 6

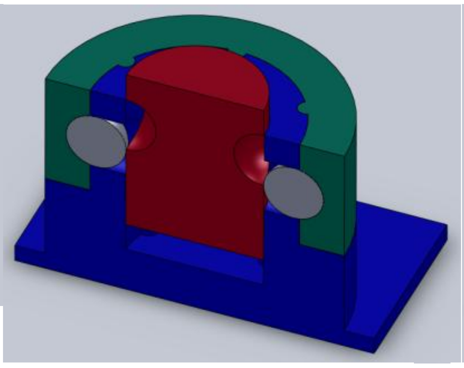


Figure 8

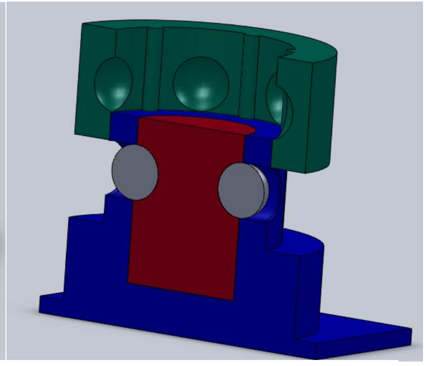


Figure 7

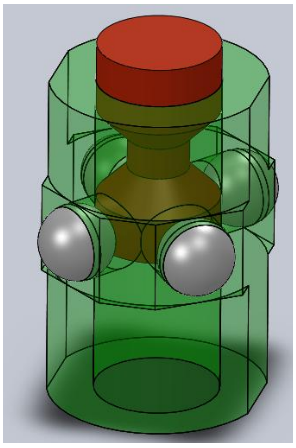


Figure 9

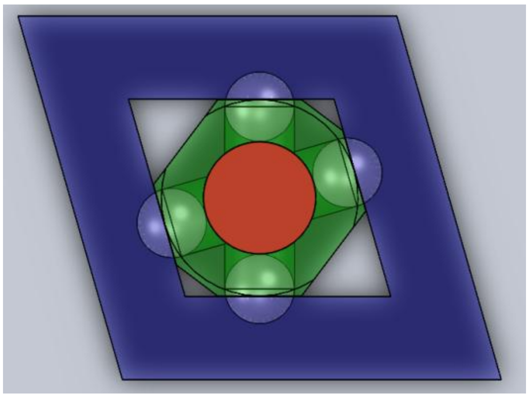


Figure 11

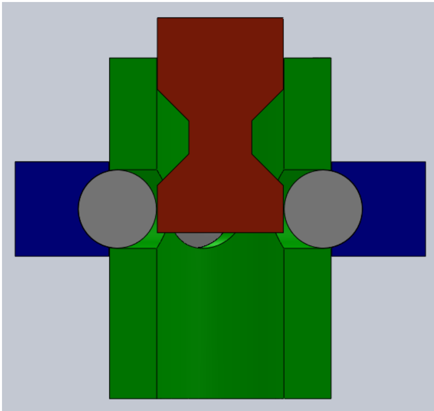


Figure 10

2.3.2 Description

Upper three figures (6,7,8): This idea derived from the Ball-Bearing Clip-on (4.1) which had an issue related to the spring-forced fixing. We solved this by removing the spring and replacing it with a solid pin (red) which will reduce in diameter when moved downwards as illustrated in figure 7 and 8. The outer casing (grey) is the missile body and the inner casing (blue) is the cover bracket. There is a small spring between the inner casing's inner flat surface, and the bottom surface of the pin to allow the pin to be pushed upward with just enough force to push the balls into locking position. It is probably not required to prevent the pin from falling back down as the weight of the cover will push the balls against the pin wall, thus fixing it with enough force. This can be adjusted with correct design and/or implement a counteracting spring. The actuator can push on a plate (seal) which will push the pin down, releasing the cover. It will follow to seal the gap. The force required to do this is very small as it only has to alleviate forces from the small spring and the friction from the balls on the pin, which is not extensive.

As an alternative to the circular opening in the missile body, we designed a concept for diamond-cut hole as illustrated in the lower three figures above (figure 9,10,11).

2.3.3 Evaluation

The concept consists of few parts and has a low complexity. The parts are designed to allow for easy assembly and mounting. Without the pin the cover would fall by itself. Low actuator force means less size. The draft angle can be solved by larger clearance values. All functional requirements are met.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
4	5	5	4	5	3	5	39,6

Table 8: Section of matrix in ch 1.6.2

2.3.4 Conclusion

As the concept fulfills all requirements and because of the way it releases, fixes and seals, this concept will be further evaluated.

2.4 Ball-Bearing Closed Chamber Pin Puller

2.4.1 CAD Models

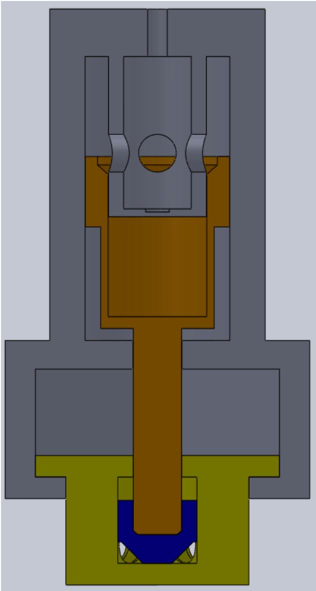


Figure 13

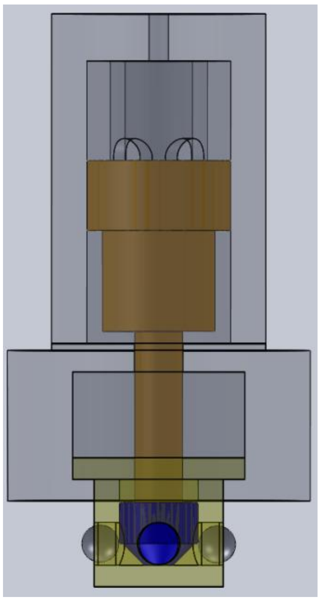


Figure 15

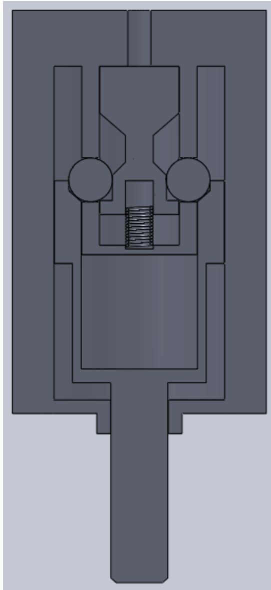


Figure 14

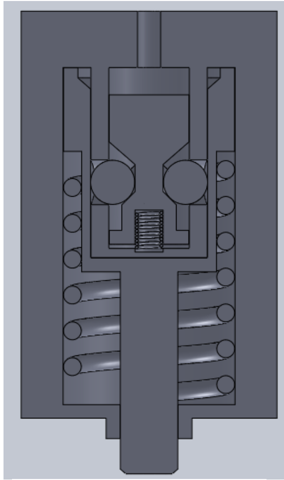


Figure 12

2.4.2 Description

In figure 13, one can see the pin (orange) in a pin puller (grey) with a ball-pushing head (blue) inside the seal which also work as a ball-bearing bracket for fixing of the cover (green). The pin puller is directly mounted on an enforced surface on the outer shell of the missile. The cavity (grey) is inside the outer shell of the missile. The ball-bearing bracket protrudes from the missile and into a bracket on the cover. The actuator (pin puller) is mounted with the spring contracted (figure 14, spring not shown). When released, the pin will retract so that the ball-pushing head will stop against to the top surface of the ball-bearing bracket, pulling it into its socket, sealing the hole. The force from the cover on this mechanism will be consumed by the missile itself (grey against green), which means that the pin puller only has to generate enough force to pull the seal into the cavity.

2.4.3 Evaluation

There are few parts in this design. There are some smaller issues to assembly, but only in design. The parts move together in one linear motion. As the actuator (pin puller) is directly mounted and requires low force, the size is equally small. The draft angle can be solved by increased clearance values. All functional requirements are met, and some of them are solved to work parallel to each other. (Pin puller is not considered in this evaluation as it is from a second-party manufacturer)

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
5	4	5	5	5	4	5	41,7

Table 9: Section of matrix in ch 1.6.2

2.4.4 Conclusion

Because of the low space requirement, that it fulfills all requirements and has a good design considering functional movement and requirements, this concept will be further evaluated.

2.5 Evaluation results

We held a meeting with several persons from KDS after we developed this report. The meeting was a great way for the group to get opinions from outsiders. KDS had different opinions regarding the individual ideas, and since we have listed the group's opinion earlier in this report, we will only list KDS's opinions below.

- Rotator:
  - Good detainment
  - High friction
  - Many jamming possibilities
  - Many moving parts in many directions

- Rotating Stoppers:
  - Release can be uneven and result in jamming
  - High friction between the stoppers and the lid
  - Good detainment
- Bolt-In:
  - Surface coating on the seal can be worn off due to vibration or shock
  - All movement in vertical direction
  - Makes use of vertical load
  - Material thickness is an issue regarding the rotating axis. There can be jamming
- Pin-Puller:
  - Release speed is a critical factor to avoid jamming
  - The surface coating will not be worn because it is not in contact with other parts
  - The detent ball slots have to be design so that the balls are detained after release
  - ”Pin-puller” is an existing system, which is positive

The required goal from this meeting was to end with one concept for optimization. KDS had the same view as the group of which idea they thought would be best to optimize. The chosen idea is:
”Ball Bearing Closed Chamber Pin-Puller”

3 Discarded: New Concepts

3.1 Diamond Bolt

3.1.1 CAD Models

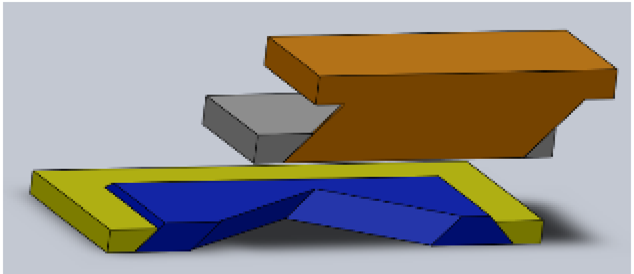


Figure 18

Figure 16

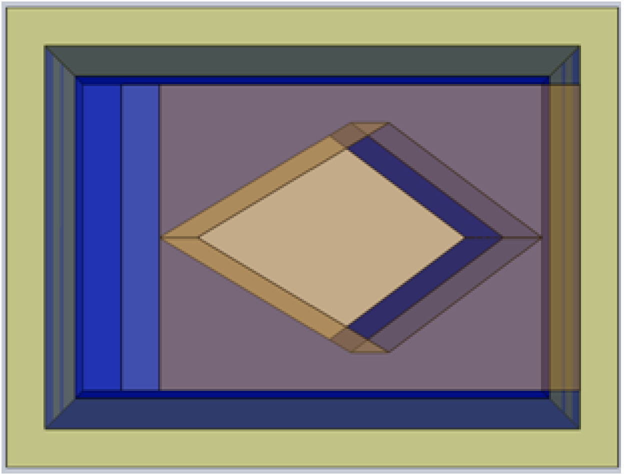


Figure 17

3.1.2 Description

A diamond shaped bolt (orange) protrudes the missile's outer shell (grey) and enters the bracket (blue) on the cover (green). As illustrated in figure 16, the bolt is in an angle which creates an area of vertical resistance, fixing the cover. When actuated, the bolt gets pulled back into its socket, sealing the gap.

3.1.3 Evaluation

The concept consists of few parts and is easy to assemble and design. It releases and seals in one linear motion. There are major issues concerning draft angel and vast shear forces as the contact between bolt and cover bracket decreases when the bolt retracts. There are also some issues regarding friction.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
5	5	3	3	3	1	3	29,8

Table 10: Section of matrix in ch 1.6.2

3.1.4 Conclusion

This concept will be discarded.

3.2 Cork Screw Bolt-in

3.2.1 CAD Models

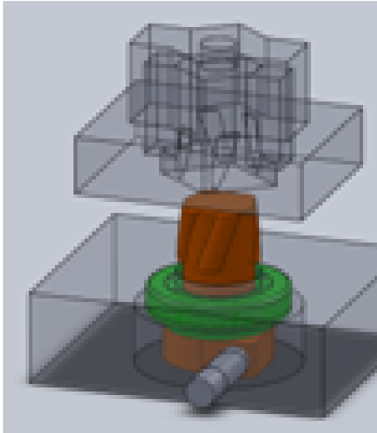


Figure 21

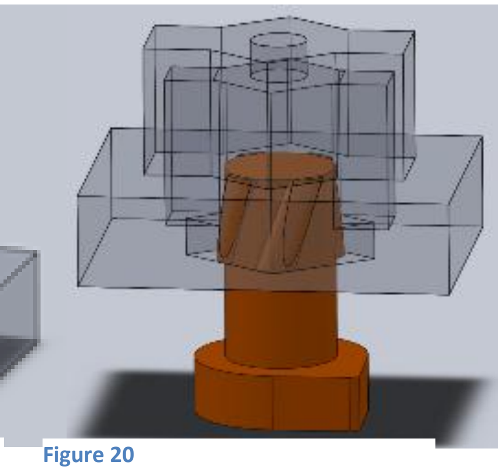


Figure 20

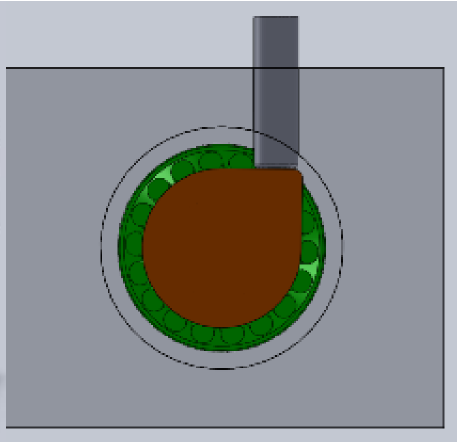


Figure 19

3.2.2 Description

As illustrated in figure 20, there is a bolt (orange) with threads which will prevent the bolt from retracting as this will require rotation. This rotation is prevented by a pin as illustrated in figure 21. When the cover pulls on the bolt, it will try to rotate. When the actuator retracts the pin, it allows the bolt to rotate and exit the missile. The translucent part is inside the missile and contains a spring-loaded seal which will follow the bolt to seal the gap.

3.2.3 Evaluation

The vertical force transferred into rotational force by the threads between the bolt and the missile fixing bracket will create a large momentum which will be difficult to account for and makes it difficult to design properly. It also requires the actuator to be placed in the cover, which would be space relieving, but would demand signal transfer through the rear fixing.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
5	5	3	3	3	1	3	29,8

Table 11: Section of matrix in ch 1.6.2

3.2.4 Conclusion

This concept will be discarded due to the complexity of movement and placing of actuator.

3.3 Ball-bearing Slider

3.3.1 Idea Drawing

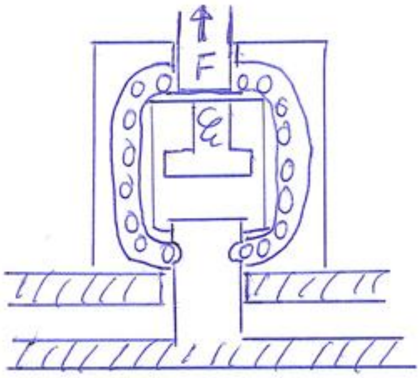


Figure 22

3.3.2 Description

Figure 22 shows the mechanism in its fixing position. The pin at the top (F), will force the balls sideways. This force is transferred to fixing of the cover by a chain of balls. When the pin is retracted the cover will force the balls sideways and the centered spring-loaded piston will follow to seal the gap.

3.3.3 Evaluation

Several issues regarding complexity, space, jamming and draft angle.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	2	3	3	4	1	4	25,7

Table 12: Section of matrix in ch 1.6.2

3.3.4 Conclusion

This concept will be discarded.

3.4 Trapdoor

3.4.1 Idea Drawing

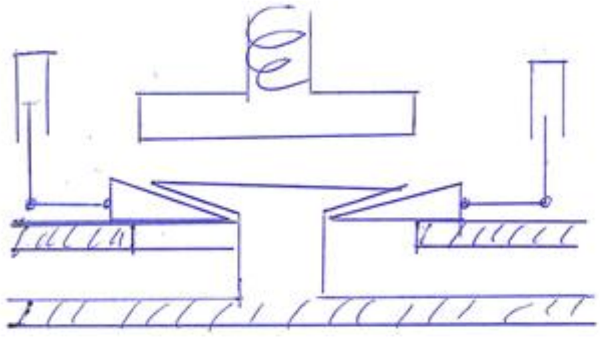


Figure 23

3.4.2 Description

The concept of this idea is taken from a dumper's trapdoor. Figure 23 illustrates the mechanism in its locked position. There are two linear pin pullers, one on each arm. When the pin puller retracts, the weight of the cover will force the arms to the side, allowing the cover to exit and the piston to follow, sealing the gap.

3.4.3 Evaluation

Some issues regarding complexity of movement caused by the separate arms. This separation also requires separate actuators, or a link between them which would only increase complexity and create redundancy issues.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	3	2	2	4	5	3	27

Table 13: Section of matrix in ch 1.6.2

3.4.4 Conclusion

With separate moving parts this concept is more complex and more space consuming than others, even with small solenoid actuators. This concept will be discarded.

3.5 The Expander

3.5.1 Idea Drawing

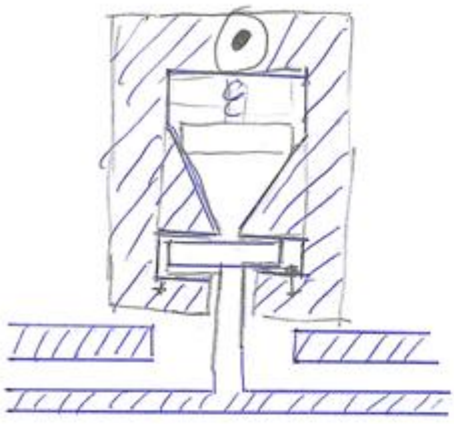


Figure 24

3.5.2 Description

The centered stopper-piston travels vertically to force the brackets to each side allowing the cover to be released. The stopper follows to close the gap. The brackets are hinged topside and will rotate along its radial perimeter.

3.5.3 Evaluation

The mechanism has a quite easy design, which consists of few moving parts. For the actuator to overcome the friction between the brackets and the stopper, in addition to the friction between the cover-pin and brackets, it would need to be large/strong, therefore space consuming.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
4	3	2	3	3	5	3	28,3

Table 14: Section of matrix in ch 1.6.2

3.5.4 Conclusion

The concept is not ideal. Although it meets the functional requirements, this concept will be discarded.

3.6 Hinge-lock

3.6.1 Idea Drawing

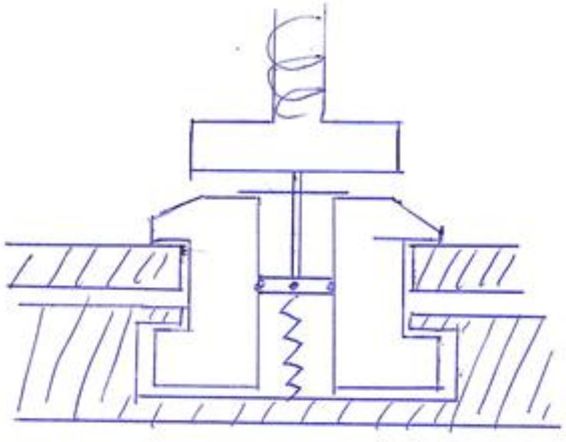


Figure 25

3.6.2 Description

Figure 25 illustrates the mechanism in its fixing position. In between the cover's fixing brackets there is a center-hinged clutching plate that is hinged to the brackets. The spring shown is preventing the plate from folding. When actuated, the small vertical center-pin will move downwards, compressing the spring which will allow folding of the clutching plate, which again allows the brackets to travel towards the center, releasing the cover. When the cover is released, the spring-loaded stopper will follow to seal the gap.

3.6.3 Evaluation

The mechanism has multi-directional movement of parts and may cause jamming due to friction and vibration. As the mechanism requires minimal force, the spring will not have to be of a considerable size. The idea fulfills all the functional requirements, and the draft angle can be chosen after need, but there are issues regarding fragile parts i.e. the clutching plate and center-pin.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	2	3	5	5	5	4	32,3

Table 15: Section of matrix in ch 1.6.2

3.6.4 Conclusion

Although a moderate overall score, this concept will be discarded.

3.7 V-Bracket Push-Rod

3.7.1 CAD Model

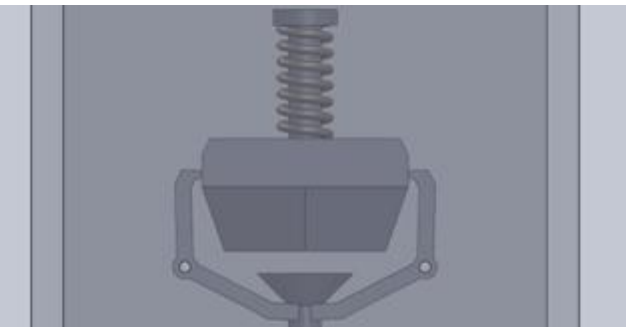


Figure 27

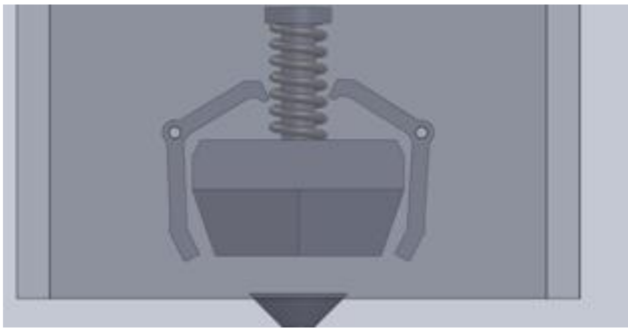


Figure 26

3.7.2 Description

Fastening: This idea is well designed regarding the vertical load requirement. The higher the vertical load, the better detainment will occur within the tolerances of the material characteristics. The brackets will be pushed into the sides of the piston as the cover is pulled downwards. This will result in bending force in the bracket and shear force in the pins that the brackets rotate on. It is critical for the design to fabricate the brackets with properties that can cope with the shear- and bending forces. It should be noted that the brackets can be modeled in many other ways than that which is shown, but the principle is to allow rotation for release.

Release: Either a pin-pushing actuator or spring-loaded piston with pin-puller actuator will allow the piston to travel downwards. The length of the brackets upper arms are designed in a way that they slide on top of the piston when the piston is pushed down. The cover is then released, and the piston seals the hole in the fuselage.

3.7.3 Evaluation

This concept requires complex design of coherency between moving parts and intended movement pattern. The concept has no major issues regarding assembly. It can be installed in the fuselage and fixed with a bolt through the cover. There is a quite high risk of jamming when the release occurs and the brackets are subjected to friction on the sides of the piston, but might be solved with low-friction components and/or ball-bearings. The concept might be space consuming due to the area of the brackets' movement around their axes. The cover is self-removing once rotation of the brackets is allowed. The draft angle is not a problem due to flexibility in bracket size.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	4	2	2	4	5	4	29,8

Table 16: Section of matrix in ch 1.6.2

3.7.4 Conclusion

Despite overall moderately high scores, this concept will be discarded in favor of other concepts.

4 Discarded: Initial Concepts

4.1 Ball-bearing Clip-on

4.1.1 Idea Drawing

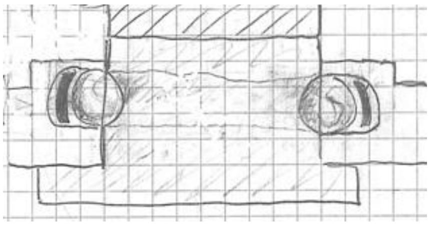


Figure 28

4.1.2 CAD Model

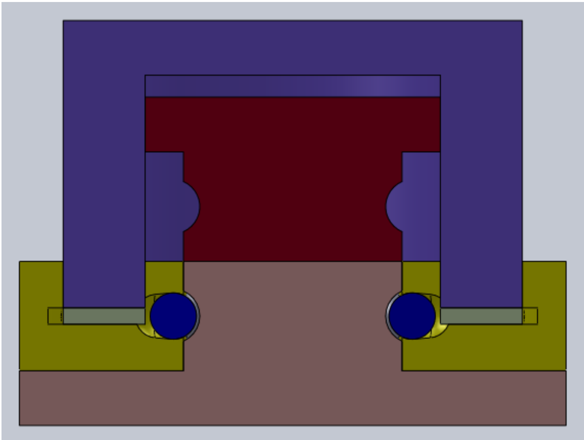


Figure 30

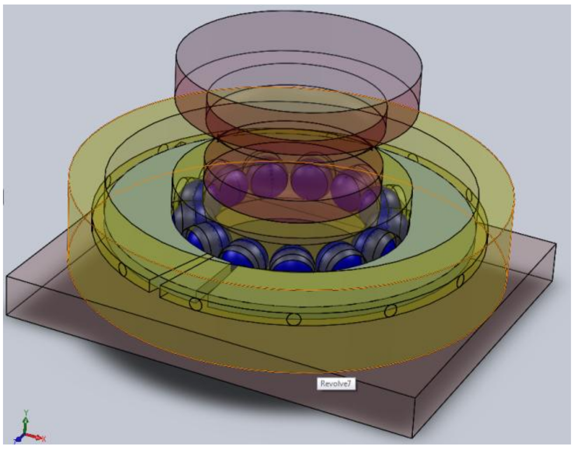


Figure 29

4.1.3 Description

Figure 30 shows a ball-bearing socket in fixing position. The cover has a bracket with a cylinder-shaped bolt (grey) with a ball-bearing trail. When the bolt gets pushed into the gap in the missile's body, the ball-bearings will be pushed outwards against a circular spring (blue-grey). As the diameter of the bolt is reduced at the ball-bearing trail, the ball-bearings (blue) will be forced into this trail, thereby locking the bolt. To release the bolt, there is a piston (red) pushing downwards in a vertical linear motion. The piston and the bolt are of equal size and will push the bolt to release, overtaking its position, thereby closing the gap. The purple cover work as bolt and seal housing and also allows for mounting of the spring. (Figure 29 illustrates a translucent assembly).

4.1.4 Evaluation

The concept consists of moderate amount of parts. The parts are constructed to allow for easy assembly, but there are still some issues to this regard. The path of movement from actuation to release is as one vertical linear motion, but there might be issues regarding close-contact surfaces and vibrations. It requires some space to allow bolt, piston and actuator to be on top of each other. The actuator has to be strong enough to work against the spring. The requirements of draft angle might be met with larger clearance values.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
4	3	3	3	2	2	3	25,7

Table 17: Section of matrix in ch 1.6.2

4.1.5 Conclusion

The biggest disadvantage with this concept is the spring-loaded fixing. It requires a force equal to fixing force to release, and does not solve the functional requirements as well as other concepts. This concept will be discarded.

4.2 Lock Box

4.2.1 Idea Drawing

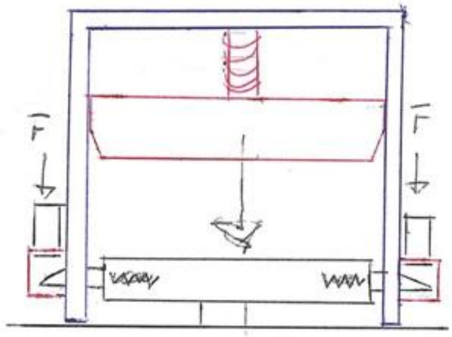


Figure 32

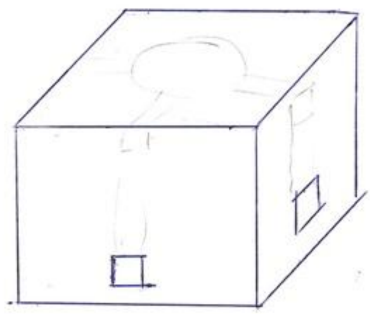


Figure 31

4.2.2 CAD Model

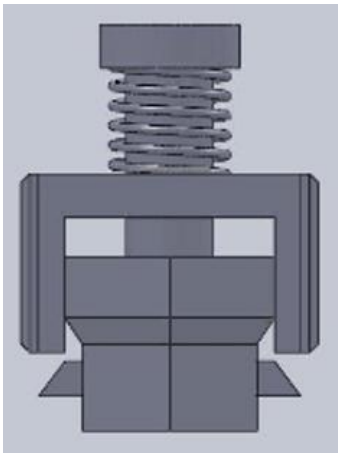


Figure 33

4.2.3 Description

After working a while on this idea, we managed to cut it down in the overall size, but can still be considerably smaller (current height: 40mm). An actuator will exert a force on the pin which. The pin will push the spring which will force the outer casing to push the pins into the cover, allowing release. In the same motion the actuators force will move stopper down and seal the gap.

4.2.4 Evaluation

An actuator would have to exert a large force to set all the parts into motion as the mechanism is working against the direction pull. There is a probability of large shear forces and friction on the pins. The spring will have to be powerful enough to push the pins inward, which means that the actuator has to be even stronger. There are uncertainties to size as a result of the force required for release and there are possible jamming scenarios.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	3	3	2	4	3	3	26,5

Table 18: Section of matrix in ch 1.6.2

4.2.5 Conclusion

As it is not preferable to work against the direction of pull and other issues previously mentioned. This concept will be discarded.

4.3 Snap Lock

4.3.1 Idea Drawing

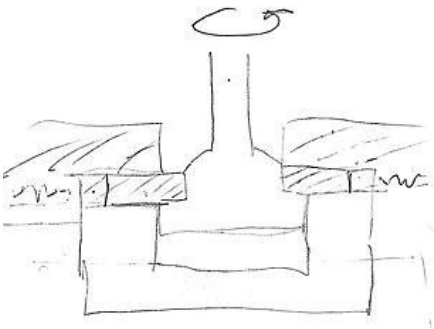


Figure 34

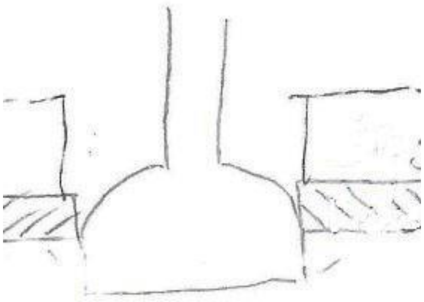


Figure 35

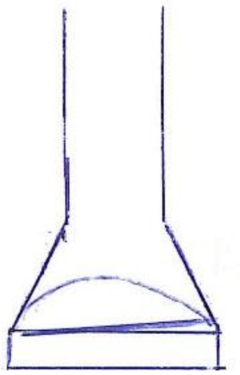


Figure 36

4.3.2 Description

In this concept the pin works as a seal for the hole in the missile, and as the locking mechanism for the cover. The pin holds the cover with sliding-blocks on the two sides that are horizontal. It releases by rotating, so that the sliding-blocks are pushed to the sides. The pin is spring-loaded, so when it is released from the cover, the pin will retract and cover the hole. We thought of a rotational spring and preventive actuator for pin-rotation. The pin could be mounted opposite of what is illustrated which would be less space-consuming but would require a separate seal for gap-closure.

4.3.3 Evaluation

The mechanism does not consist of many parts. There is a possibility of jamming due to friction on the sliding-blocks. It has low space requirement. There are issues regarding friction between the close-contact surfaces between the pin and the sliding-blocks. Draft angle is not an issue due to the flexible width of the sliding-blocks.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	3	3	5	4	5	3	31,5

Table 19: Section of matrix in ch 1.6.2

4.3.4 Conclusion

This concept will be discarded.

4.4 Magnet

4.4.1 Idea Drawing

Figure 37

4.4.2 Description

Two strong magnets would attract each other when a magnetic field is active. The magnetic field will require a constant power, without it, the magnets will separate.

4.4.3 Evaluation

The concept is feasible in theory; however it will need a constant power source from the moment it is installed until the moment it is released. To hold the required load, the magnets would have to be very strong, hence quite space consuming. There is no physical hole in the body. All the functional requirements are fulfilled, but there are concerns when it comes to the fact that there is no mechanical fixing.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	2	3	5	5	5	4	32,3

Table 20: Section of matrix in ch 1.6.2

4.4.4 Conclusion

We decided to reject this idea seeing that the demagnetizer is too space consuming, in addition it requires a constant power source. Other than these reasons this is a great idea, which would be reliable.

4.5 Bolt Slider

4.5.1 Idea Drawing

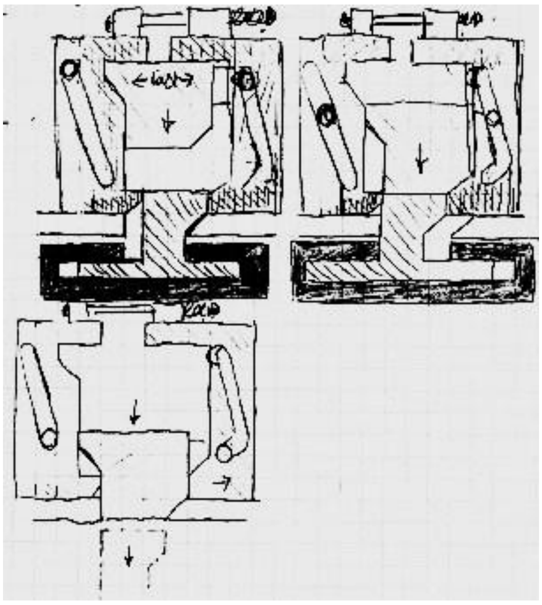
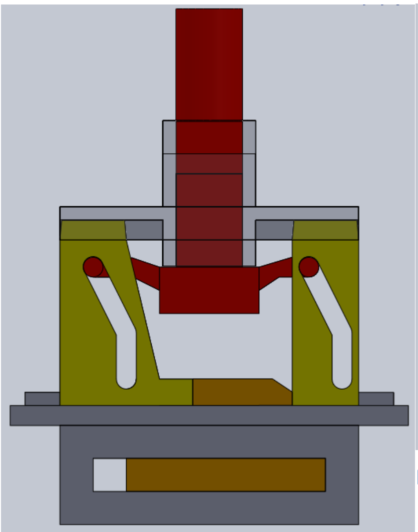


Figure 38

4.5.2 CAD Model



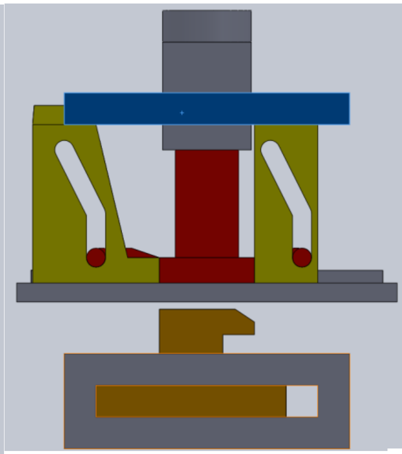


Figure 39

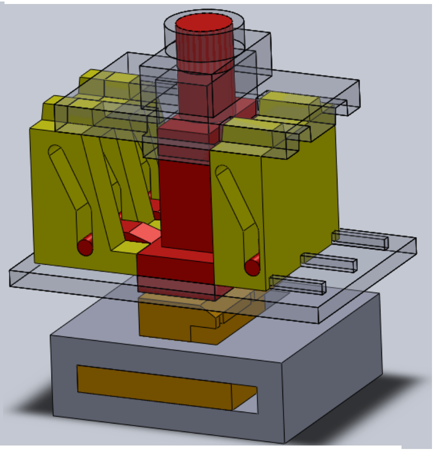


Figure 40

Figure 41

4.5.3 Description

The translucent parts in figure 41 and 40 are fixed and are part of the missile. There are two brackets (green) on each side of the sealing pin (red) which can slide back and forth, guided by the vertical movement of the sealing pin. When the pin is actuated it travels directly vertically and the guides will force the brackets to the side. The left bracket will allow the locking bolt (orange) to travel to the left. The right bracket will push it to the left and the cover will pull it out of the missile's body. The pin will at the same time seal the gap.

4.5.4 Evaluation

This is a very complex design. There are many contact surfaces and a lot of motion in several directions to allow release. The force needed to release might be large to account for the friction. It fulfills all functional requirements, but not very efficiently. Best feature is the sliding locking bolt, which would counter the draft angle issue.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
2	2	2	3	3	4	3	23,2

Table 21: Section of matrix in ch 1.6.2

4.5.5 Conclusion

This concept is discarded due to several issues.

4.6 The Clip-on

4.6.1 Idea Drawing

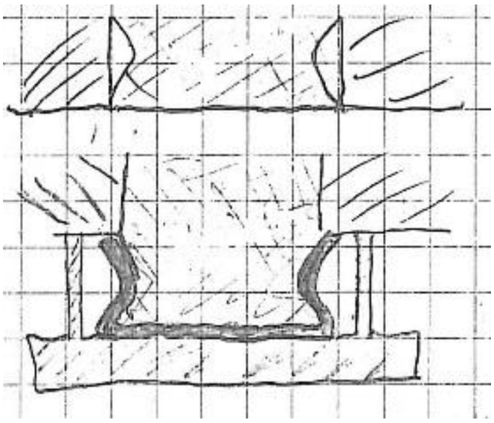


Figure 42

The top drawing illustrates the "after-release position" where the bolt has been pulled out of the clip and into its socket, closing the gap in the outer body of the missile.

4.6.2 CAD Model

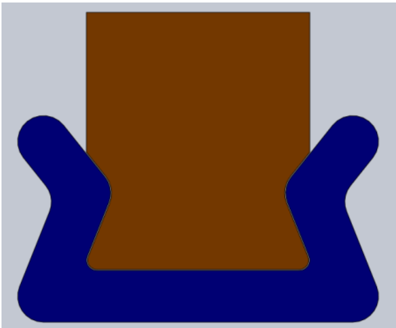


Figure 44

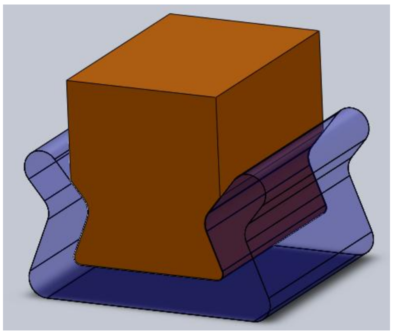


Figure 43

4.6.3 Description

The figures 44 and 43 illustrate the pre-release position, where a horizontally mounted flexible clip (blue) embraces a vertically positioned bolt (orange), fixing the cover. The bolt gets pulled into its socket by an actuator, releasing the cover and closing the gap in the outer body of the missile.

4.6.4 Evaluation

The mechanism fulfills all the functional requirements. The mechanism is relatively small, as the clip is inside the cover. Draft angle is not an issue in this mechanism as the clip's walls are collinear with the axis of draft. The force needed for release has to be larger than the pulling force from the cover.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Req.	SUM
5	5	2	5	1	5	2	30,6

Table 22: Section of matrix in ch 1.6.2

4.6.5 Conclusion

This will need a very powerful actuator which would be space-consuming. This concept will be discarded.

4.7 Strap In

4.7.1 Idea Drawing

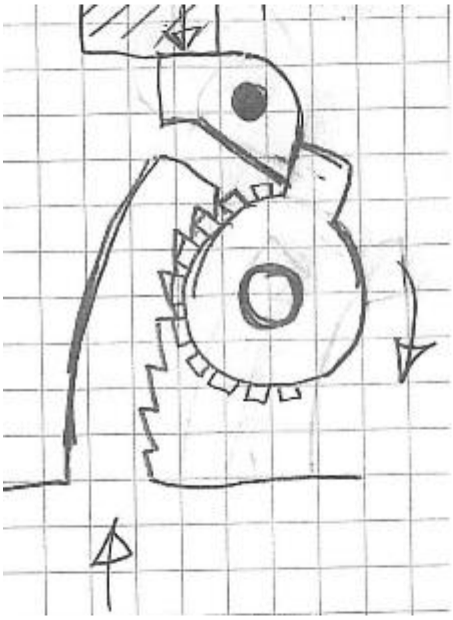


Figure 46

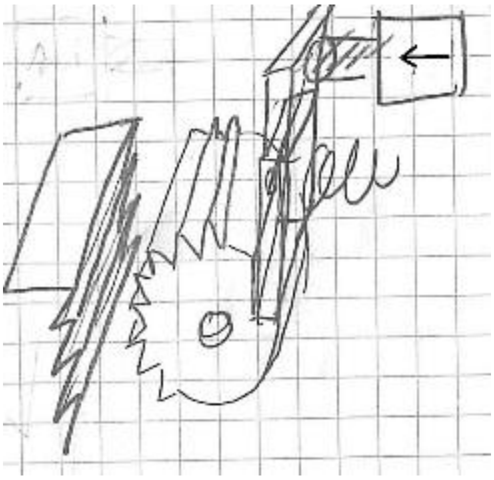


Figure 45

4.7.2 Description

Figure 45 and 46 illustrates an idea derived from the locking mechanism on a snowboard binding. The bolt protruding from the cover will engage a geared wheel with a stopper. When the bolt is in correct position the gear will be unable to release until allowed by the stoppers limiter. This will be actuated by any downward vertical force. Figure 8 illustrates the same principle but with another stopper. The stopper is a plate with rotational axis at the middle and the actuator as a limiter. The stopper will allow release when actuated by any horizontal force (in the direction illustrated).

4.7.3 Evaluation

The concept releases the cover in one vertical semi-linear motion. It is easy to assemble and easy to manufacture. It might use a directly mounted solenoid. There some complexity regarding design and construction. It acquires some space. Fragility and accuracy might be an issue. Issue of gap closure is not yet solved.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	2	2	3	3	1	1	18,6

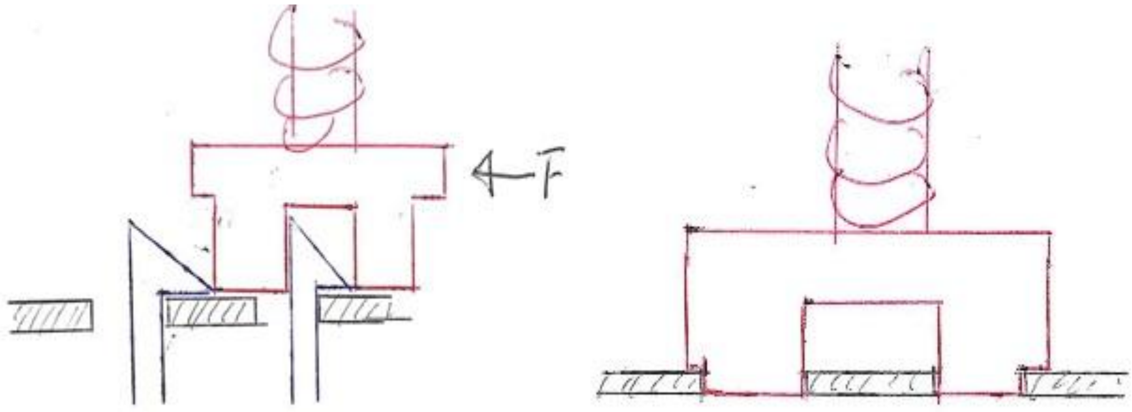
Table 23: Section of matrix in ch 1.6.2

4.7.4 Conclusion

This concept will be discarded.

4.8 Horizontal Slider

4.8.1 Idea Drawing



4.8.2 Description

The mechanism builds on the clip-on and a slide-to-release principle. The cover is held in a fixing position when the two clips are hanging onto the edge inside the missile. The stopper moves leftward, pushing the clips to release.

4.8.3 Evaluation

The concept consists of few moving parts. There are issues regarding actuation and vast shear forces on the edge of the clips as the contact between clips and missile decreases.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
4	3	3	4	3	3	3	28,8

Table 24: Section of matrix in ch 1.6.2

4.8.4 Conclusion

This concept will be discarded.

4.9 Rotating Slider

4.9.1 Idea Drawing

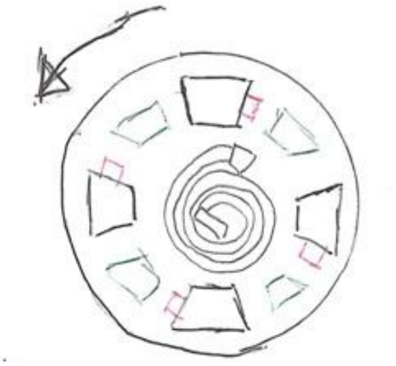


Figure 48

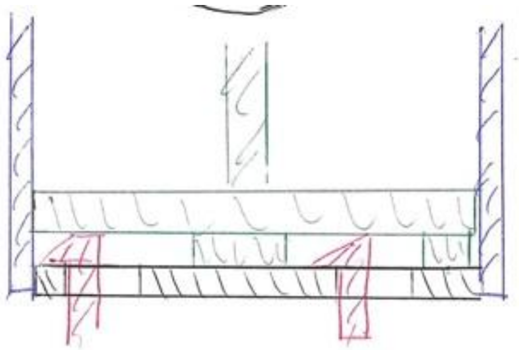


Figure 47

4.9.2 Description

This idea can be found as "Idea 5.2" in the Concept Generation Report. It is based on a rotating motion, and is divided into three circular disks. They are hereby called "top disk" (TD), "stationary disk" (SD) and "bottom disk" (BD).

- The TD has pegs on the bottom-side. This is to ensure release of the hooks from the BD when intended.
- The SD is the disk in the middle which is thought to be fixed in the allowable volume in the missile.
- The BD has hooks on the top-side. This is to ensure attachment to the inside of the SD.

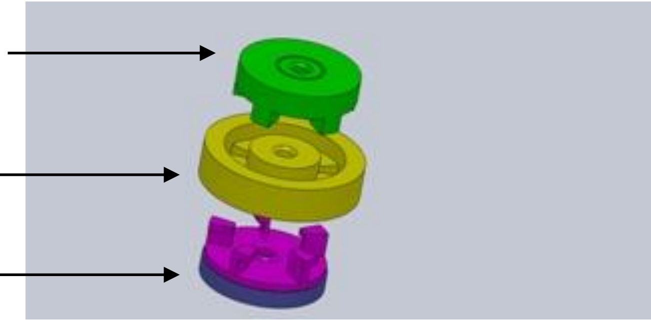


Figure 49

Fastening:
The BD is pushed through the holes in the SD and turned 25 degrees by an internal spring. The tip of the hooks makes contact with the pegs from the TD inside the SD. The TD and BD are held in position by counteracting loads from torsional springs within the TD and BD. An alternative to springs are torsional actuators.

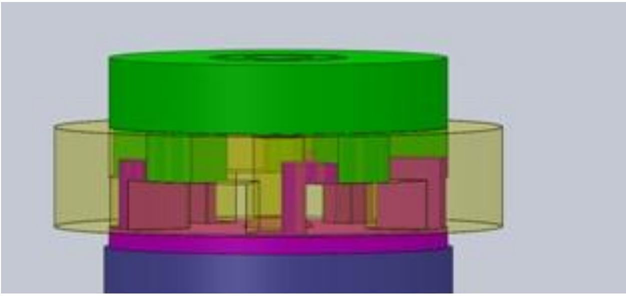


Figure 50

Release:
The TD is connected to a rotary actuator. When a signal is given to the release mechanism, the TD turns approximately 25 degrees within milliseconds (depending on the actuator). The pegs in the TD push the hooks of the BD in a circular motion towards the holes that are located in the SD.

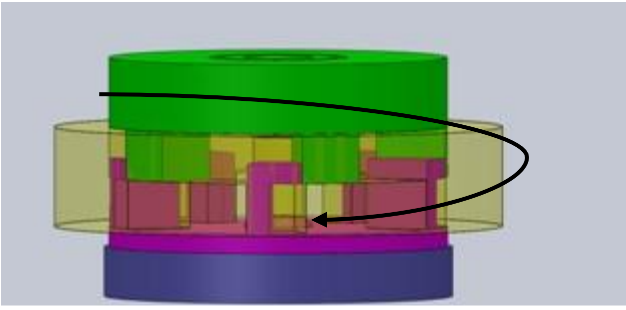


Figure 51

This causes the BD to fall out of the SD, and the TD follows through the holes and seals them.

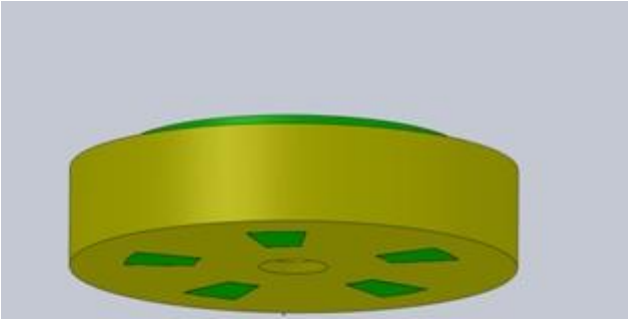


Figure 52

4.9.3 Evaluation

A positive aspect of this idea is that the same mechanism is used for both locking and releasing, which results in a rather non-complex system. The system is depending on torsional springs or an actuator to keep the hooks in place when it is in pre-release position. The mechanism is depending on a strong and reliable actuator, as it has major issues regarding friction. The high friction may result in an un-even release. The concept does not take up that much space, but it possibly needs a quite large actuator. Functional requirements are not met in a preferable way.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	3	2	4	3	3	3	27,4

Table 25: Section of matrix in ch 1.6.2

4.9.4 Conclusion

Though some issues can be solved with the use of low friction parts and/or ball-bearings, this idea will be discarded.

4.10 Rotational Lock

4.10.1 Idea Drawing

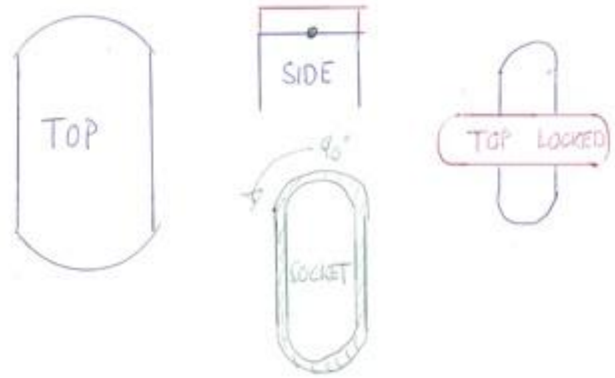


Figure 53

4.10.2 Description

The mechanism is in locking position as illustrated to the far right in figure 53. To release, the top will rotate to fit the slot, and the cover will pull out. A seal with the same proportions will follow to seal the gap.

4.10.3 Evaluation

The design of this idea is quite simple with few moving parts, which reduce jamming scenarios. Size can be quite small. It meets all the functional requirements, but we see a design problem when it comes to the draft angle.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
5	4	2	4	3	3	3	30

Table 26: Section of matrix in ch 1.6.2

4.10.4 Conclusion

We made a model of the idea, but we were not satisfied with the outcome of it. This concept will be discarded.

4.11 U-Pin Slider

4.11.1 Idea Drawing

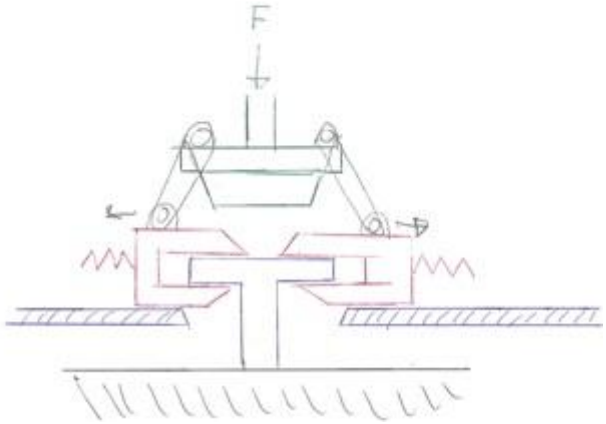


Figure 54

4.11.2 CAD Model

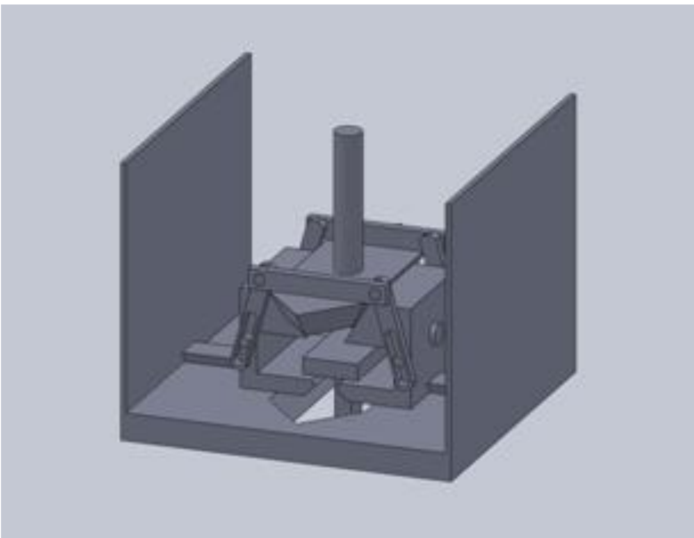


Figure 56

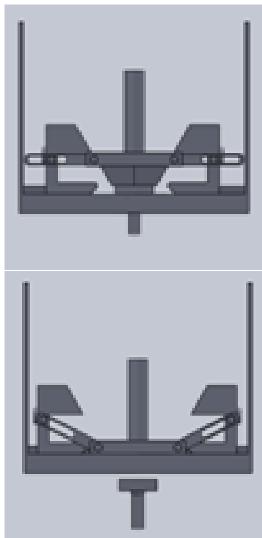


Figure 55

4.11.3 Description

In locking position the vertical load will be held by the sliding brackets and the trapezoidal rails to prevent the brackets from bending. When actuated, the sealing piston will travel downwards vertically, pushing the brackets aside, releasing the cover.

4.11.4 Evaluation

This idea consists of many moving parts. Installing this system can also be difficult because of the number of parts. The release motion is also considered poor because of the jam possibilities. The idea has low flexibility in size and is rather big. Draft angel will not be a problem but can be difficult to optimize. Overall this idea solves all functional requirements but not in a desirable way.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angel	Functional Req.	SUM
2	3	3	2	3	4	3	25

Table 27: Section of matrix in ch 1.6.2

4.11.5 Conclusion

This idea will be discarded due to several issues.

4.12 Pivot Clips

4.12.1 Idea Drawing

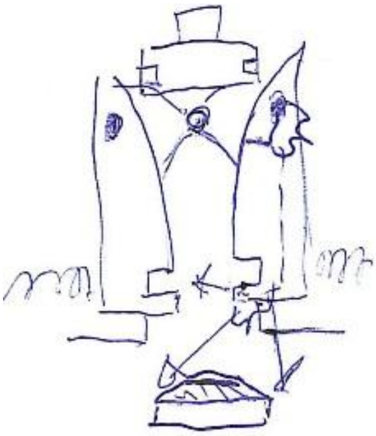


Figure 57

4.12.2 CAD Model

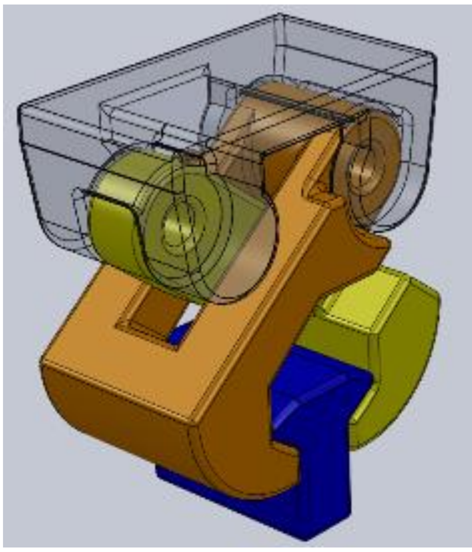


Figure 59

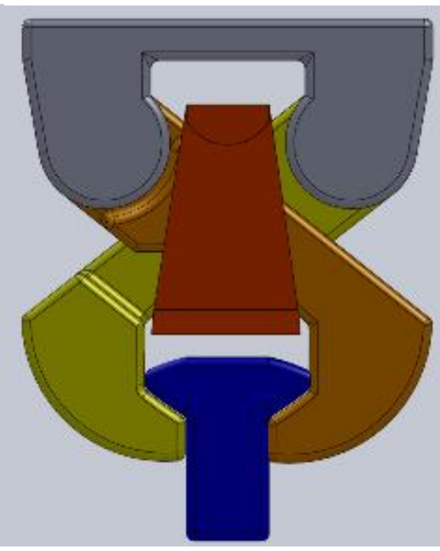


Figure 58

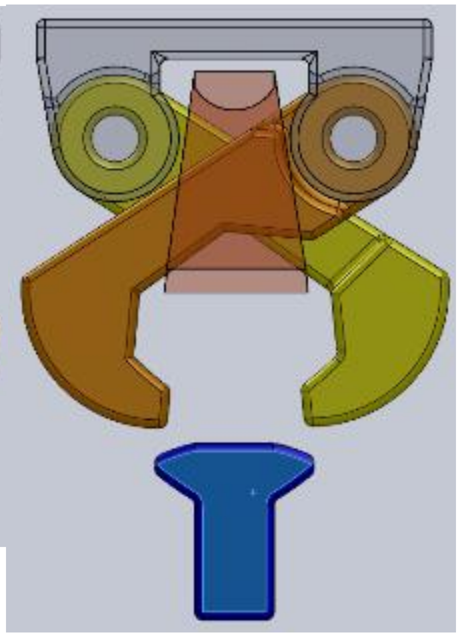


Figure 60

4.12.3 Description

In locked position (figure 60 and 59) the cover is held in place by the gripping arms. An actuator lifts a bracket (red), pushing the arms aside and releasing the cover. This concept is designed to transfer the pulling force from the cover (blue)into normal forces on the rotational axis of the gripping arms. A seal aligned underneath the red bracket will follow to seal the gap (not shown).

4.12.4 Evaluation

This mechanism will be very vulnerable to tolerances in the parts. It will also be difficult to optimize the design. The motion required for the system to release is also vulnerable to tolerances. The system must also have a certain size and have low flexibility in design changes. Overall this idea is not considered suitable.

Complexity	Assembly	Movement	Size	Force Needed	Draft Angle	Functional Req.	SUM
3	3	2	2	3	4	3	24,9

Table 28: Section of matrix in ch 1.6.2

4.12.5 Conclusion

This concept will be discarded.

KDS/ GROUP 8

Production Foundation

JSM Air Intake Cover & Wing Support System Release Mechanism - "Tobben" 7.0

Øystein Ellefsen and Morten Brodahl

24.05.2011

This document contains the production foundation for the final design of “Tobben” 7.0

Contents

1 Introduction

1.1 Abbreviations

ØE	Øystein Ellefsen
MB	Morten Brodahl

Table 1: Abbreviations

1.2 Purpose of this Document

This document contains the production foundation for the final design of "Tobben" 7.0. This includes 2D drawings and material lists.

1.3 Document Version

Document version	Date	Activities	Author
0.1	11.05.2011	Document Established, Added Headings	ØE
0.2	11.05.2011	Added Pictures and text to 2.1-2.11, Appendix	ØE
0.3	11.05.2011	Added Material Tables to 3.1 and 3.2	ØE
0.4	19.05.2011	Edited materials	ØE
1.0	23.05.2011	First Draft	ØE
1.1	23.05.2011	Edit table 3	MB
2.0	24.05.2011	Second Draft	ØE

Table 2: Document version

1.4 Related Documents

Document Name	Description
Concept Optimization Report	Contains Information About Design Choices

Table 3: Related Documents

2 Production Foundation

2.1 Exploded View

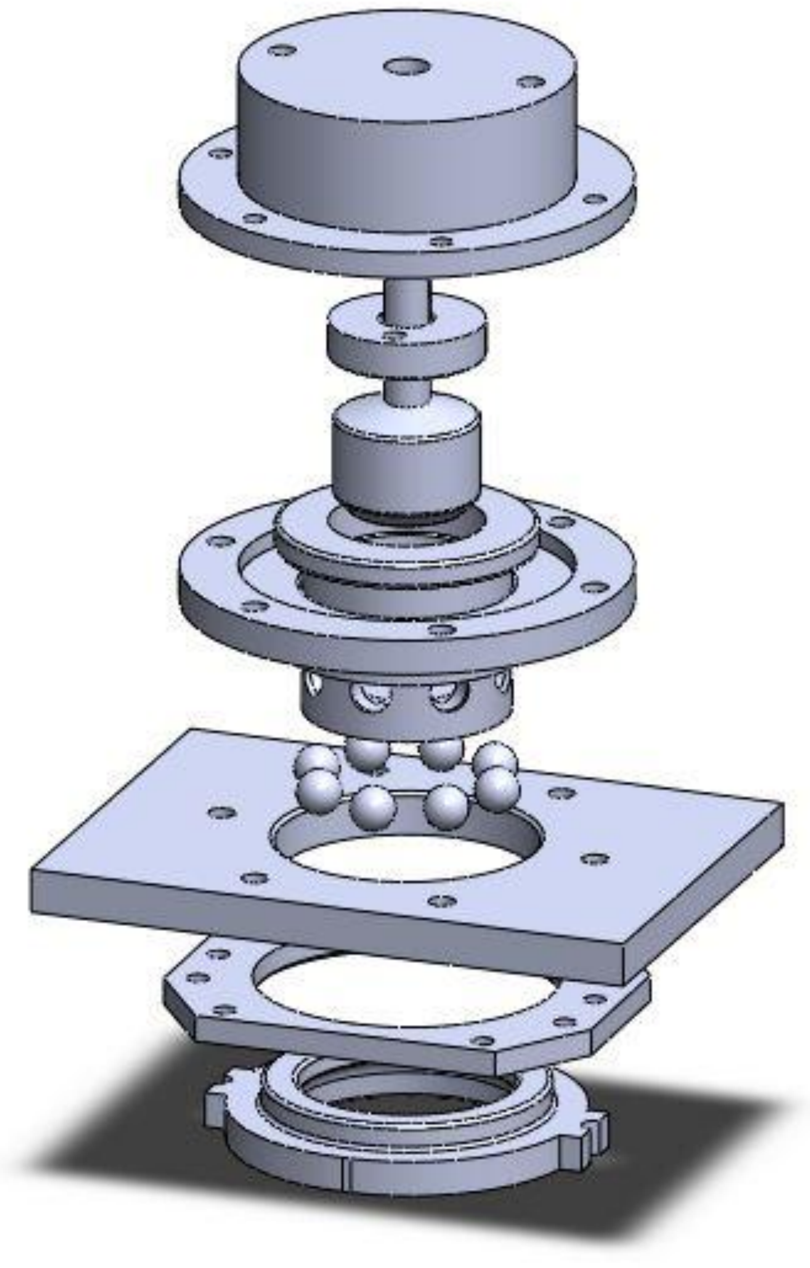


Figure 1: Exploded View

2.2 Exploded View Split

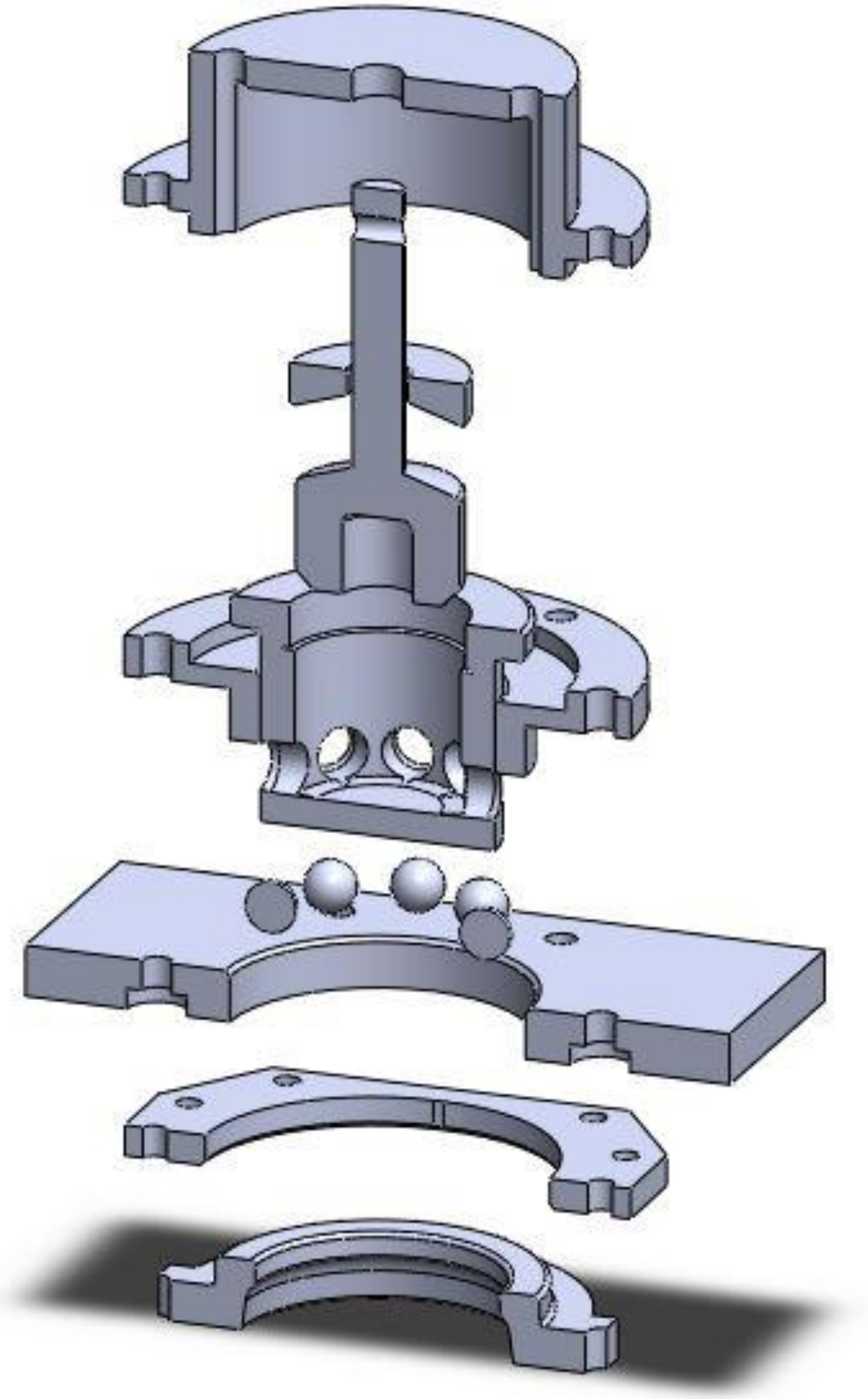


Figure 2: Exploded View Split

2.3 Ball

Figure 3: Ball

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Ball

2.4 Ball-Housing

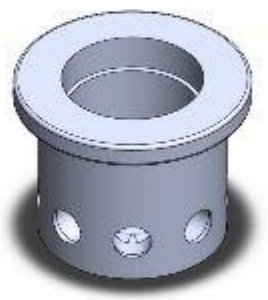


Figure 4: Ball-Housing

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Ball-Housing

2.5 Casing

Figure 5: Casing

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Casing

2.6 Casing Bracket

Figure 6: Casing Bracket

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Casing Bracket

2.7 Pin

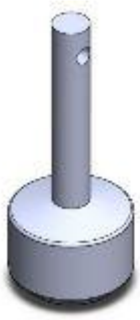


Figure 7: Pin

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Pin

2.8 Pin Stopper

Figure 8: Pin Stopper

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Pin Stopper

2.9 Inner Bracket

Figure 9: Inner Bracket

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Inner Bracket

2.10 Outer Bracket

Figure 10: Outer Bracket

- 2D drawings of this part can be found under Appendix For Production Foundation.PDF: Tobben 7.0 Outer Bracket

3 Materials

3.1 Bill of Materials

Part	Material	Quantity (mm^3)
Balls	Alfa-Beta-TI Alloys	112,76
Ball-Housing	Stainless Steel	14127,43
Casing	Aluminum Alloys	42748,28
Pin	Alfa-Beta-TI Alloys	8219,43
Pin Stopper	Aluminum Alloys	1274,63
Inner Bracket	Stainless Steel	12159,88
Outer Bracket	Stainless Steel	6068,71
Casing Bracket	Stainless Steel	17639,36

Table 3: Bill of Materials

3.2 Suggested Materials

Material	Grade	Form	UTS	YS	Elong.	Spec
Balls	TI-6Al-4v Solution Heat, Treated and Aged	Round Bar	972MPa	903 MPa	10%	AMS 4965, AMS 6930 Round, Square, Hex Bar
Ball-Housing	Custom 465 H950	Bar	1667 MPa	1528 MPa	10%	AMS 5936 Bar
Casing	7050-T7451	Plate	500 MPa	431 MPa	9%	AMS 4050
Pin	TI-6Al-4v Solution Heat, Treated and Aged	Round Bar	972MPa	903 MPa	10%	AMS 4965, AMS 6930 Round, Square, Hex Bar
Pin Stopper	7050-T7451	Plate	500 MPa	431 MPa	9%	AMS 4050
Inner Bracket	Custom 465 H950	Bar	1667 MPa	1528 MPa	10%	AMS 5936 Bar
Outer Bracket	Custom 465 H950	Bar	1667 MPa	1528 MPa	10%	AMS 5936 Bar
Casing Bracket	Custom 465 H950	Bar	1667 MPa	1528 MPa	10%	AMS 5936 Bar

Table 4: Suggested Materials

4 Appendix

- Appendix For Production Foundation.PDF

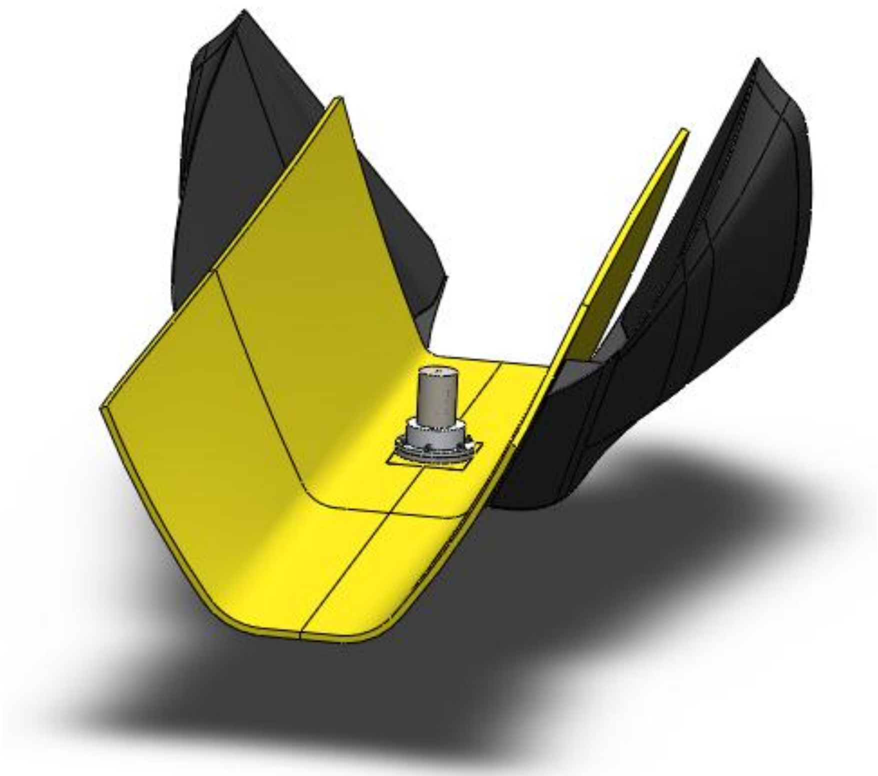
KDS/ GROUP 8

User Guide

JSM Air Intake Cover & Wing Support System Release Mechanism – "Tobben" 7.0

Marius Tøien, Lars Meskestad and Øystein Ellefsen

24.05.2011



This document contains information on how to install and maintain "Tobben" 7.0

Contents

1 Introduction

1.1 Abbreviations

MT	Marius Tøien
ØE	Øystein Ellefsen
LM	Lars Meskestad
JSM	Joint Strike Missile

Table 1: Abbreviations

1.2 Purpose of this Document

This document will guide you through the assembly and maintenance of “**Tobben 7.0”**. It also contains list of parts and how to install “**Tobben” 7.0** onto the Joint Strike Missile.

1.3 Document Version

Document version	Date	Activities	Author
0.1	10.05.2011	Document Established	MT
0.2	10.05.2011	Added Chapters, Introduction, Related Documents	ØE
0.3	10.05.2011	Added Part List	ØE
0.4	21.05.2011	Added ch. 3	LM
0.5	22.05.2011	Added ch. 4	LM
0.6	23.05.2011	Edited document	ØE
1.0	23.05.2011	First Draft	ØE
1.1	23.05.2011	Added ch. 5 and finilized document	LM
2.0	24.05.2011	Second Draft	LM
2.1	24.05.2011	Edited headlines	LM
3.0	24.05.2011	Third Draft	LM

Table 2: Document version

1.4 Related Documents

Document Name	Description
Concept Optimization Report	Contains basis for design choices
Production Foundation	Contains dimensions and part description

Table 3: Related Documents

2 Part List:

Part No. (#)	Part Name	Qty.	Description
1	Casing Bracket	1	
2	Ball Housing	1	
3	Ball	8	
4	Pin	1	
5	Pin Stopper	1	
6	Casing	1	
7	Inner Bracket	1	
8	Outer Bracket	1	
9	Hex Flange Machine Screw	6	B18.6.7M – M3x0.5x6
10	Socket Set Screw Oval Point	2	B18.3.6M – M3x0.5x6

Table 4: Part List

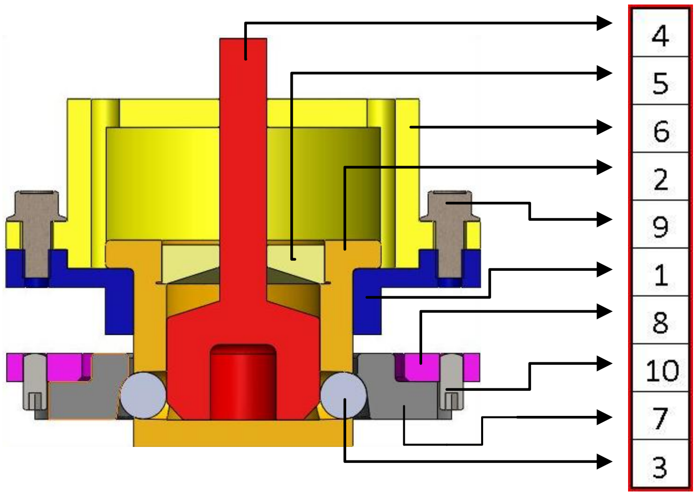


Figure 2 - Split View

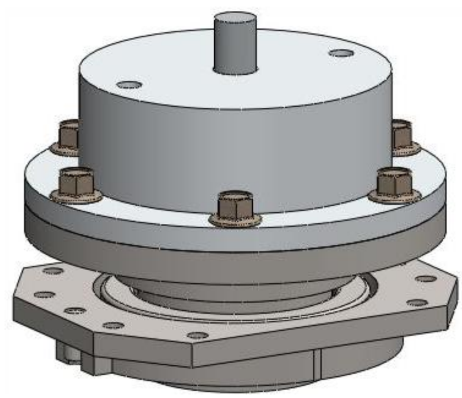


Figure 1 – Isometric View

For thorough part description, see Table 3: Related Documents

3 Assembly instructions: “Tobben” 7.0

Step 1: Ball Housing (#2)/ Casing Bracket (#1)

Insert **Ball Housing** (#2) into **Casing Bracket** (#1)

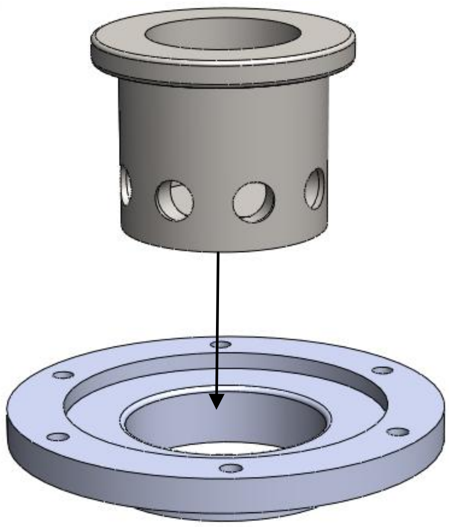


Figure 4 - Step 1 Before

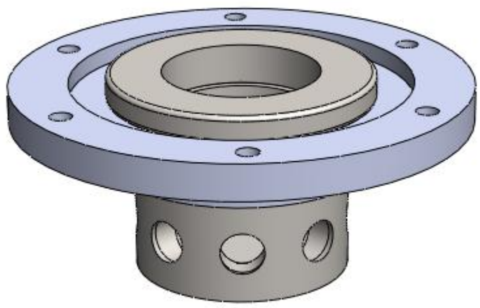


Figure 3 - Step 1 After

Step 2: Balls (#3)

Insert eight (8) of **Ball** (#3) into **Ball housing** (#2) from inside.

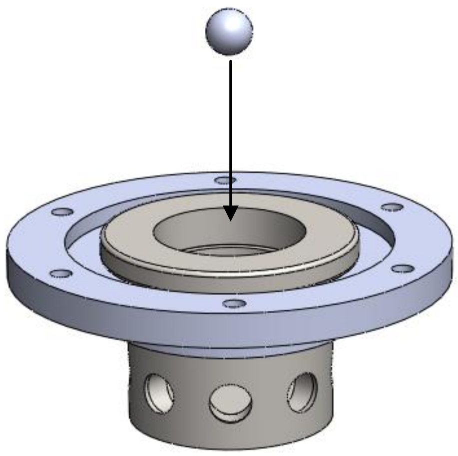


Figure 6 - Step 2 Before

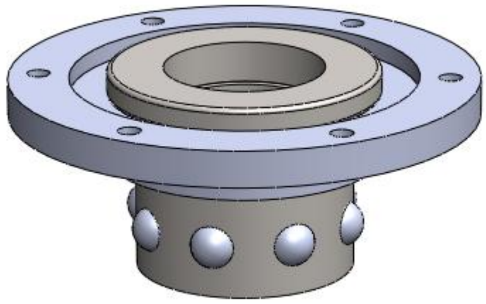


Figure 5 - Step 2 After

Step 3: Pin (#4)

Insert **Pin** (#4) into **Ball Housing** (#2). Make sure **Pin** (#4) is fully inserted.

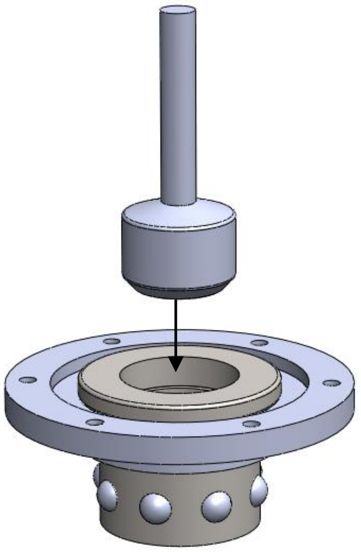


Figure 8 - Step 3 Before

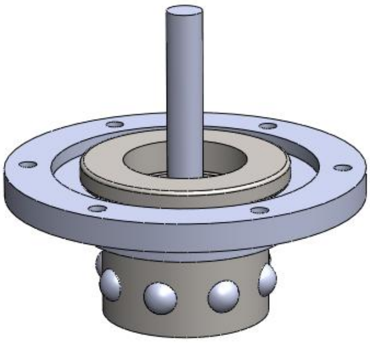


Figure 7 - Step 3 After

Step 4: Pin Stopper (#5)

Screw **Pin Stopper** (#5) into socket in **Ball Housing** (#2)

NB! Mount Pin Stopper (#5) with flat surface visible (upwards)

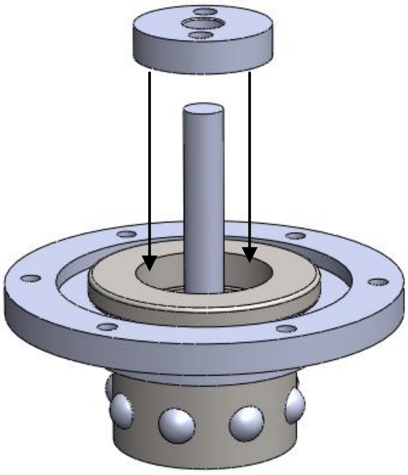


Figure 10 - Step 4 Before

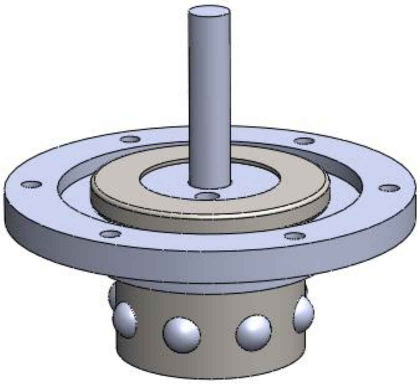


Figure 9 - Step 4 After

Step 5: Lubrication

If required: Apply necessary amount of lubricant into holes in **Pin Stopper** (#5)**.** Turn and move **Pin** (#4) up and down to allow lubricant to cover all contact surfaces inside the **Ball Housing** (#2).

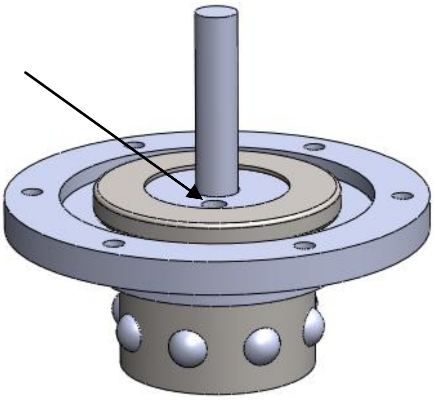


Figure 11 - Ball Housing Lubrication

Step 6: Casing (#6)

Mount **Casing** (#6) onto **Casing Bracket** (#1).

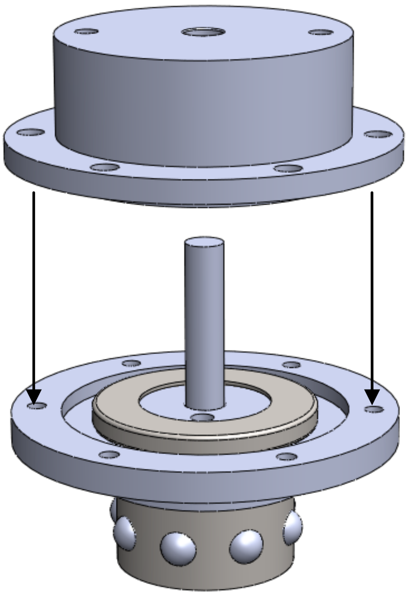


Figure 12 – Step 6 Before

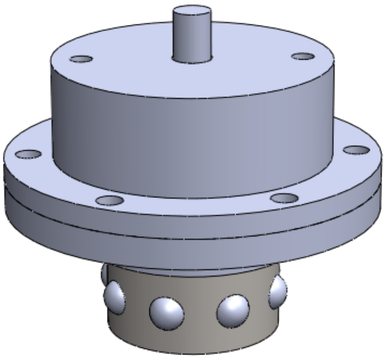


Figure 13 - Step 6 After

Step 7: Hex Flange Machine Screws (#9)

Fasten six (6) **Hex Flange Machine Screws** (#9) into flange holes on **Casing** (#6) and **Casing Bracket** (#1). Make sure fasteners do not protrude from the bottom-surface of **Casing Bracket** (#1), see figure 16.

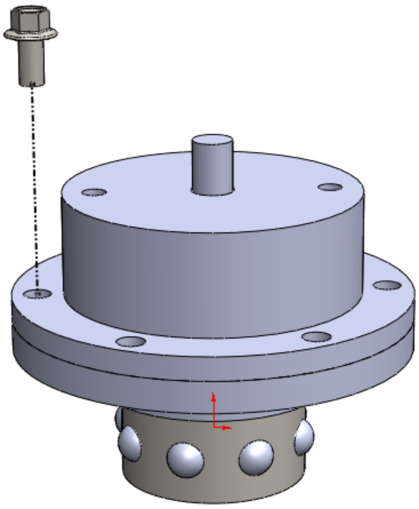


Figure 16 - Step 7 Before

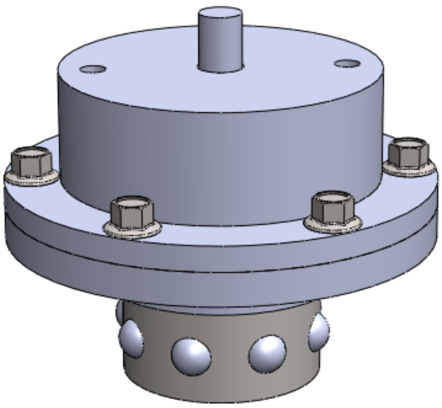


Figure 14 - Step 7 After

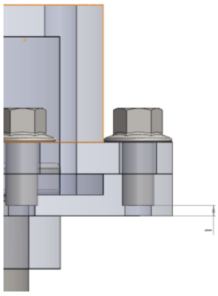


Figure 15 - Fasteners Split View

Step 8: Verification of Surface-transition and Function

Pull **Pin** (#4) up, pulling **Ball Housing** (#2) into **Casing** (#6). Verify surface transition from bottom-surface of **Ball Housing** (#2) to bottom-surface of **Casing Bracket** (#6) with respect to step and gap < 0.1 mm, see figure 18.

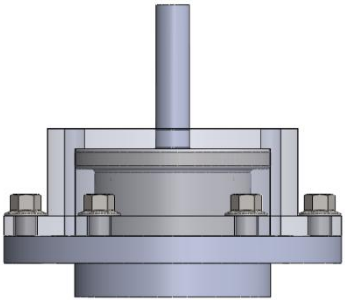


Figure 17 - Pin Retracted - Transparent Casing

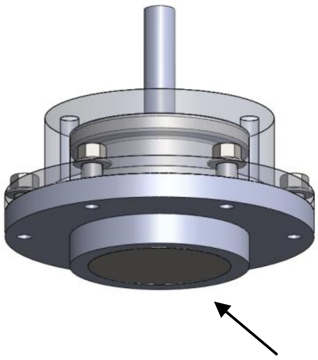


Figure 18 - Surface Transition Inspection

Step 9: Lubrication

If required: Apply necessary amount of lubricant into holes in **Casing** (#6).

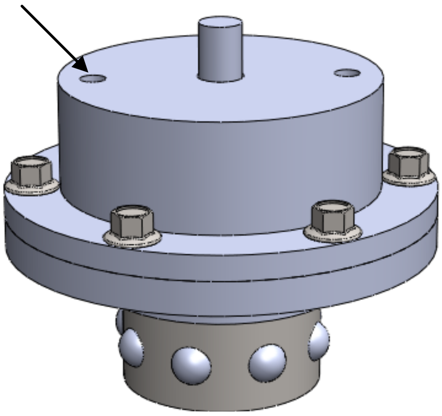


Figure 19 - Casing Lubrication

4 Installation of "Tobben" 7.0 onto JSM-Skin

Installation on Joint Strike Missile: Requires JSM –Skin, – Air Intake Cover & Wing Support System and an Actuator. Hereby refered to as **Skin** and **Cover** and **Actuator.** Installation of a **Gasket** between **Cover** and **Tobben 7.0** is preferable and is illustrated in **Step 7** but is not a part of the release mechanism (**Tobben 7.0**). **Fittings** for holes as illustrated in **Step 10** is preferable but not part of the release mechanism (**Tobben 7.0**). **Screws** for installation of **Cover** to **Brackets** in **Step 9** have custom properties not mentioned in this document, are not a part of the release mechanism (**Tobben 7.0**)and are for illustrational purposes only.

NB! Surface Coating is NOT illustrated in the following procedures.

Step 1: Adhesive

Apply adhesive film onto contact-surface between **Skin** and **"Tobben" 7.0**, see figure 21.

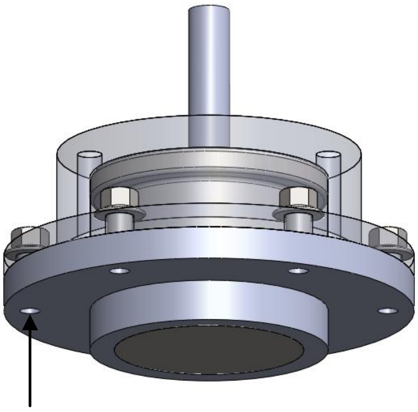


Figure 20 - Adhesive film position

Step 2: Placement of "Tobben 7.0"

Insert **Tobben 7.0** into hole in **Skin**.

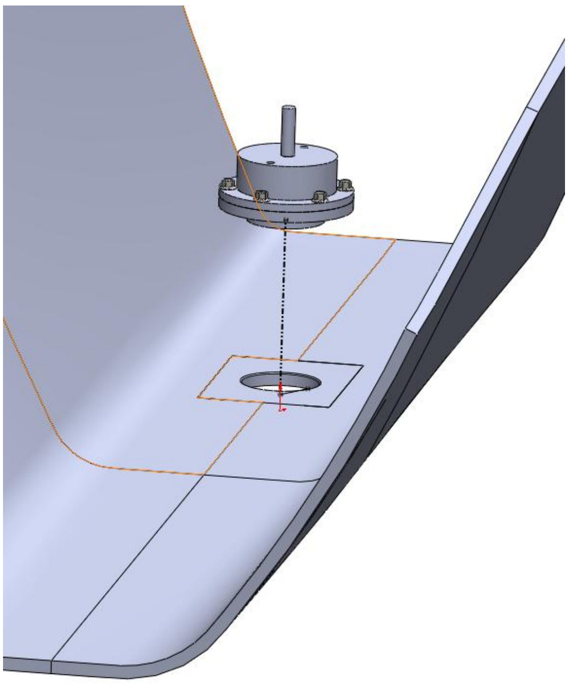


Figure 22 - Step 2 Before

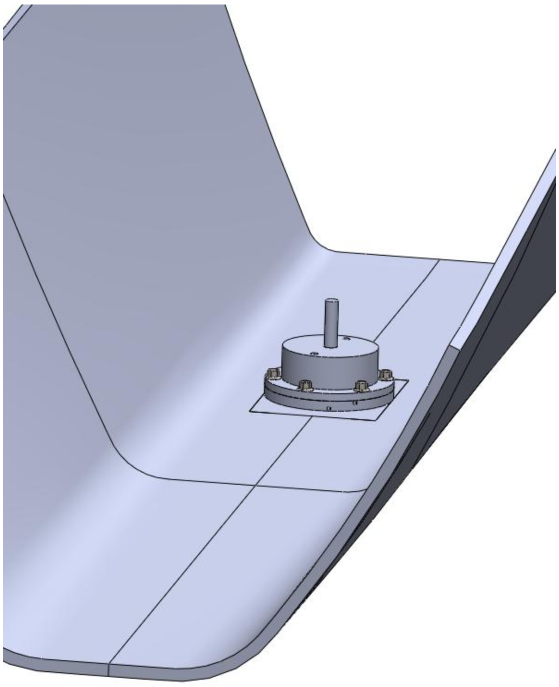


Figure 21 - Step 2 After

Step 3: Verify Surface-transition

Pull **Pin**(#4) to retract **Ball Housing** (#2), figure 24.

Verify surface trasitions between bottom-surfaces of **Ball Housing** (#2), **Casing Bracket** (#1) and **Skin** with respect to step and gap < 0.1mm, figure 25.

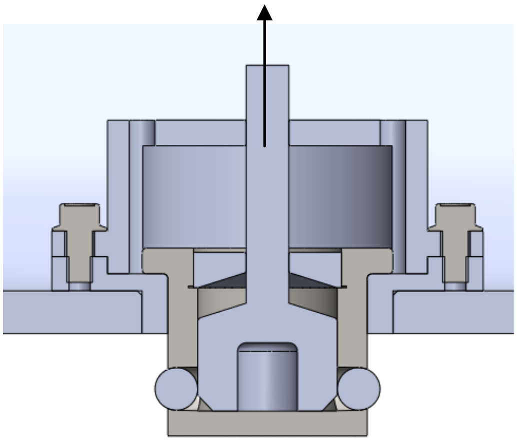


Figure 23 - Pin Retraction - Split View

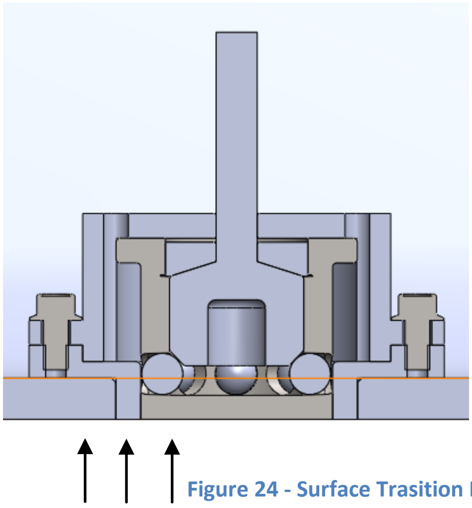


Figure 24 - Surface Trasition Inspection

Step 4: Bracket Assembly

Place **Outer Bracket** (#8) onto **Inner Bracket**(#7), as illustrated in figure 26, with chamfer on **Outer Bracket** (#8) (blue in figure 27) towards **Inner Casing** (#7). Lubricate contact surfaces as needed.

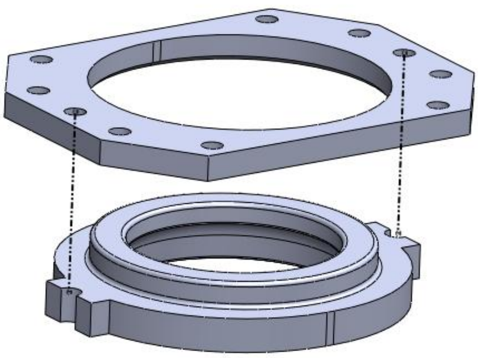


Figure 25 - Step 4 Before

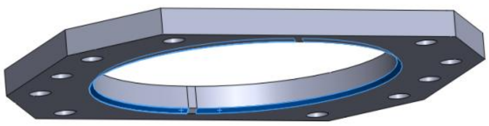


Figure 26 - Chamfer position on Outer Bracket (#8)

Fasten 2 x **Socket Set Screw Oval Point** (#10) into holes in **Outer Bracket** (#8), as illustrated in figure 29. Make sure **Socket Screws** (#10) does not protrude from **Outer Bracket's** (#8) top-surface, see figure 28.

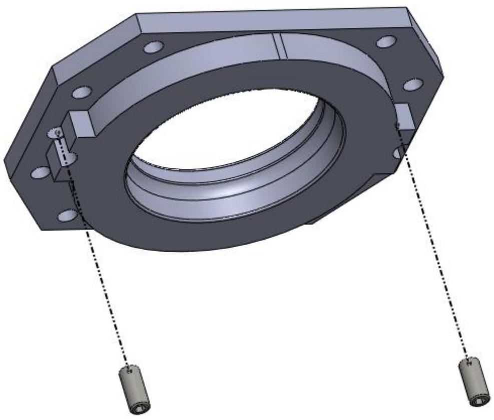


Figure 28 - Screw insertion position - Outer Bracket (#8)

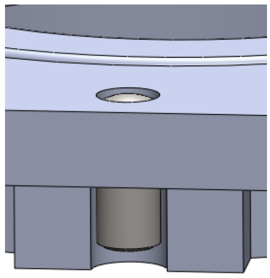


Figure 27 - Socket Screw Position - Close View

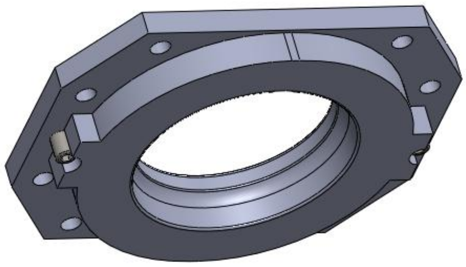


Figure 29 - Step 4 After

Step 5: Installing Brackets

Pull **Pin** (#4) to allow **Balls** (#3) to retract (figure 33). Do **NOT** retract **Ball Housing** (#2).
Place **Brackets** (#7/8) onto **Ball Housing** (#2), see figure 31/32.

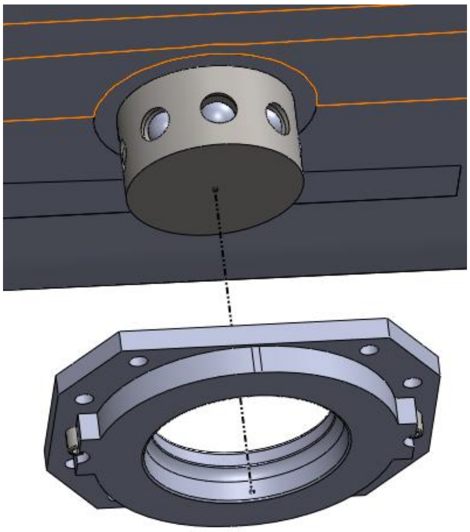


Figure 32 - Retracted balls

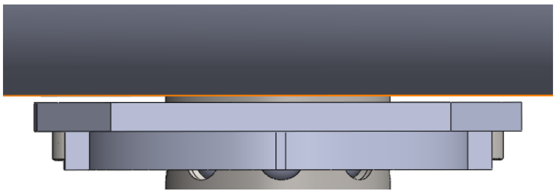


Figure 30 - Brackets Positioning

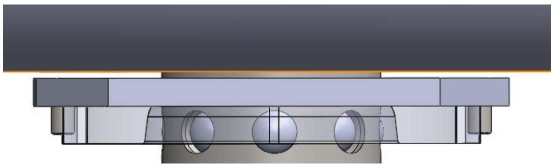


Figure 31 - Brackets Positioning - Transparent Inner Bracket (#7)

Push **Pin** (#4) down, pushing **Balls** (#3) out (figure 34). Pull **Brackets** (#7/8) down to rest on **Balls** (#3) (figure 35).

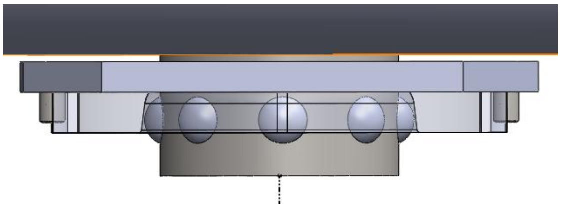


Figure 33 - Ball Lockout

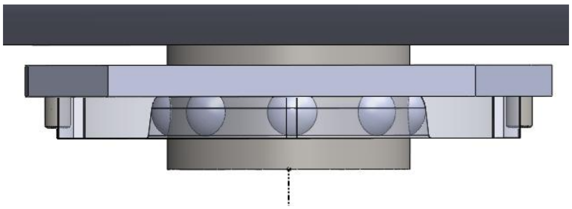


Figure 34 - Step 5 After

Step 6: Install Actuator

Mount intended **Actuator** to **Pin** (#4) before fastening **Actuator** to **Casing** (#6). The **Actuator** shown is for illustrational purposes only.

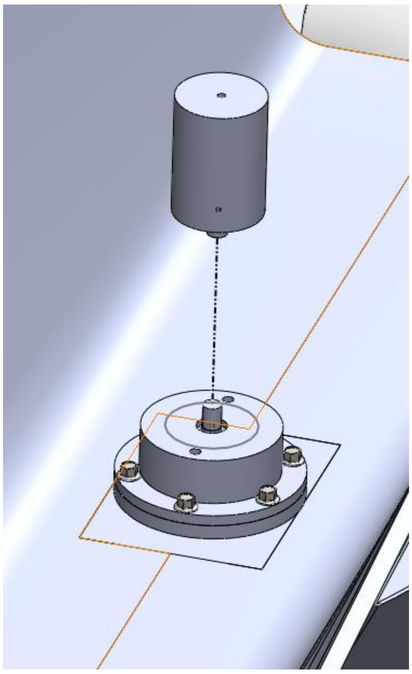


Figure 36 - Step 6 Before

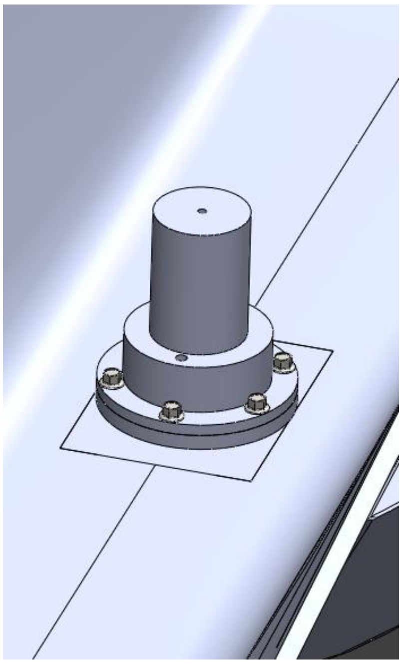


Figure 35 - Step 6 After

Step 7: Install Gasket

If necessary: Apply **Gasket** onto **Cover** for damping. As illustrated in figure 38/39.

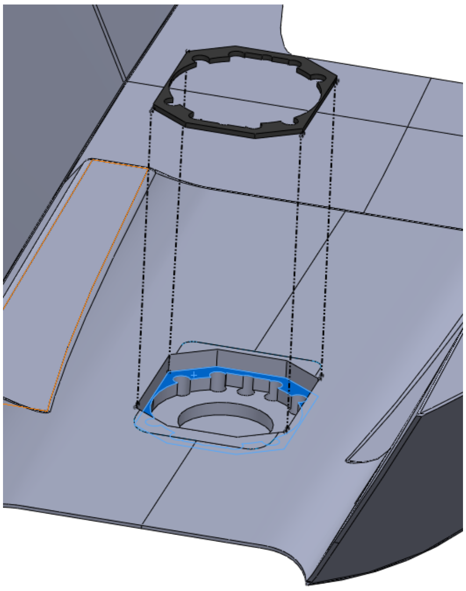


Figure 38 - Step 7 Before

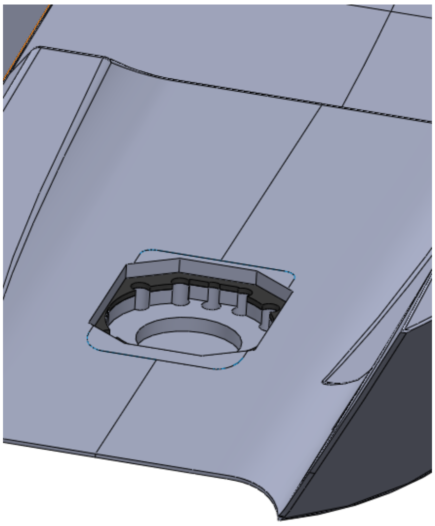


Figure 37 - Step 7 After

Step 8: Install Cover

Mount **Cover** onto **Skin** at rear axis rotation point.

Rotation axis shown is not part of assembly. Illustrative purposes only.

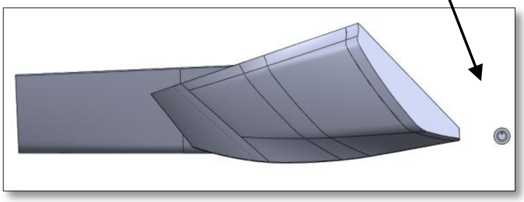


Figure 39 - Rotation Axis

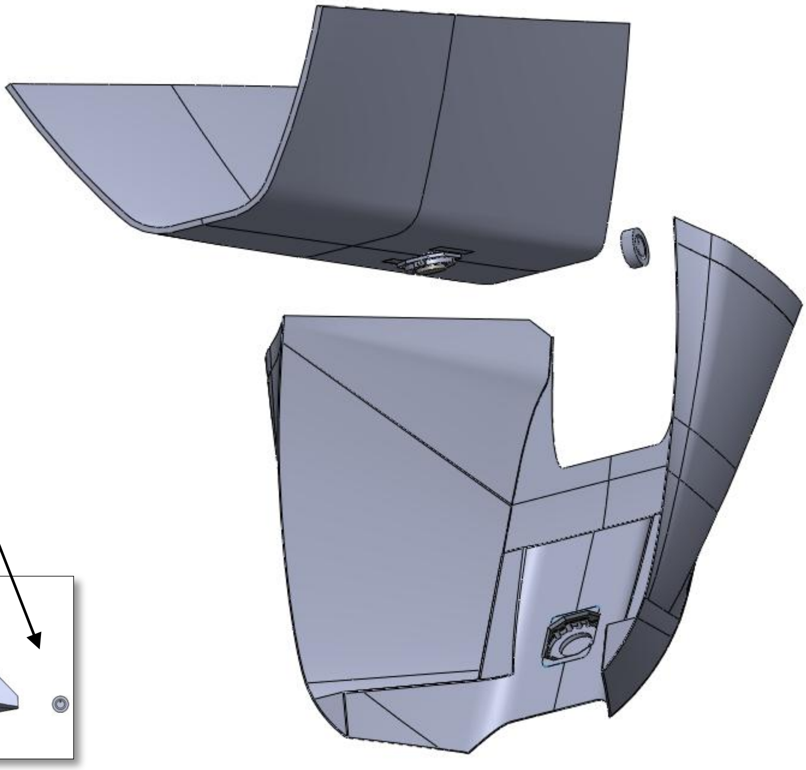


Figure 40 - Step 8

Step 9: Mount Cover to Brackets

Insert 8 x preferred **Screws** (M3x05x10) as shown in figure 42/43.

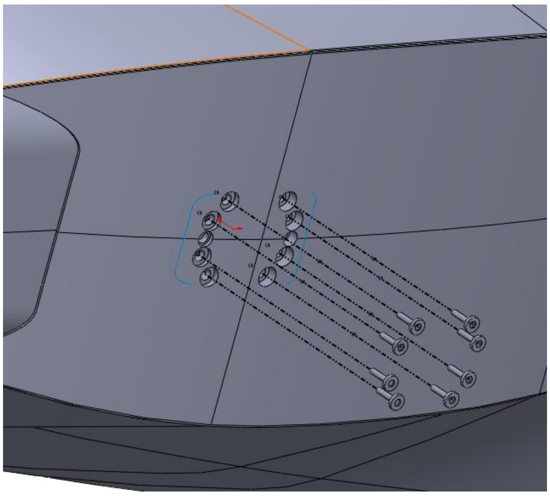


Figure 42 - Cover Fasteners Position

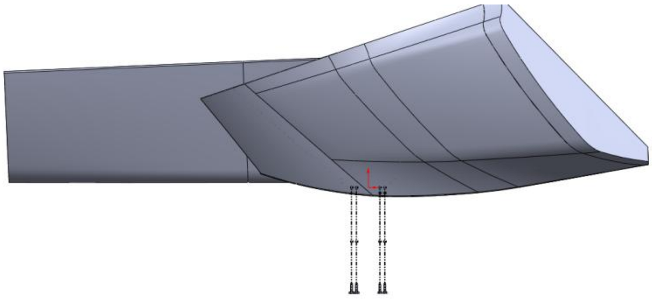


Figure 41 - Cover Fasteners Position - Side View

Screw into **Outer Bracket** (#8), as shown in figure 44/45. **Tobben 7.0** and **Skin** are not shown, for visual purposes. Adjust cover position relative to Skin by ± 1 mm in both directions of x/y plane.

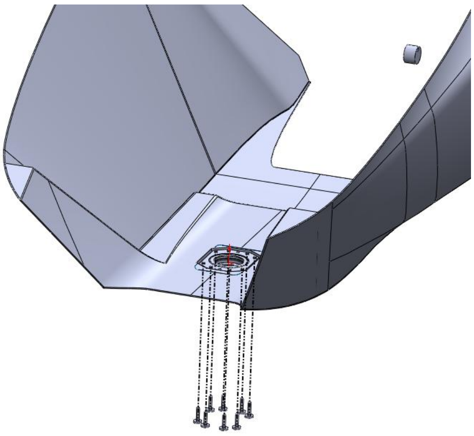


Figure 43 - Cover/ Outer Bracket position

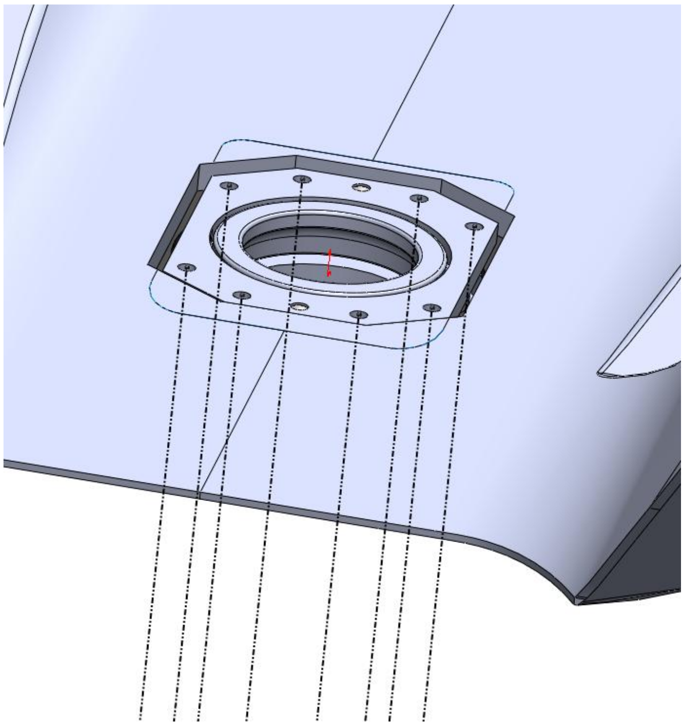


Figure 44 - Cover/ Bracket Position - Close View

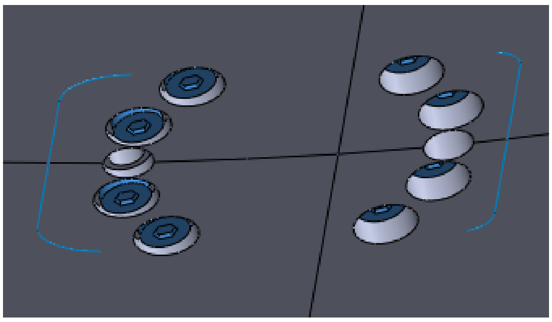


Figure 45 - Step 9 After

Step 10: Remove Socket Set Screws

Remove 2 x **Socket Set Screw Oval Point** (#10) (color blue in figure 48) from **Outer Bracket** (#8), see figure . Insert **Fittings** into holes, as illustrated in figure 47.

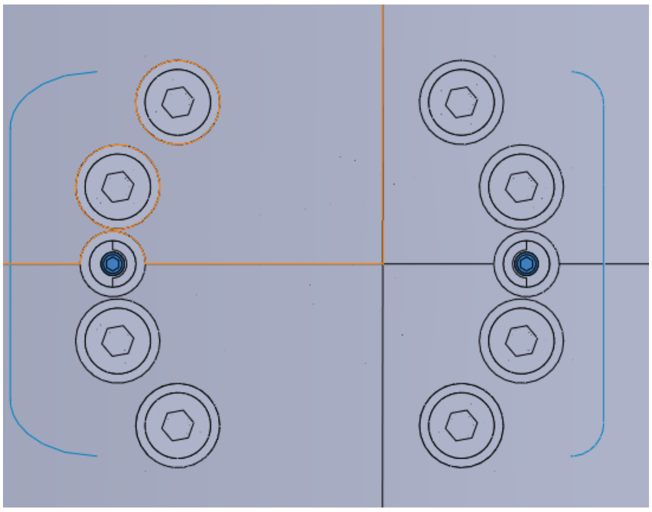


Figure 46 - Step 10 Before

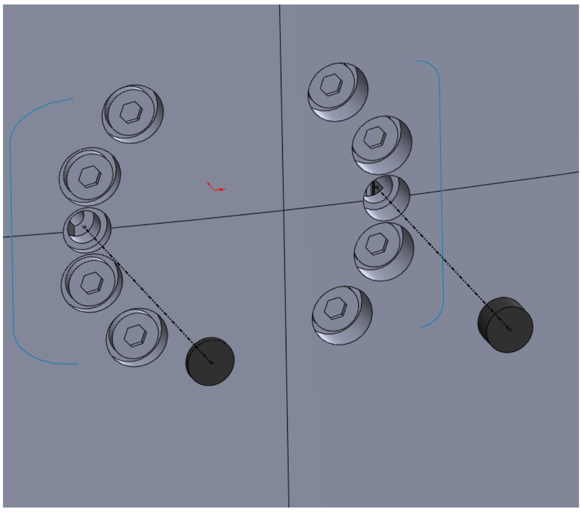


Figure 47 - Fittings

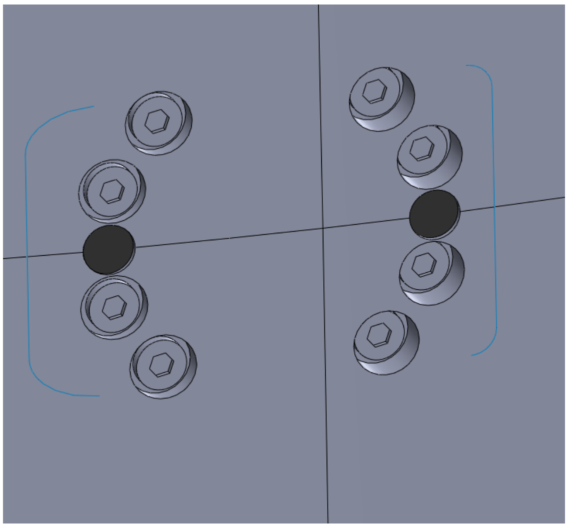
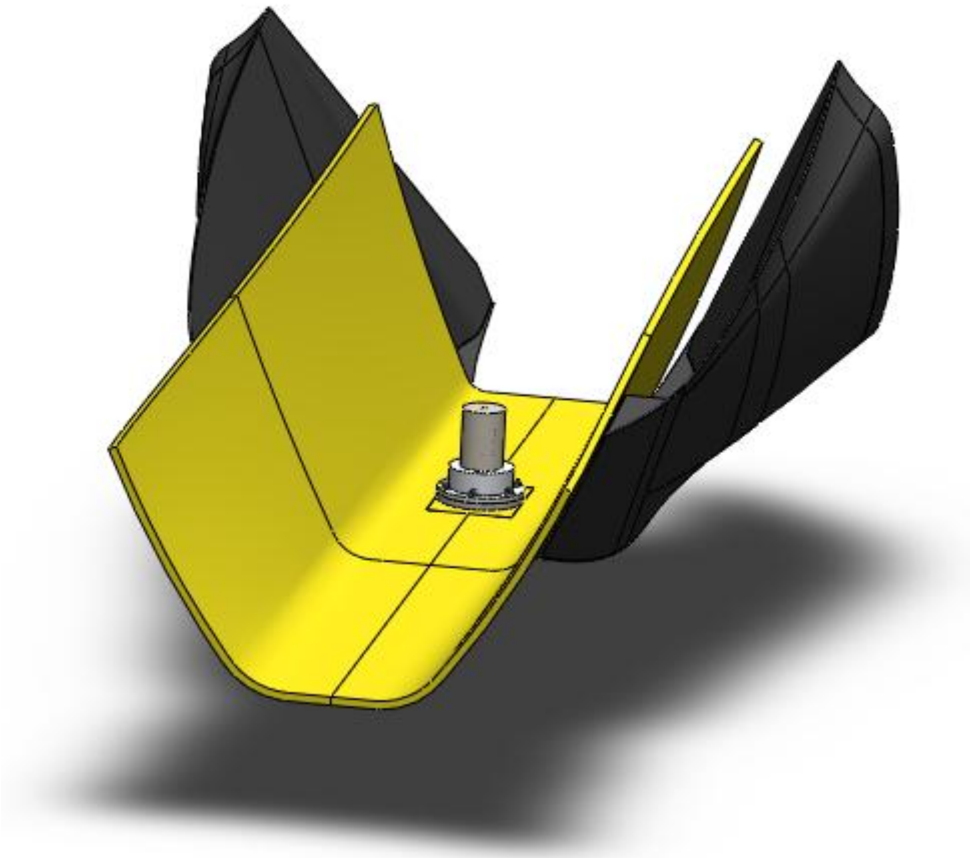


Figure 48 - Step 10 After

The installation of the release mechanism - Tobben 7.0 onto the Joint Strike Missile is now complete.



5 Maintenance

To maintain **Tobben 7.0**, repeat **Step 9** and/or **Step 5** in **chapter 3 – Assembly: Tobben 7.0**. If necessary, lubricate according to **Step 4** in **Chapter 4 – Installation**.

NB! **Actuator** is a critical component for the function of **Tobben 7.0** and should be maintained according to manufacturer.

Information about maintenance frequency of **Tobben 7.0** should be a result of testing and should be a part of this chapter when available.

KDS/ GROUP 8

Post Analysis Report

JSM Air Intake Cover & Wing Support System Release Mechanism

Lars Meskestad, Morten Brodahl, Marius Tøien, Øystein Ellefsen and Raymond Evje

26.05.2011

This document contains a post analysis of the project.

Contents

1 Introduction

1.1 Abbreviations

MB	Morten Brodahl
MT	Marius Tøien
ØE	Øystein Ellefsen
RE	Raymond Evje
LM	Lars Meskestad

Table 1: Abbreviations

1.2 Purpose of this Document

This document serves as a summary of our project. It will also contain our evaluation of the project as a whole.

1.3 Document Version

Document version	Date	Activities	Author
0.1	04.05.2011	Document Established	MB
0.2	23.05.2011	Added Chapter 1,2,3 and 4.	MT
0.3	24.05.2011	Added text to 3.3	ØE
0.4	24.05.2011	Added text to ch 2.2, 2.3 and 3.2	MT
0.5	24.05.2011	Edited Document. Added text to 3.5	MB
0.6	24.05.2011	Added risk analysis to planning, and text to 3.4	RE
0.7	24.05.2011	Edited ch 2.3	MT
0.8	24.05.2011	General editing. Added text to ch 3.1	LM
0.9	24.05.2011	Added text to ch 4	MT
1.0	24.05.2011	First Draft	LM
1.1	26.05.2011	Added graph to ch 2.3	LM
2.0	26.05.2011	Second Draft	LM

Table 2: Document version

1.4 Related Documents

Document Name	Description
Project Plan	Contains detailed information about the progress plan for the project

Table 3: Related Documents

2 Project Progression

2.1 Selecting Assignment

When we were to select assignment for our thesis we had some key priorities that we considered. These points were:

- Interesting theme
- Flexibility regarding amount of work
- Only mechanical challenges
- As realistic as possible
- Available resources from employer

After meeting with KDS we all agreed that this was an assignment that suited the group. It had a flexible amount of work and could easily be extended. We also got a generally good impression from the staff involved. The assignment seemed challenging but yet manageable.

2.2 Planning

As we started planning our project in the first semester, we quickly realized the difficulty of estimating the time consumption of each activity. It was also difficult to estimate in which phases to place each activity. As we did not have any experience with planning relative large projects, we expected to meet problems. Our solution to these problems was to have available resources in periods where we assumed to encounter problems and plan ahead for the unexpected.
In addition to conducting a risk analysis, we took into account that group members could become ill from time to time throughout the project. This turned out to be a good decision, as we almost lost 70 working hours to illness.

Our project plan was divided into two phases where the first phase dealt with generating concepts and the development of multiple concepts. This phase ended with the selection of one concept.
The second phase dealt with the optimization of the concept chosen in the first phase. This phase ended with the completion of the project.

For our project model we chose an evolutionary incremental model which we worked iteratively with. This allowed us to jump back and forth between the activities. This model suited us well since our knowledge about the problem areas increased as the project progressed. It was therefore crucial that we could go back and perform changes with the new input.

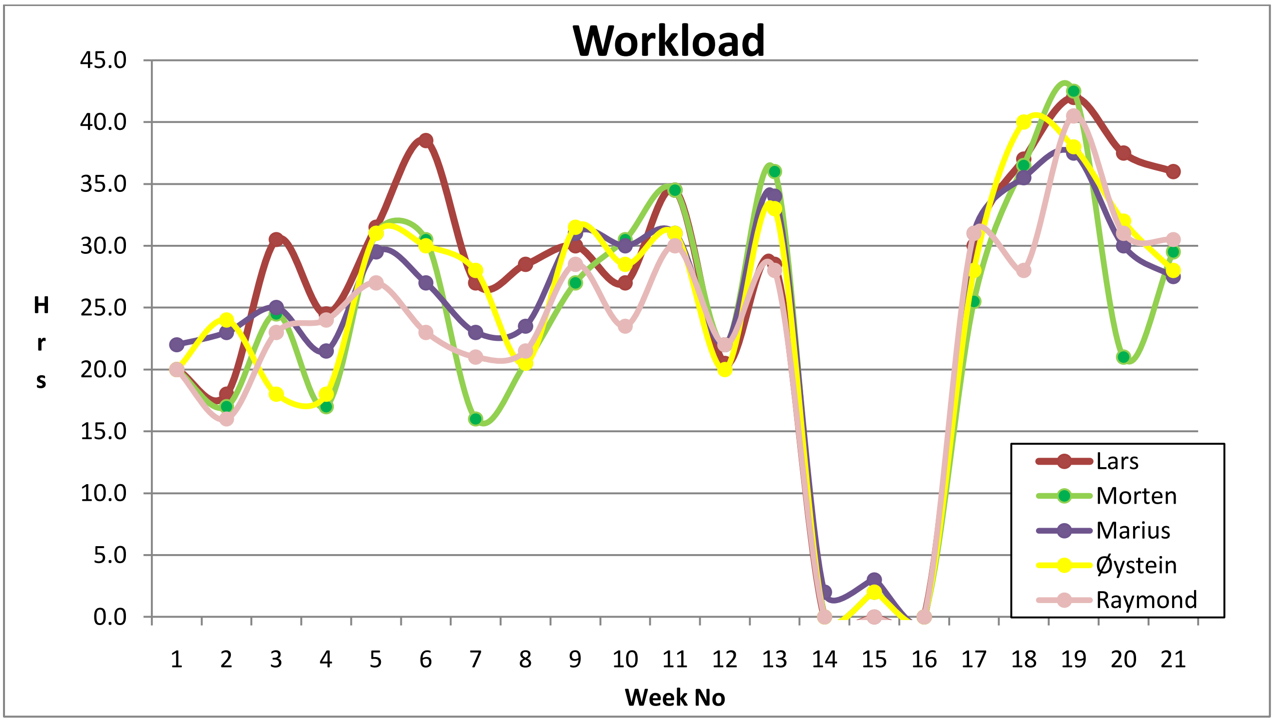
2.3 Execution

At the beginning of the first phase in the project, things went somewhat as expected and we could follow our initial plan with rather small adjustments. The first big problem we encountered was when we evaluated the generated concepts. None of the concepts generated could solve the problem in a satisfactory way. We were forced to redo and extend some of the activities to develop the concepts further and generate new ideas. To get back on schedule, we used all available resources and put in extra hours. Our internal supervisor and external supervisor were also very helpful and co-operative when we needed to discuss obstacles. This helped to reduce the time lost from discovering deviations and to get back on schedule.

From this experience we learned an important lesson for the rest of the project, and we tried to treat all problems with the same recipe; quick adjustments, extra hours and to expect the unexpected. Even though phase 2 required more frequent adjustments in the project plan due to delays and merging of some documents, we were able to roughly follow the initial plan.

In the Project Plan we have described different areas of responsibility for each group member. The purpose of this was to ensure an evenly distributed workload, and to create a more tangible management of the project. Even though a person was the responsible for a certain area, he did not have to do the actual work. This also led to a better individual understanding of the complete progression of the project. Since we worked in the same office almost every day we had good communication internally in the group and the supervising needed was kept at a minimum.

The most important thing we did during the project was to work consistently, which led to a steady progression throughout the project, as illustrated below (graph 1). This also meant that we had fewer periods with unwanted workloads. The decrease in week 14-16 is due to exam-period and Easter-holiday



Graph 1: Workload

As illustrated in the table below (table 4), the group had an evenly distributed workload. We started out by estimating 585 hours for the whole project, divided into 125 hours for the pre-study, 260 hours for phase 1 and 200 hours for phase 2. The reason for a lower estimate in phase 2 was due to the time-demanding concept development in phase 1. The estimate for phase 1 was spot-on, but the time-consuming documentation and testing in phase 2, increased hours spent.

ACTUAL WORKING HOURS			TOTAL		
PRE PHASE	PHASE 1	PHASE 2	ESTIMATED	ACTUAL	
125.0	268.5	266.0	585.0	659.5	**Lars**
125.0	234.0	249.5	585.0	608.5	**Morten**
125.0	255.5	253.5	585.0	634.0	**Marius**
125.0	227.5	238.5	585.0	591.0	**Raymond**
125.0	249.5	254.5	585.0	629.0	**Øystein**

Table 4: Working hours until 26.05.2011

3 Personal Experiences

3.1 Lars Meskestad

When we got our assignment, I opted to be project leader. This was a new area for me, but the other members of our group made this a relatively easy task. Every member has fulfilled his area of responsibility beyond measure. The task at hand has at times created frustration, but the team-spirit and group moral has kept us going. There has been a synergistic feel to the distribution of workload, and all members have shared inspiration and enthusiasm, especially when needed the most.

Our internal supervisor has given concise and tangible feedback and thereby created motivation. Our external supervisor has encouraged us to think for ourselves, which has made the task challenging but very interesting, and has allowed for a great span of creativity.

The group has worked very independently, but still in coherency with the employer. I feel that we as a group have worked consistent and completed the project in a very satisfactory way, from managing and scheduling tasks, to executing and solving them.

3.2 Marius Tøien

Overall this project has been very informative and challenging. Our group has worked very well throughout the whole project. Every group member has taken responsibility for the projects progress. Through consistent work from start to finish I think we have produced a well documented thesis. I also believe that we chose a very suitable assignment for the group, which made it easier to keep focus from start to finish.

3.3 Øystein Ellefsen

As we did not get an assignment until November, it was a bit stressful to get done what needed to be done before the second semester and presentation 1. For future projects I would recommend to start sending out assignment requests in spring/summer to avoid this. Further I think we have had a good work ethic. Every group member has taken responsibility. And there have not been any internal conflicts in the group, only constructive discussions. Our internal supervisor has been helpful concerning the documentation part of the project and as a motivator. Our external supervisor pushed us to think for ourselves. I think that is positive since it is closer to what it would be in a real company.

3.4 Raymond Evje

This project has exceeded all expectations. I think this has a lot to do with the compilation of our team. We have worked well together, and at the same time had a good atmosphere throughout the project. The assignment has been both challenging and extensive. Our supervisors have been helpful through our regular meetings. I think one of the main reasons that we (in my eyes) have been successful is that we have worked consistent through the whole project period.

3.5 Morten Brodahl

This project has been very useful because I have gotten a good indication of have it is to work as an engineer. It has been a good experience and I have found out that I like to work in teams with different people and personalities. We have worked consistent throughout the entire period, and that I believe has helped us get a good result. Our supervisors have been helpful and every group member has taken responsibility to keep good progress in the project.

4 Conclusion

The assignment we chose suited the group well. We were able to work on several activities simultaneously without interfering each other tasks. This allowed us to maintain good progress throughout the project period. The assignment was also very challenging but we were able to solve most of the problems within the group.

Looking back at the project planning, we should have estimated longer time consumption on documentation. This was probably the main reason that we fell behind schedule on a couple of occasions. However, documentation is important for all parties involved, so this problem was solved by putting in extra hours.

The group has worked great together throughout the project period. Everyone has taken responsibility and put in almost equal amount of hours. There are some differences, mostly because some group members had more school subjects and there have been illness related absence.

At the start of the project the group agreed upon a steady workload, meaning regular working days every day where there were no lectures. We followed this agreement the throughout the whole project and that is probably why the project turned out as well as it did. Our supervisors have been very helpful and co-operative during this project and have answered questions quickly and constructive.

The group considers the project successful. We feel that we have supported our employer with the material they wanted in a well-documented way. However we did not have the time to conduct as many tests as we wanted, especially physical. As there were not made a prototype when first planned, we were not able to conduct physical tests of the mechanism. At this point it was too late to try to learn more about the CAD software to analyze it more extensively.

We want to thank our friends and family for being patient in some hectic weeks. Thanks to Westad Industri AS for input and prototyping. Thanks to KDS for resources and for giving us the chance. We also want to thank Barbro Gulbrandsen for excellent administrative support.

A special thanks to Jørn Breivoll and Trond H. Sleveland for constructive discussions and guidance and everyone else involved in this project.

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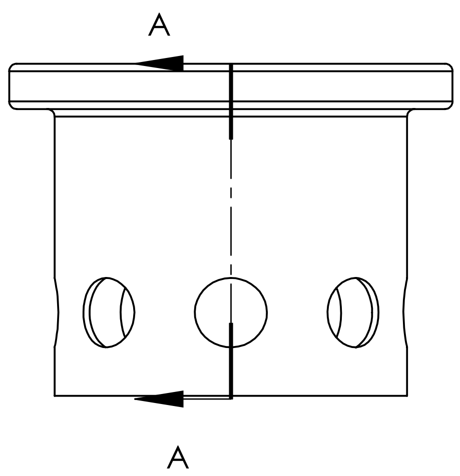

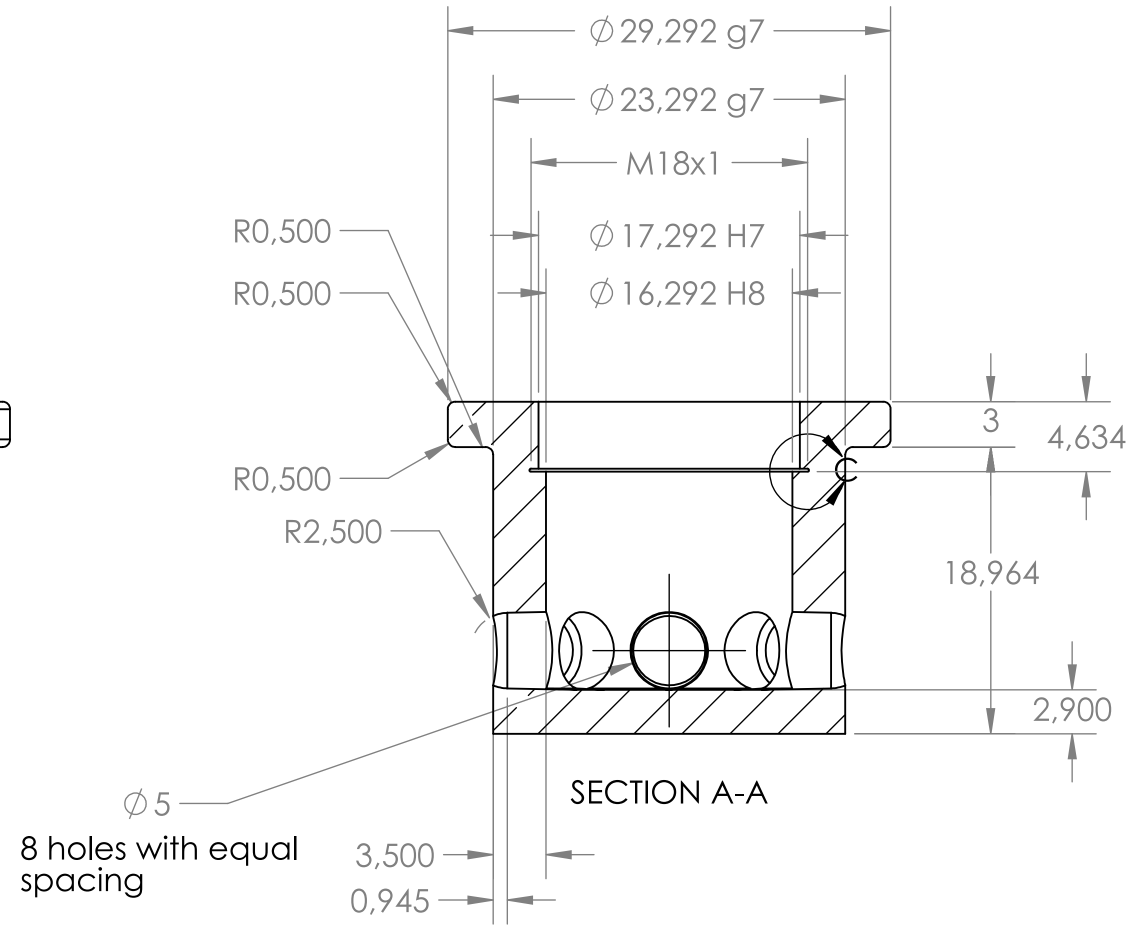

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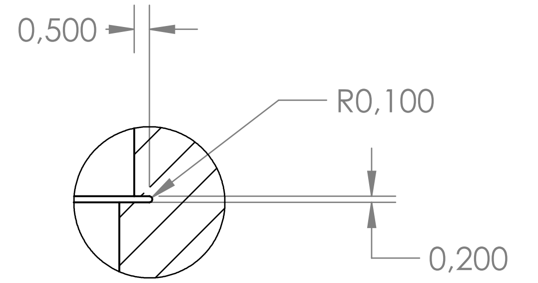

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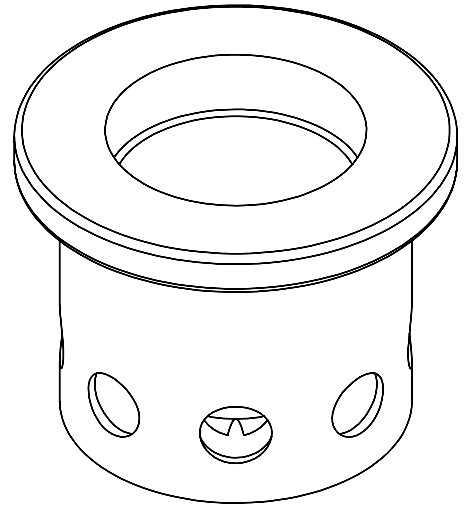

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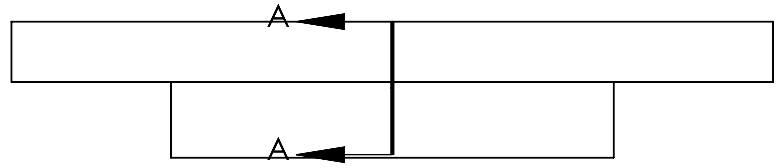

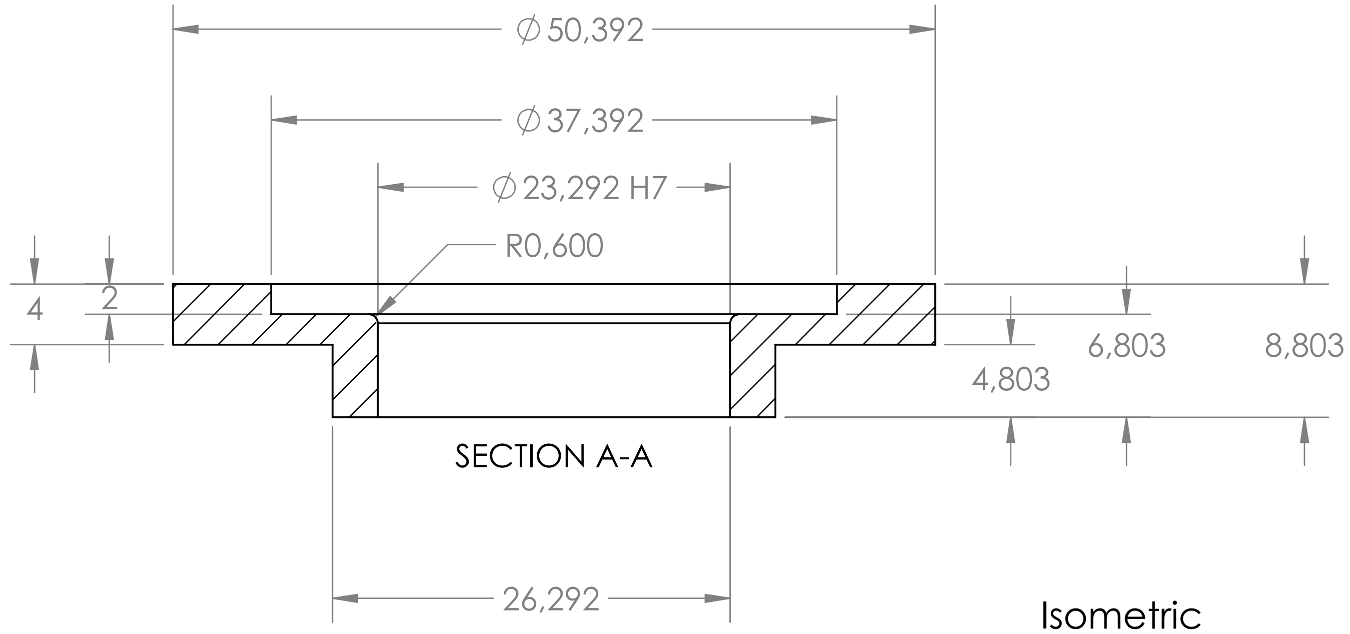

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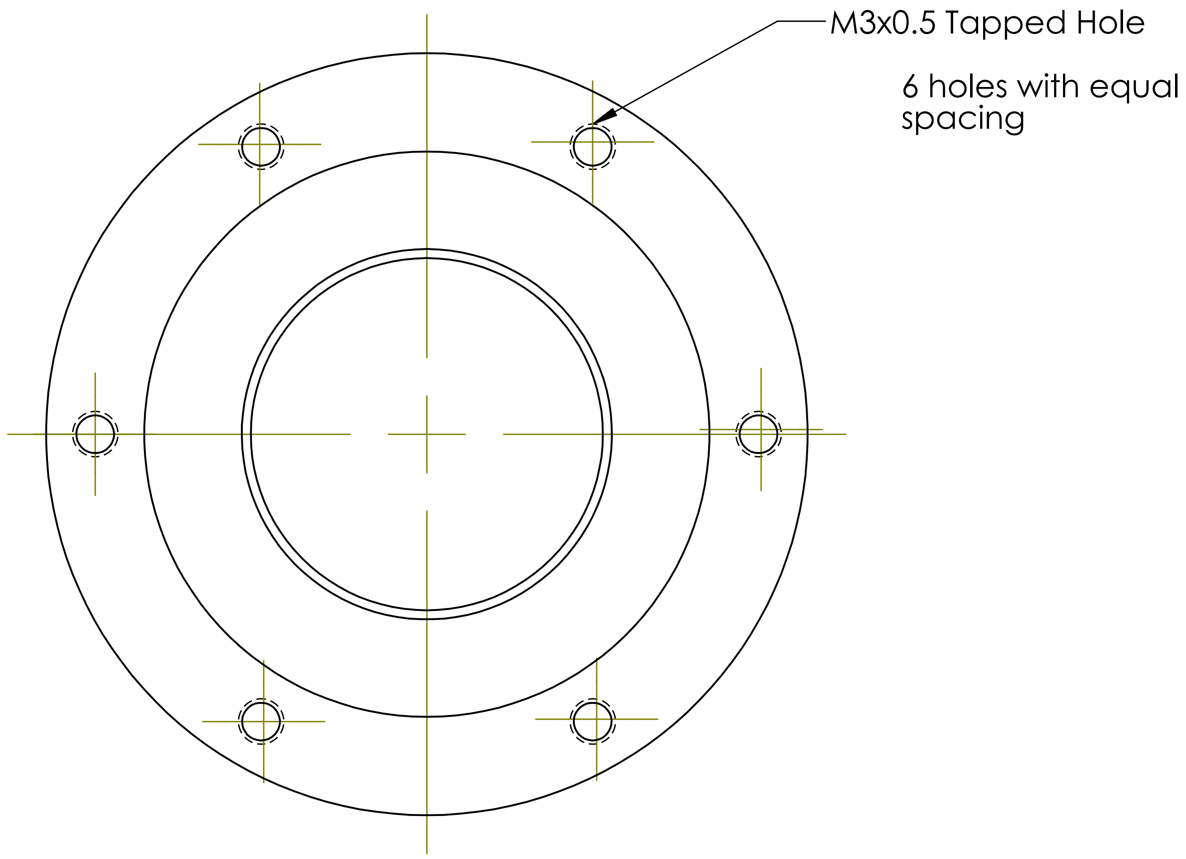

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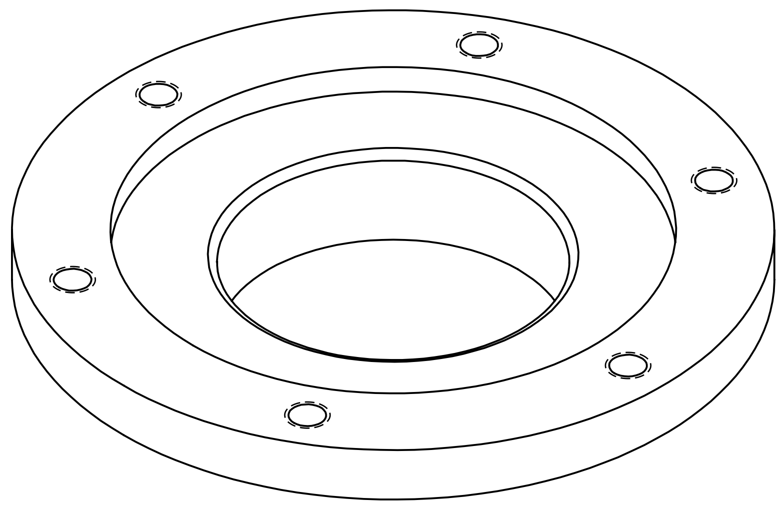

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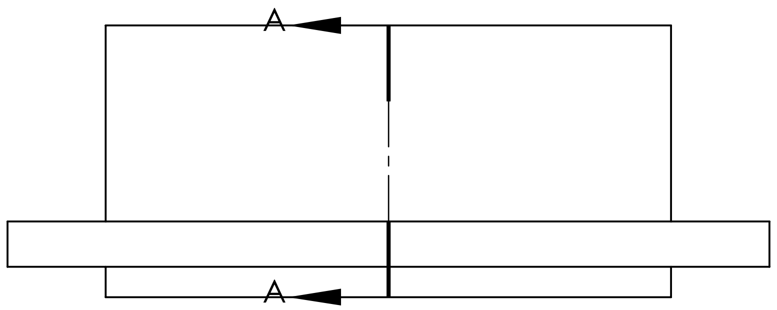

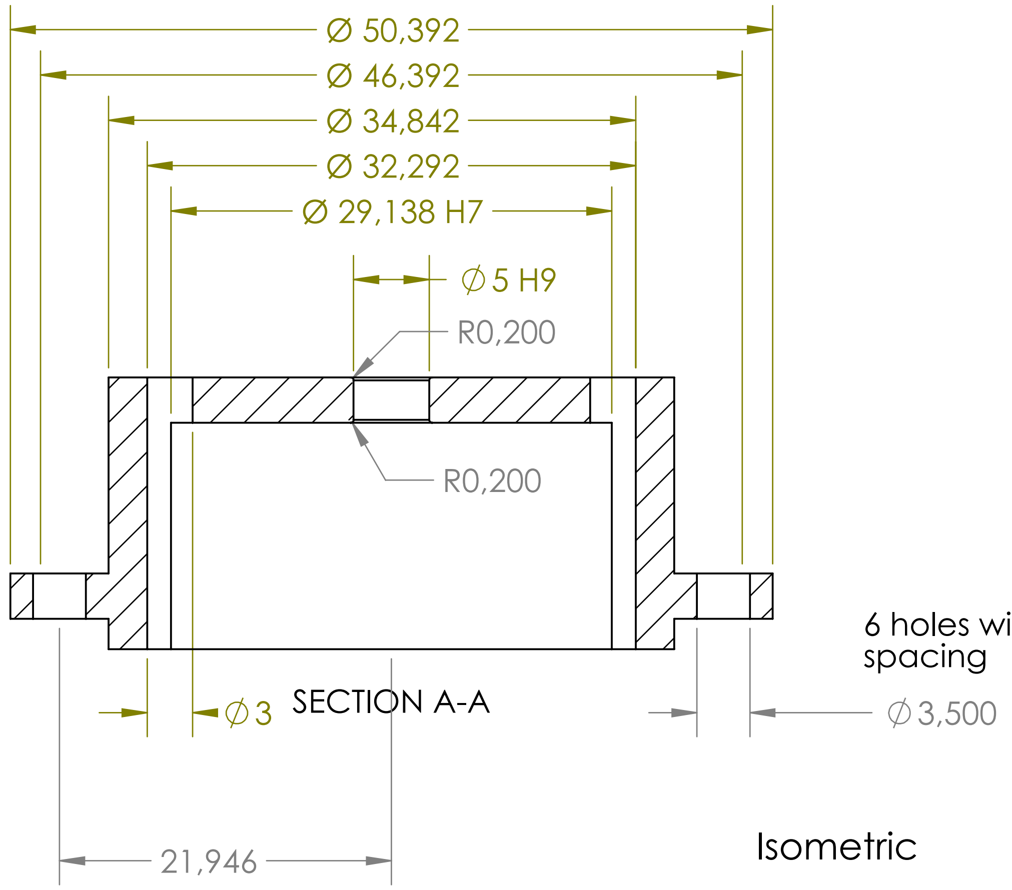

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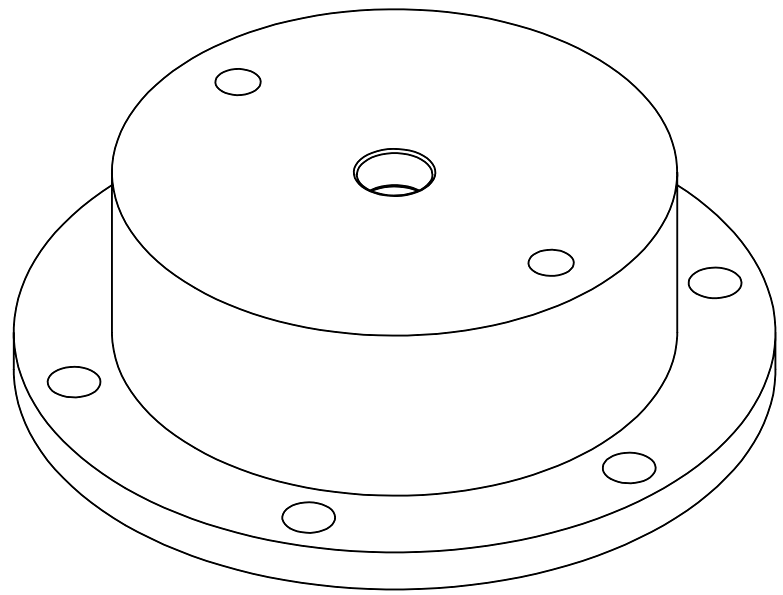

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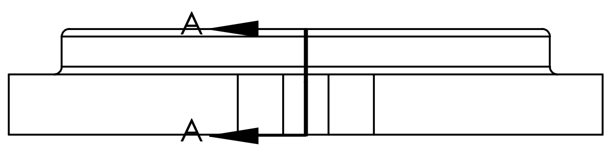

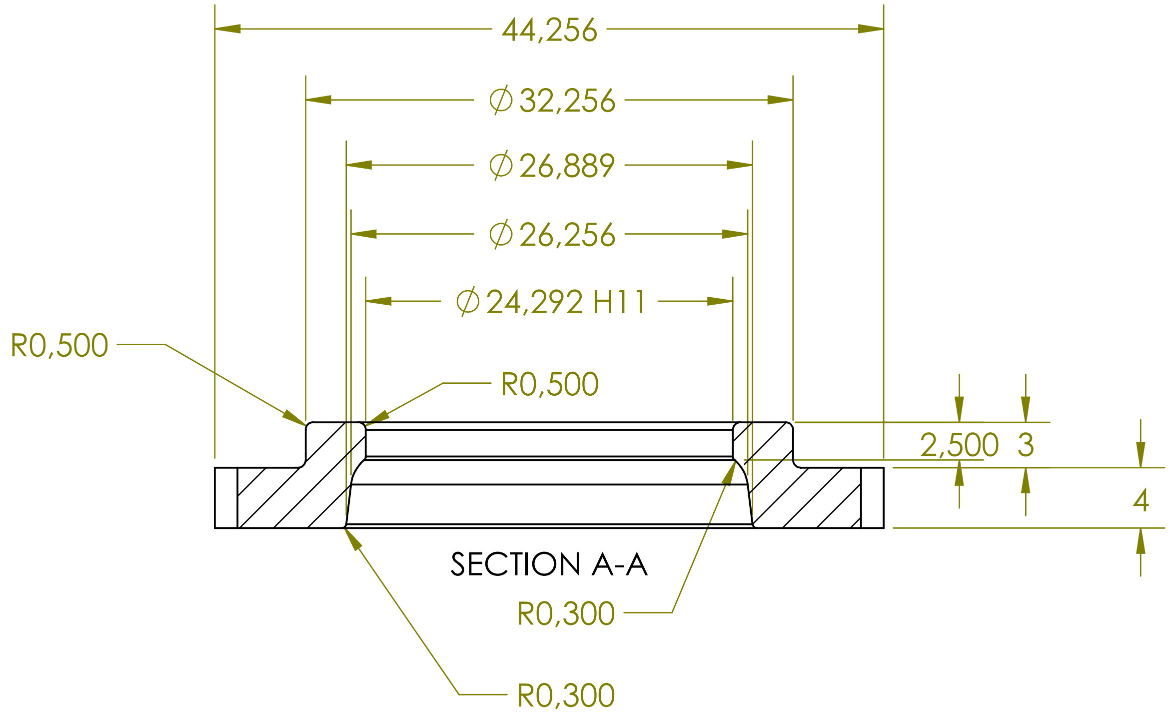

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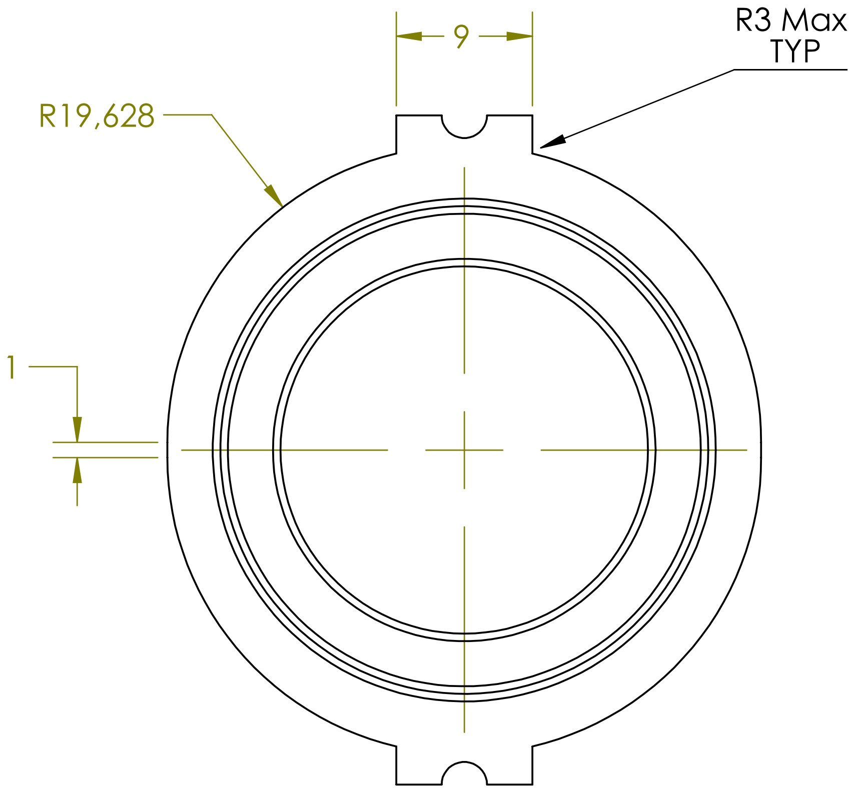

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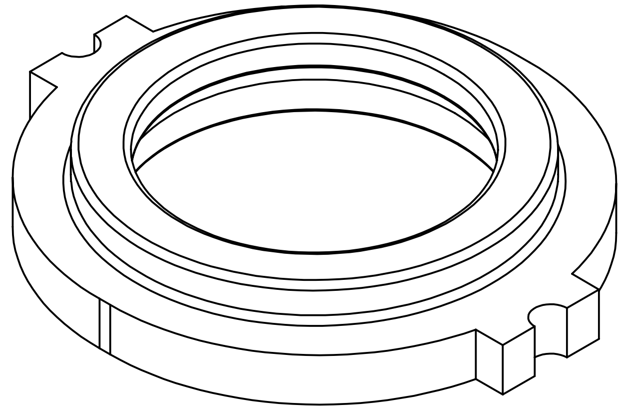

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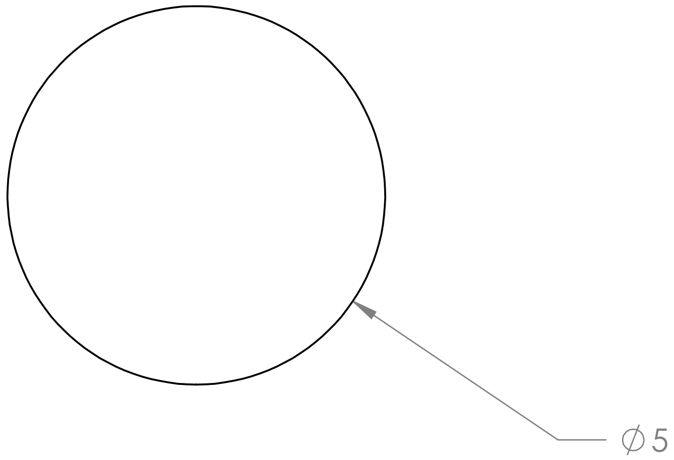

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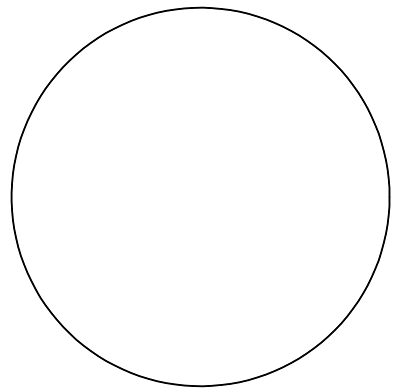

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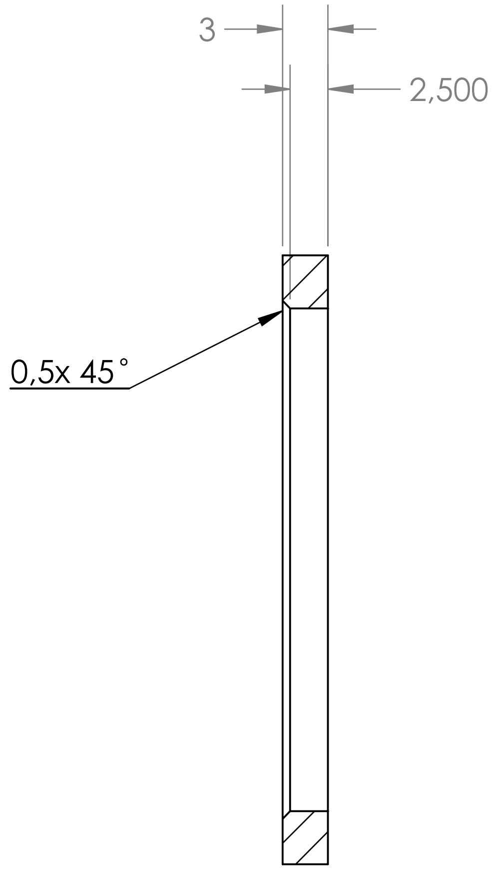

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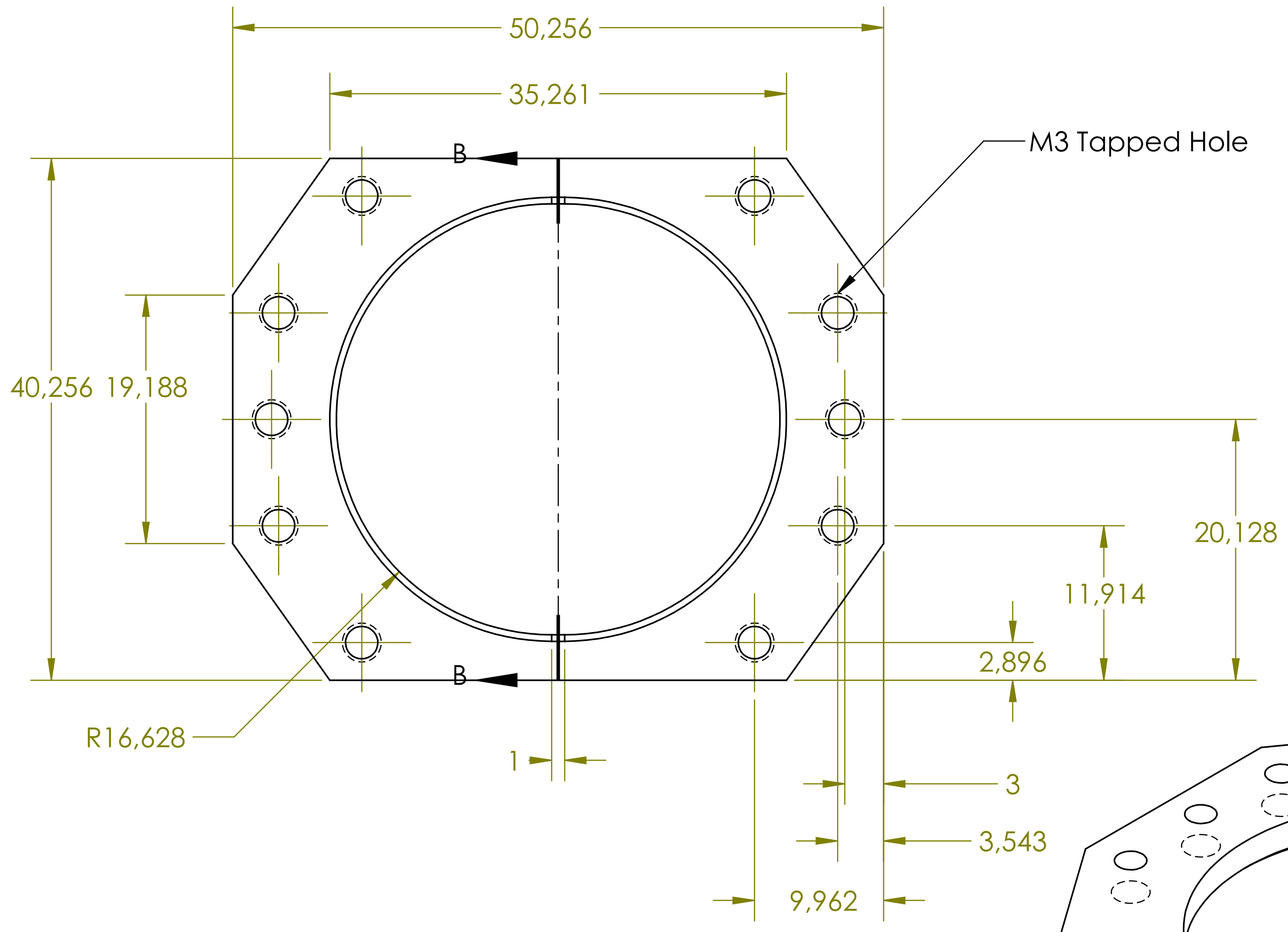

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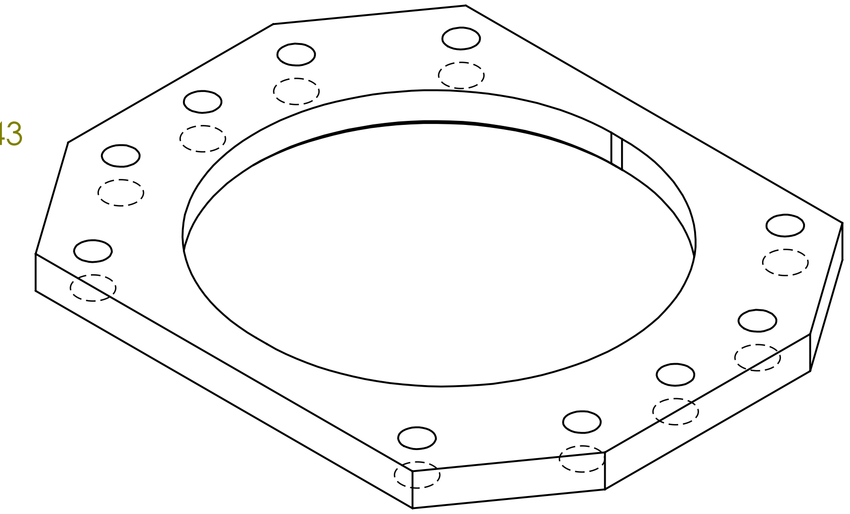

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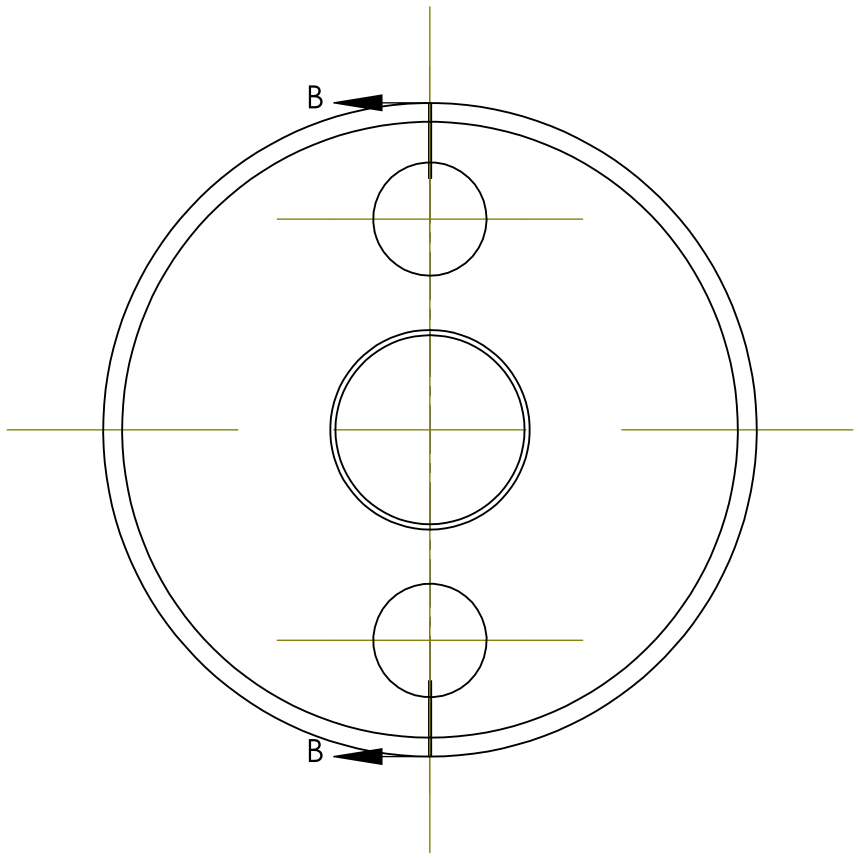

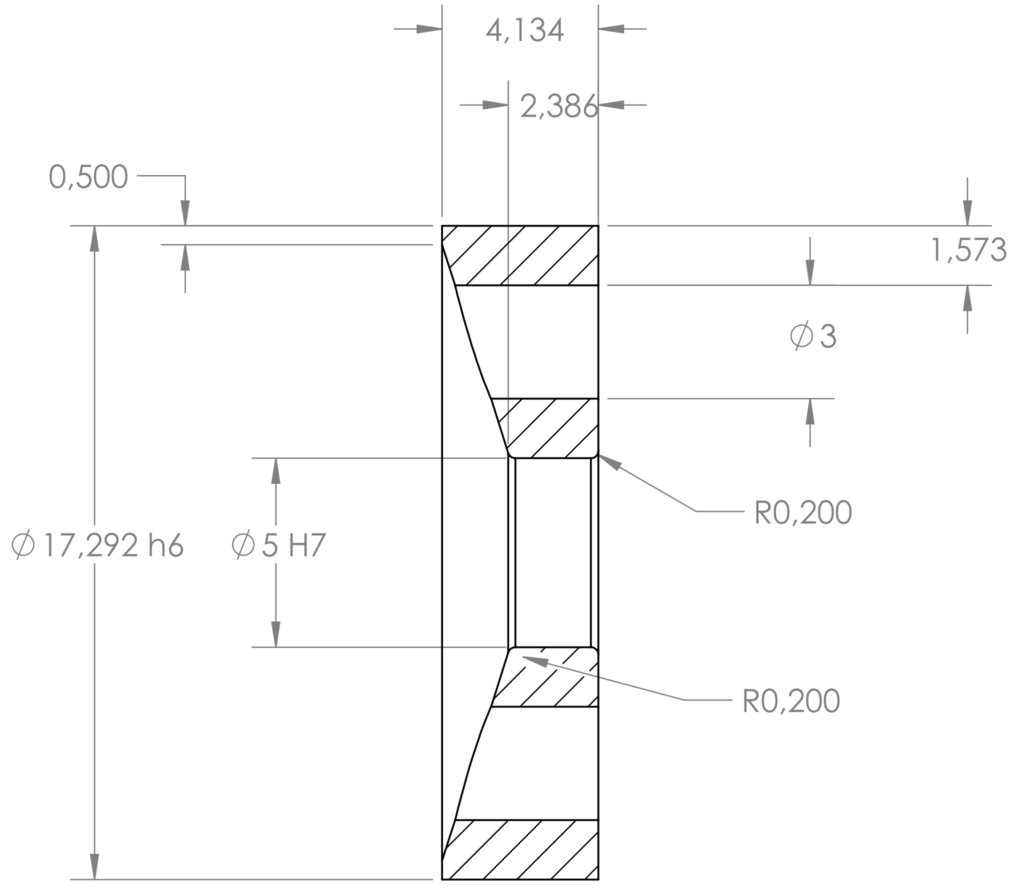

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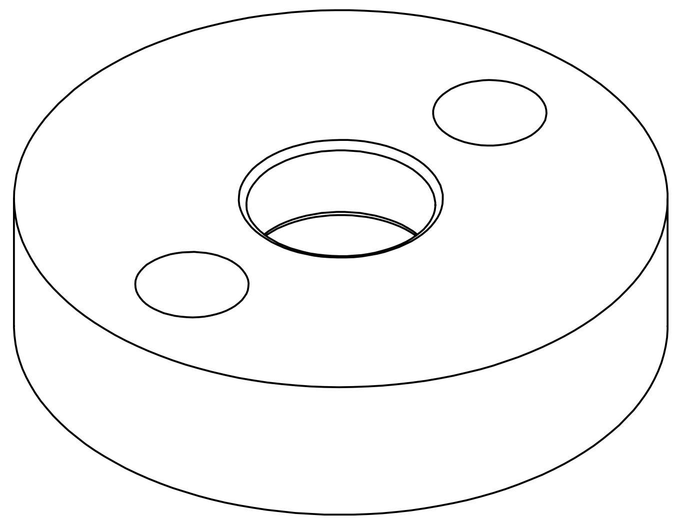

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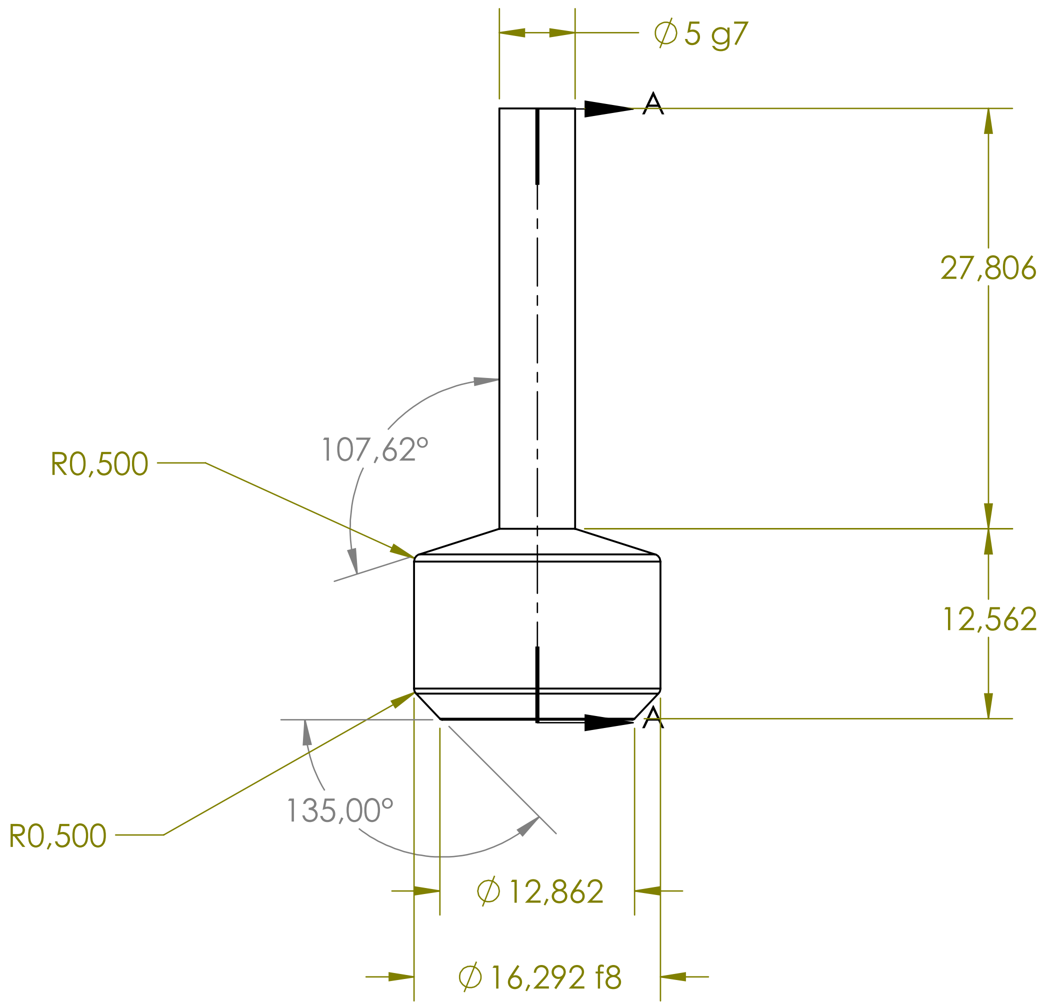

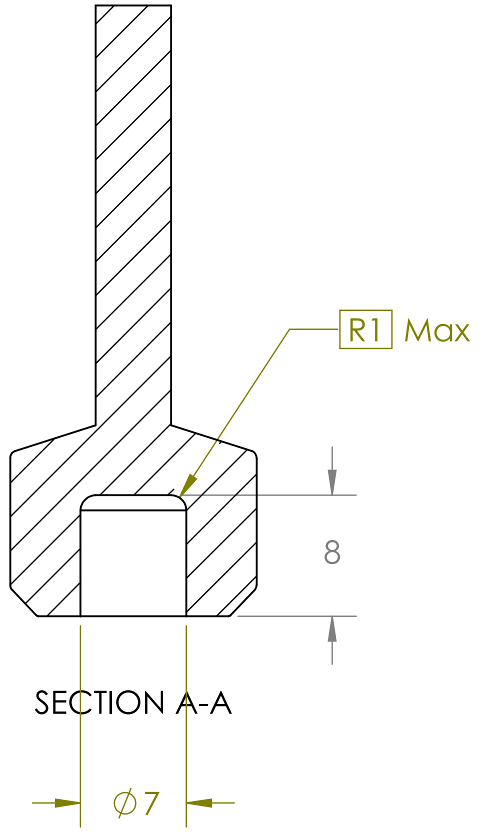

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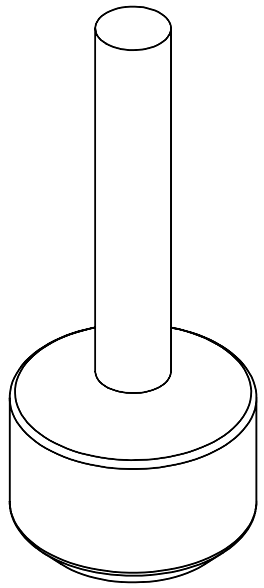

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