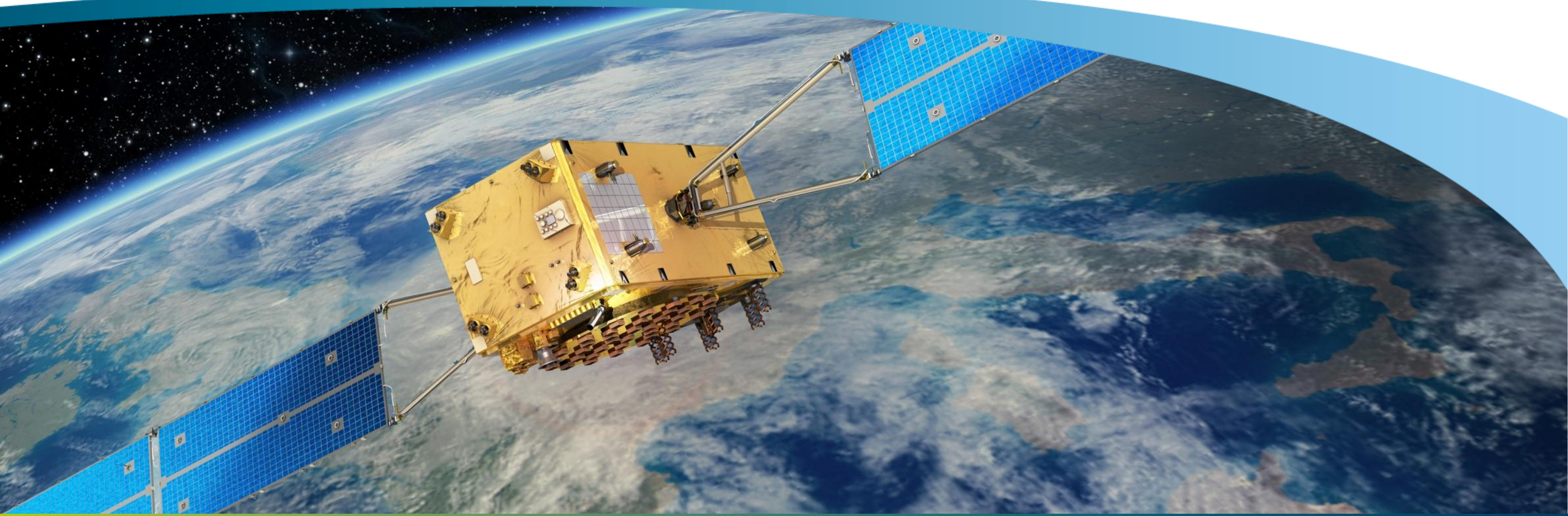
J.-C. Meyer, M. Scheper
G. Taubmann, J. Vázquez
06.05.2014, Noordwijkerhout

SENER

OHB SYSTEM

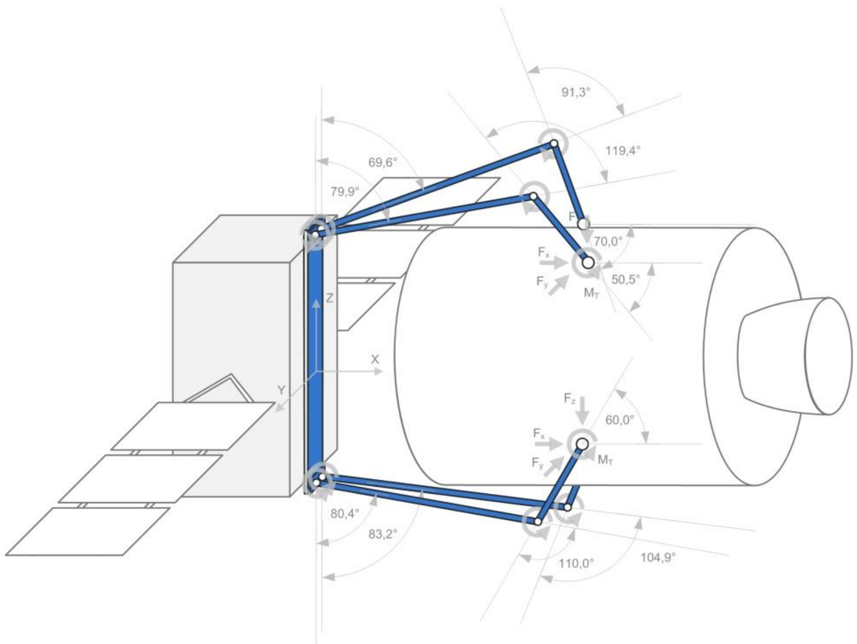


SPACE SYSTEMS

Tentacles based clamping mechanism – ADRM
e.Deorbit Symposium

Agenda

- Introduction
- Requirements
- Design options
- Trade-Off Description
- Conclusion



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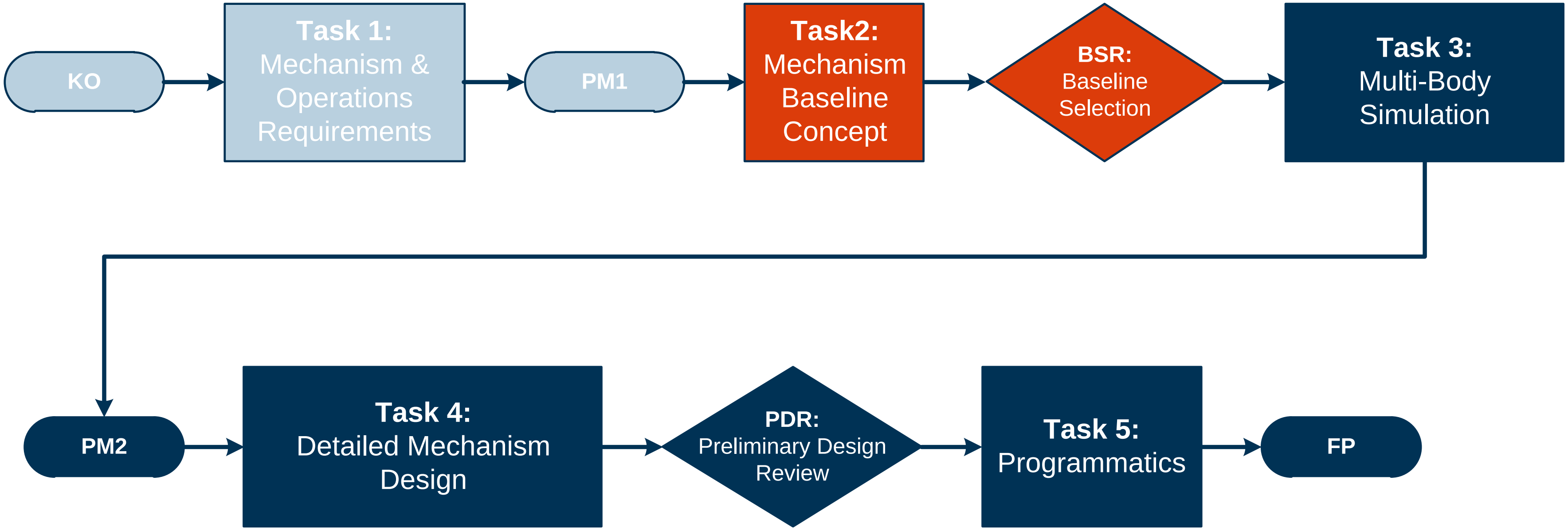
SPACE SYSTEMS

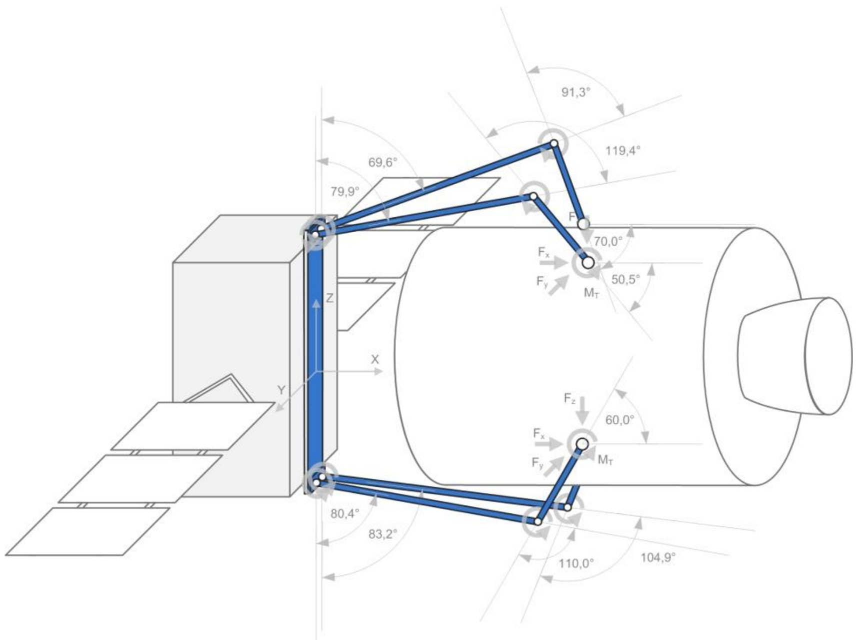
Welcome & Introduction

Workflow Description



Study Team Organization

- **OHB System** is the prime contractor
  - Systems Engineering
  - System Architecture
  - Requirements Engineering
  - Functional Architecture
  - Programmatics
- **SENER Ingeniería y Sistemas** acts as subcontractor
  - Mechanism Expertise
  - Conceptual Mechanism Design
  - Multi-body Simulation
  - Detailed Mechanism Design

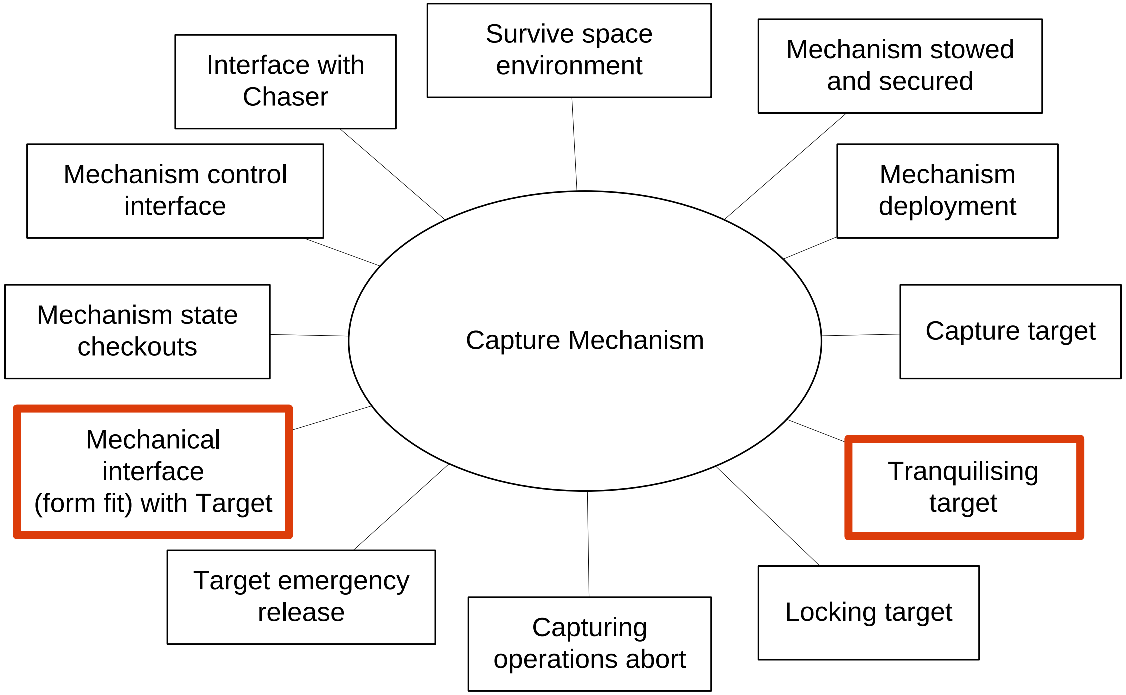


Requirements

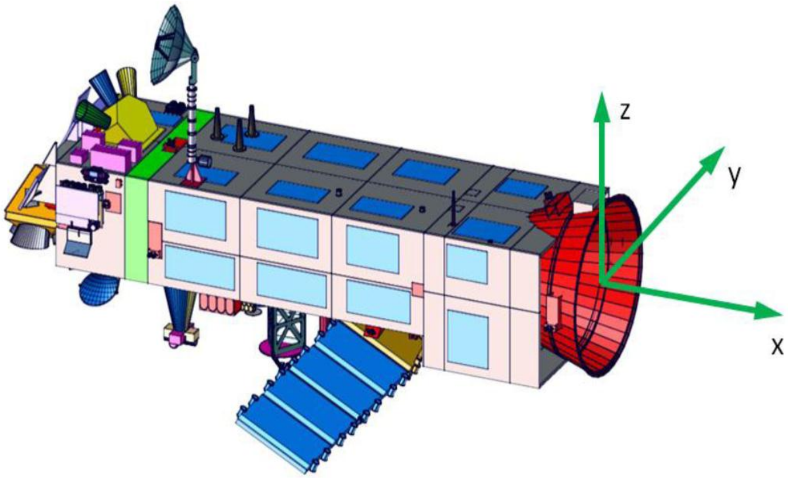
Requirements and Functions

The mechanism shall

- Create a rigid link between target and chaser (1st Eigenfrequency of stack >2 Hz, Goal: >8 Hz)
- Be capable of handling given uncertainty in relative position and attitude states
- Be able to capture an uncooperative and uncontrolled target
- Fit into VEGA fairing when stowed
- Be able to perform several capture attempts and emergency release



Target Characteristics and Capture principle



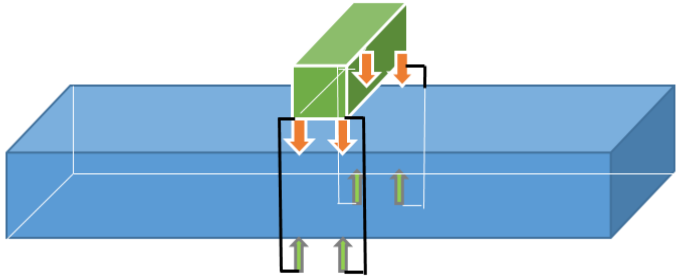
Updated target definition:

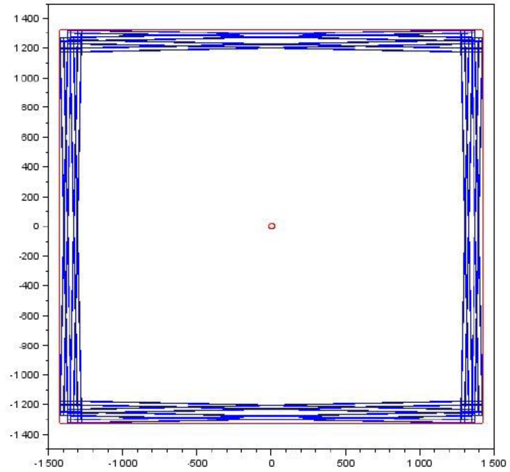
- Parallelepiped y= 3 m; z = 1.6m; 8000 kg
- Defined Moments of Inertia

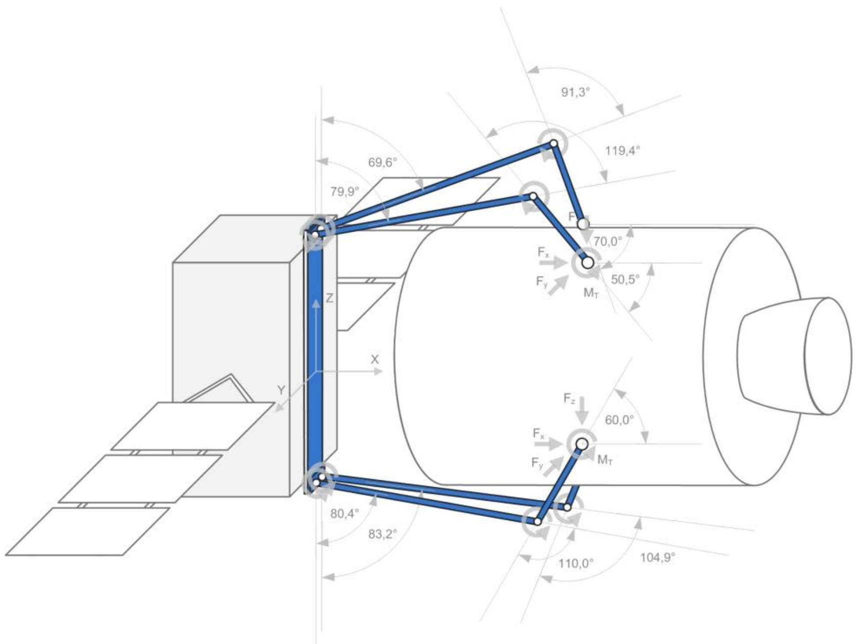
Uncertainty box enlarges mechanism size

- Closely related to AOCS performance

Rigid connection is established via preload applied on chaser side







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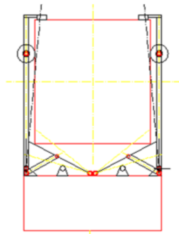
Mechanism Design Options

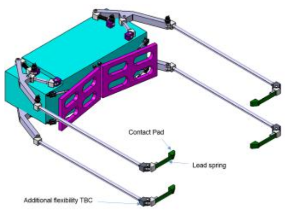
Mechanism Options – Overview

Option A



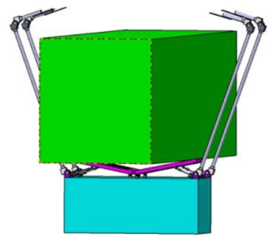
Two booms tentacle

Option B



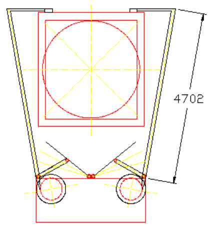
Boom on a capture mechanism

Option C



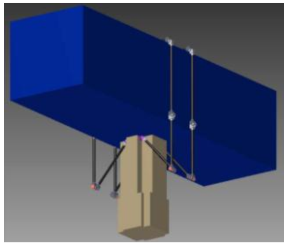
One boom tentacle

Option D



Collapsible tube mast tentacle

Option E



Tentacles at small face

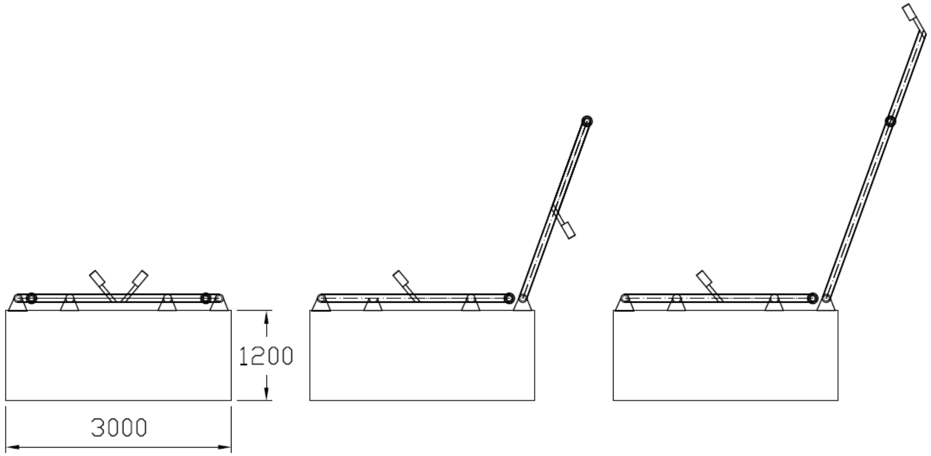
OPTION A: Two booms tentacle

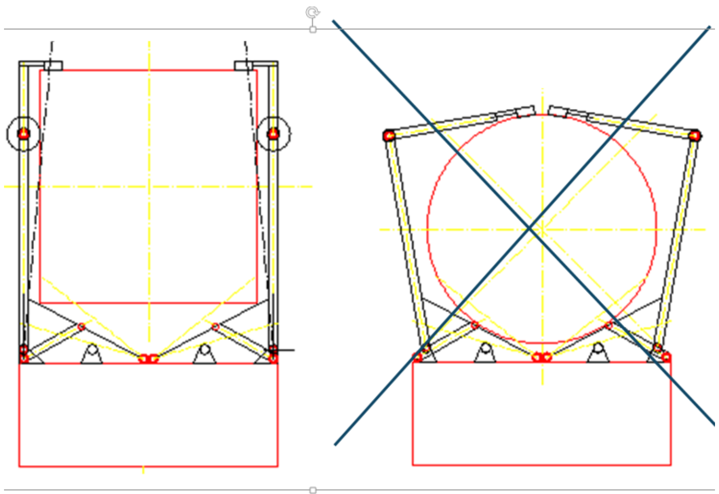
Advantages:

- Capture range up to 2x chaser length (5..6m)

Drawbacks:

- Can not capture cylindrical targets
- 4x2 booms; 4x2 hold-downs





OPTION A	Mass [kg]	Power [W]	TRL
TENTACLE (4x)	51,28	29,6	6
HDRM (2x4)	24	0	9
ATTENUATION (4x)	25,2	320	6
TOTAL ADRM:	100,48	349,6	6

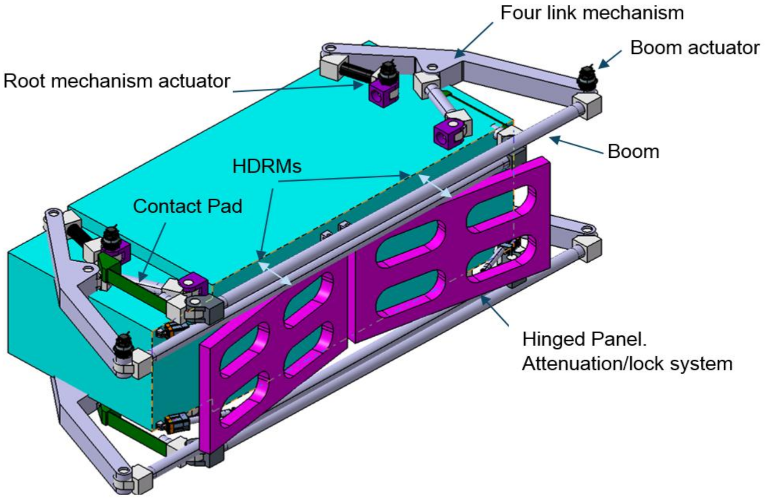
OPTION B: Boom on a capture mech.

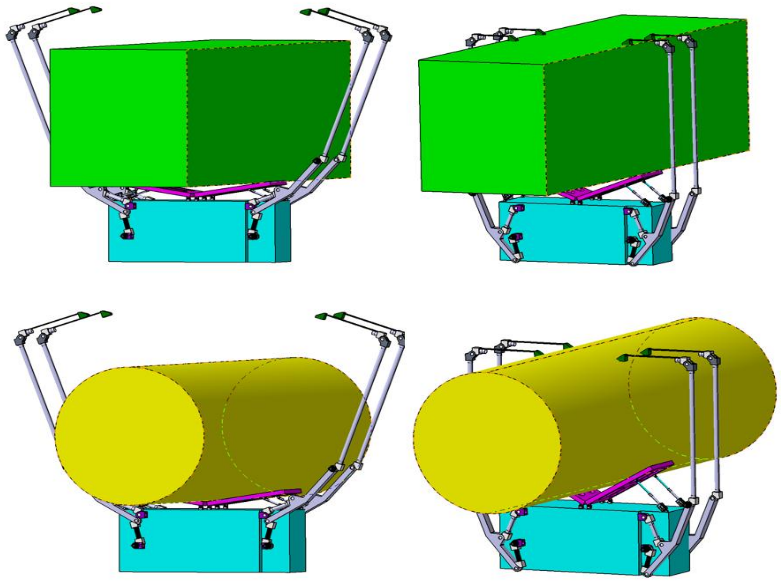
Advantages:

- Capture range up to 4m
- Capture parallelepiped and cylindrical

Drawbacks:

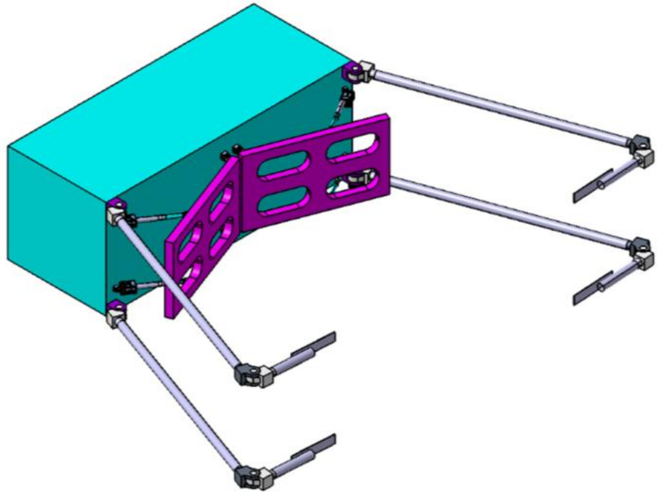
- Closing volume (attenuation) takes 24 to 120 sec.





OPTION B	Mass [kg]	Power [W]	TRL
TENTACLE (4x)	65,68	29,6	6
HDRM (4)	12	0	9
ATTENUATION (4x)	25,2	320	6
TOTAL ADRM:	102,88	349,6	6

OPTION C: One Boom Tentacle

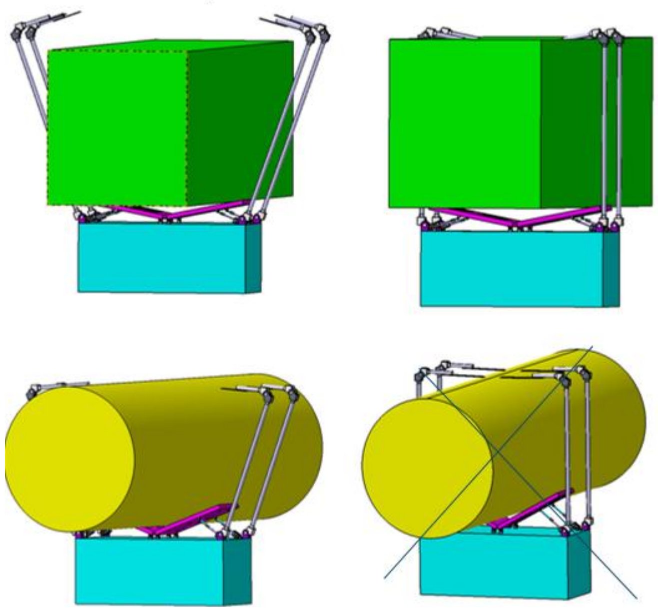


Advantages:

- Simplest Solution
- 4 booms; 4 hold-downs

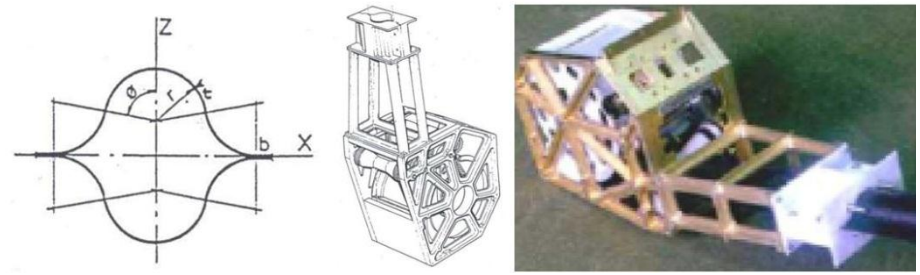
Drawbacks:

- Can not capture cylindrical targets



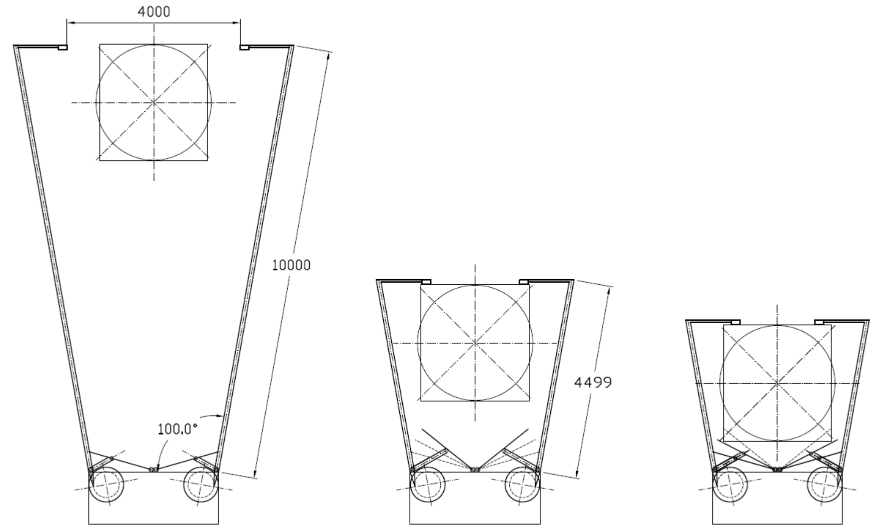
OPTION C	Mass [kg]	Power [W]	TRL
TENTACLE (4x)	36,88	14,8	6
HDRM (4)	12	0	9
ATTENUATION (4x)	25,2	320	6
TOTAL ADRM:	74,08	334,8	6

Option D – Collapsible Tube Flexible Tentacle



Components:

- CTM wound in a reel
- CTM Deployment/Retracting mechanism driven by rotary actuator
- Attenuation after capture by EMA acting on a hinged panel, or springs and dampers.



Advantages:

- No HDRM required (TBC)
- Potential power reduction without EMA

Drawbacks:

- Long Capture Time
- Significant mass
- Mechanical and thermal stability

Option E – Tentacles on small chaser side

Components:

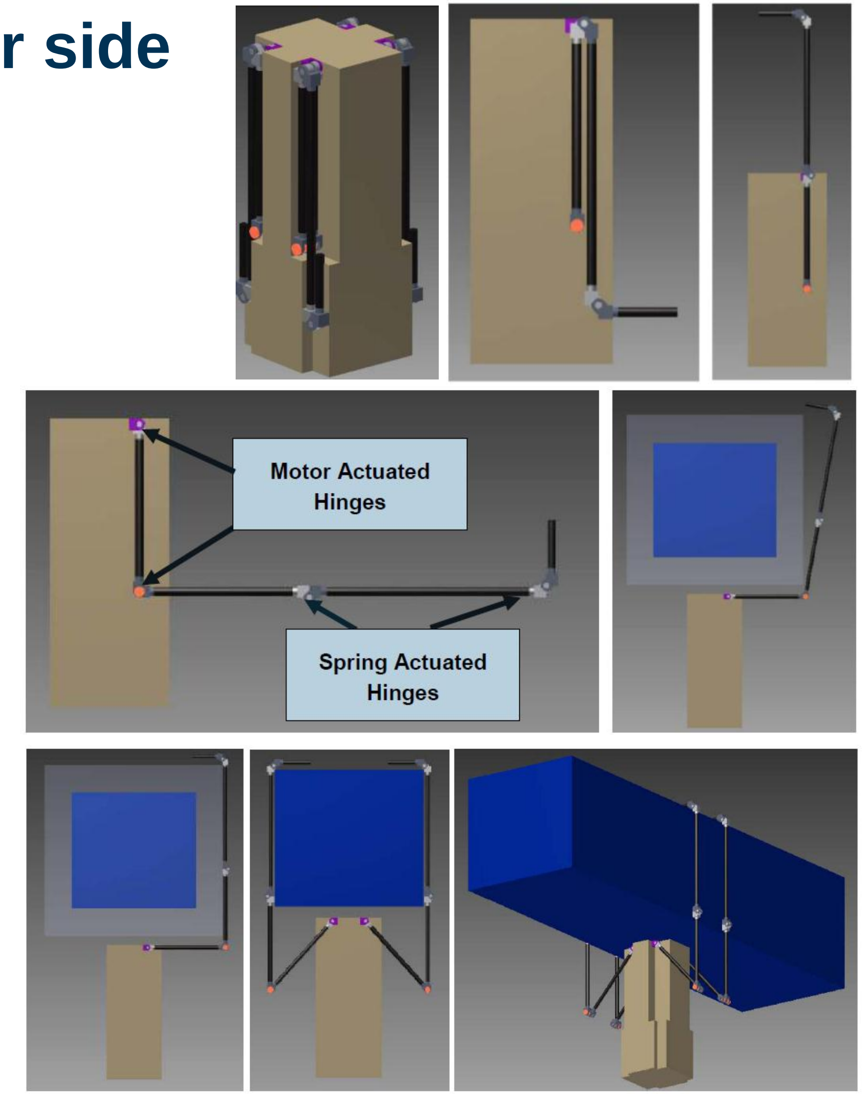
- Four rigid booms
- Two actuated spring hinges
- Two hinges actuated by rotary drives
- Attenuation after capture by EMA acting on a hinged panel, or springs and dampers.

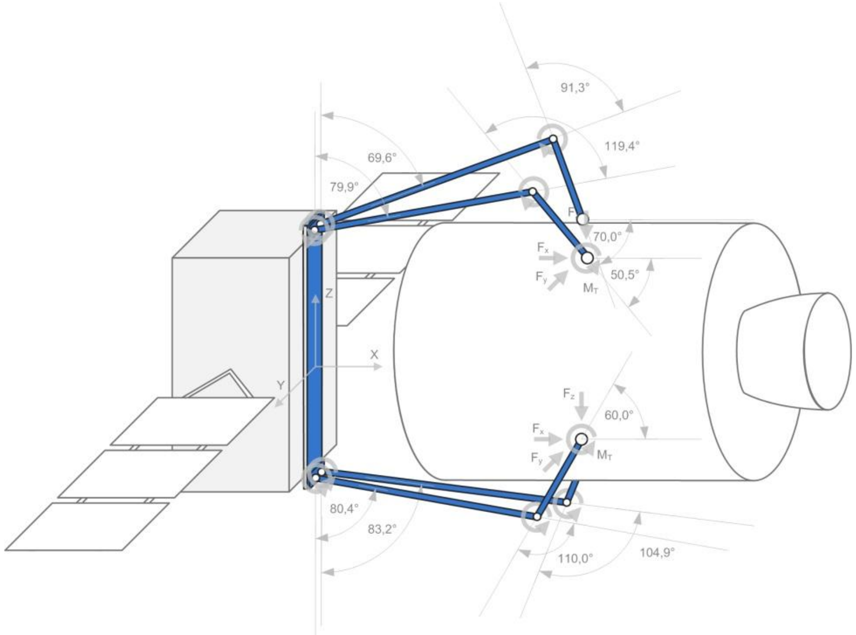
Advantages:

- Thrusters aligned with launcher
- Potential power reduction without EMA

Drawbacks:

- Complex deployment
- Poor stability of composite configuration





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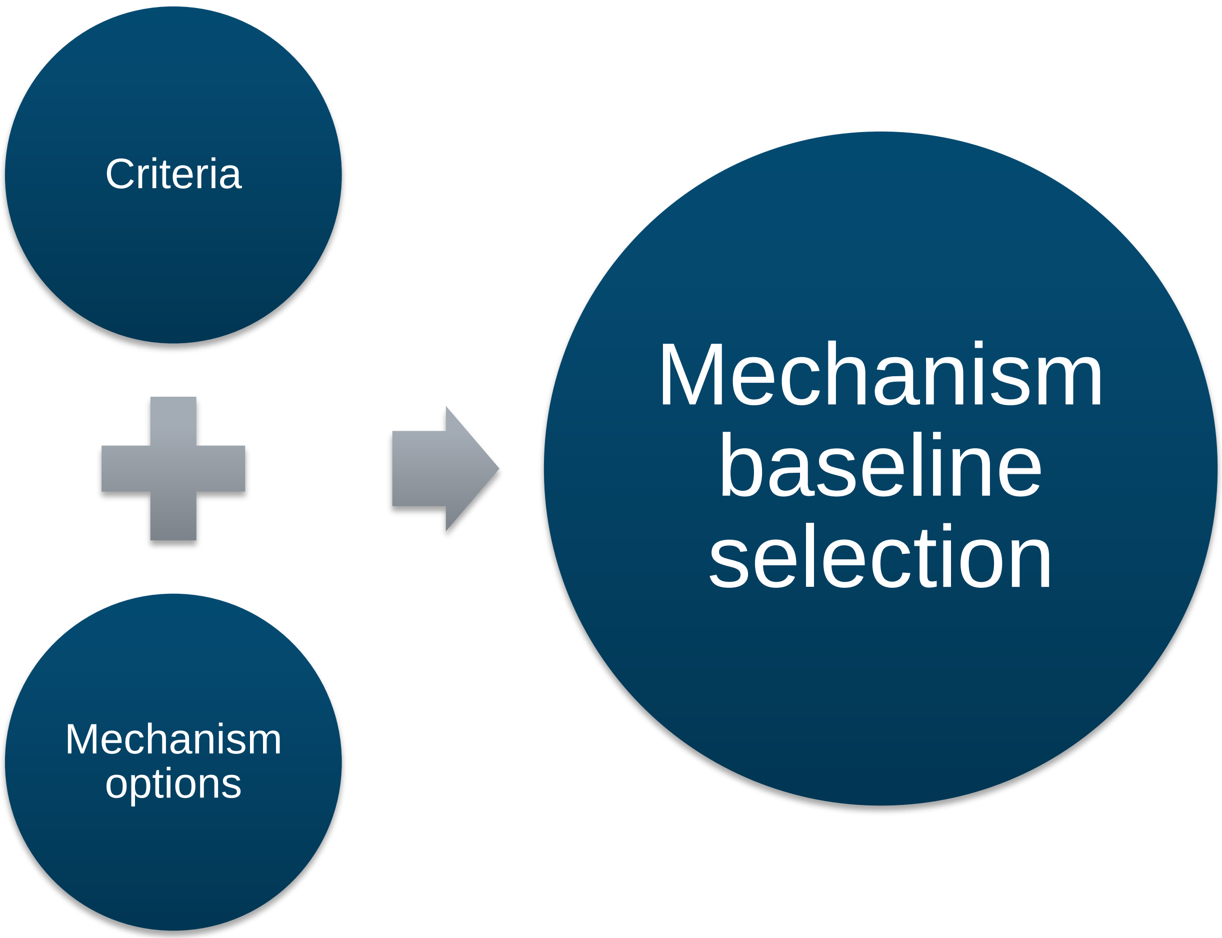
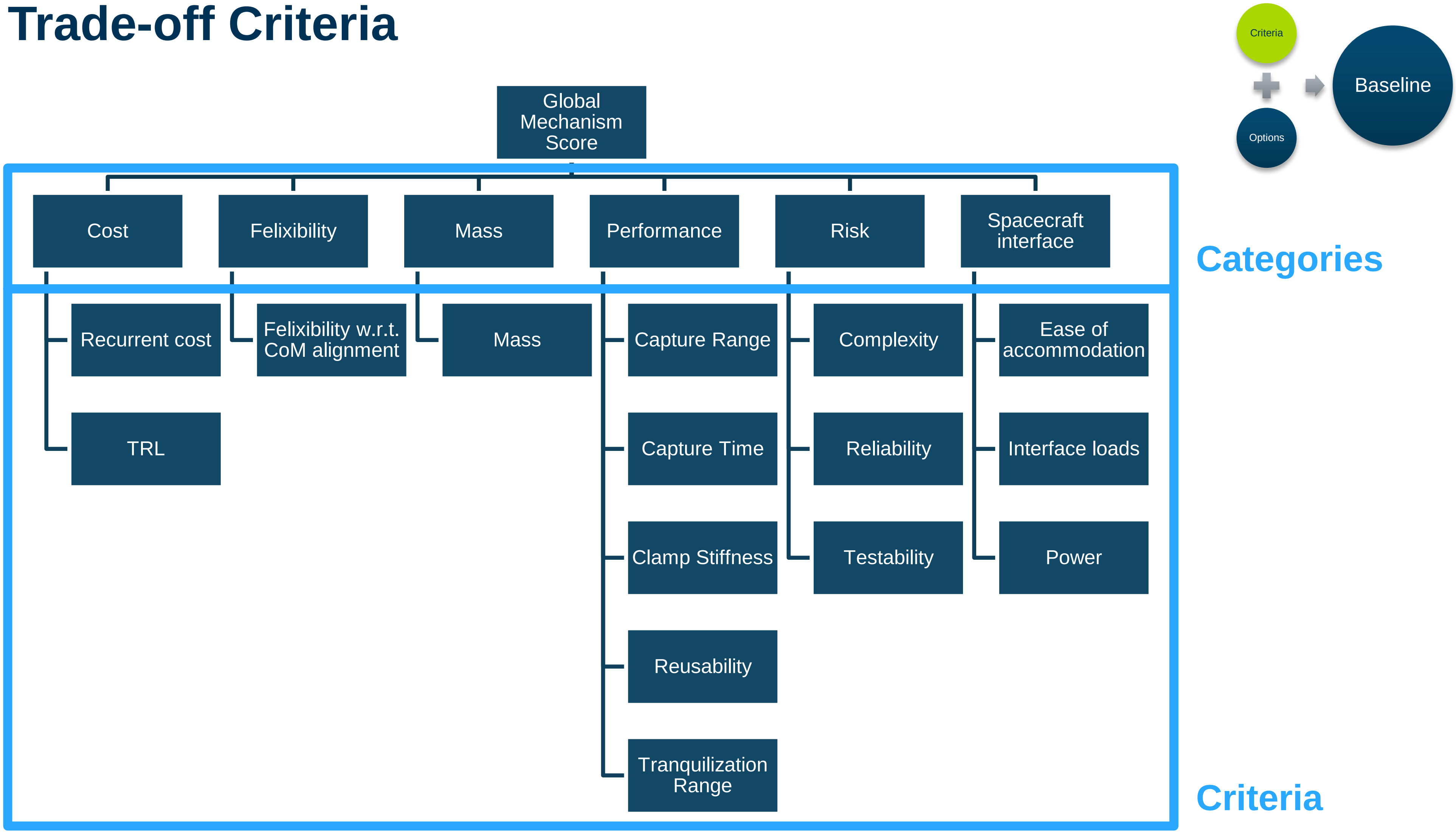
Trade-off description

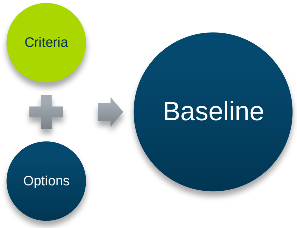
Trade-off overview



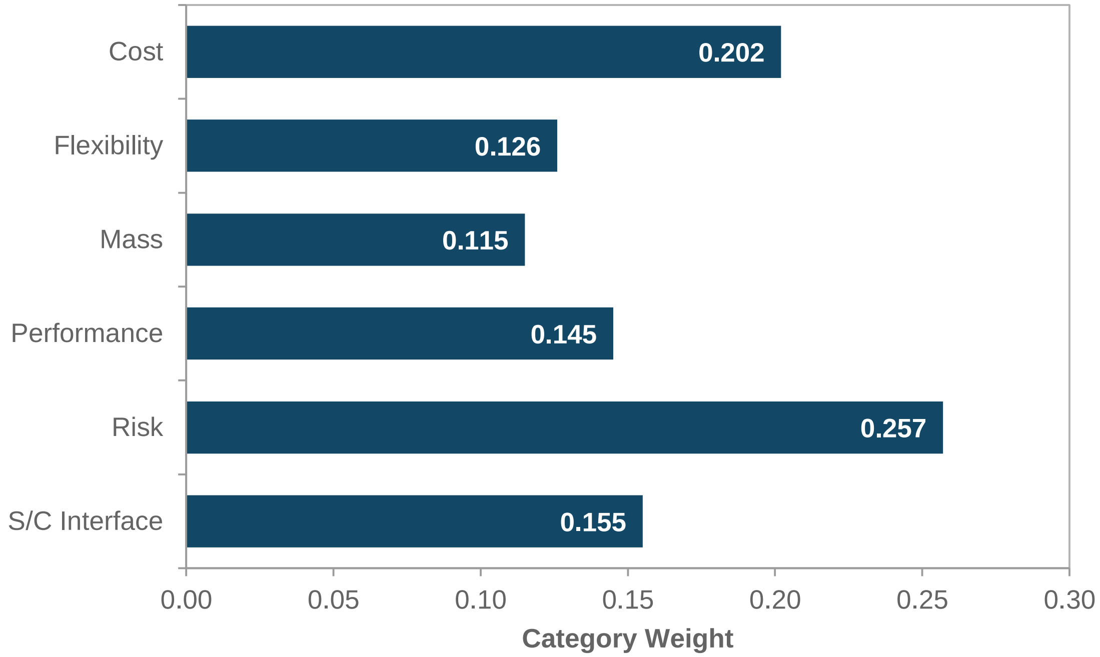
Trade-off Criteria

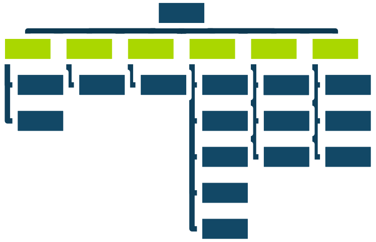


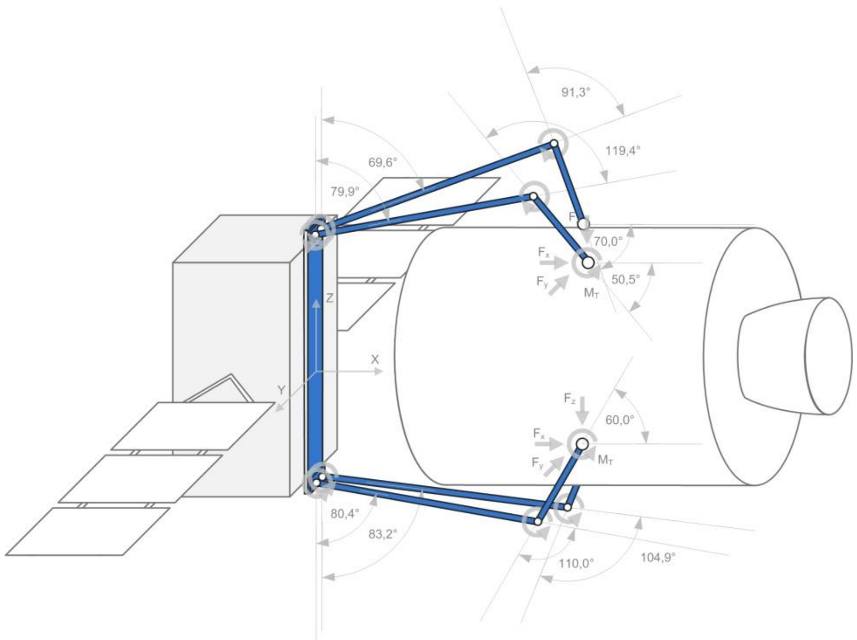
Trade-off Criteria – Category Weights



- Weighting done by pairwise comparison with expert support







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Conclusion

CONCLUSIONS

- Five main mechanism options have been identified
  - Sub-options exist considering different attenuation subsystem design options
- Trade-off criteria have been identified
- Trade-off result expected end of May 2014
- Baseline mechanism design will be validated by multi-body simulation

➢ Based on the current status of design and analysis it can be anticipated that a feasible solution will be identified.

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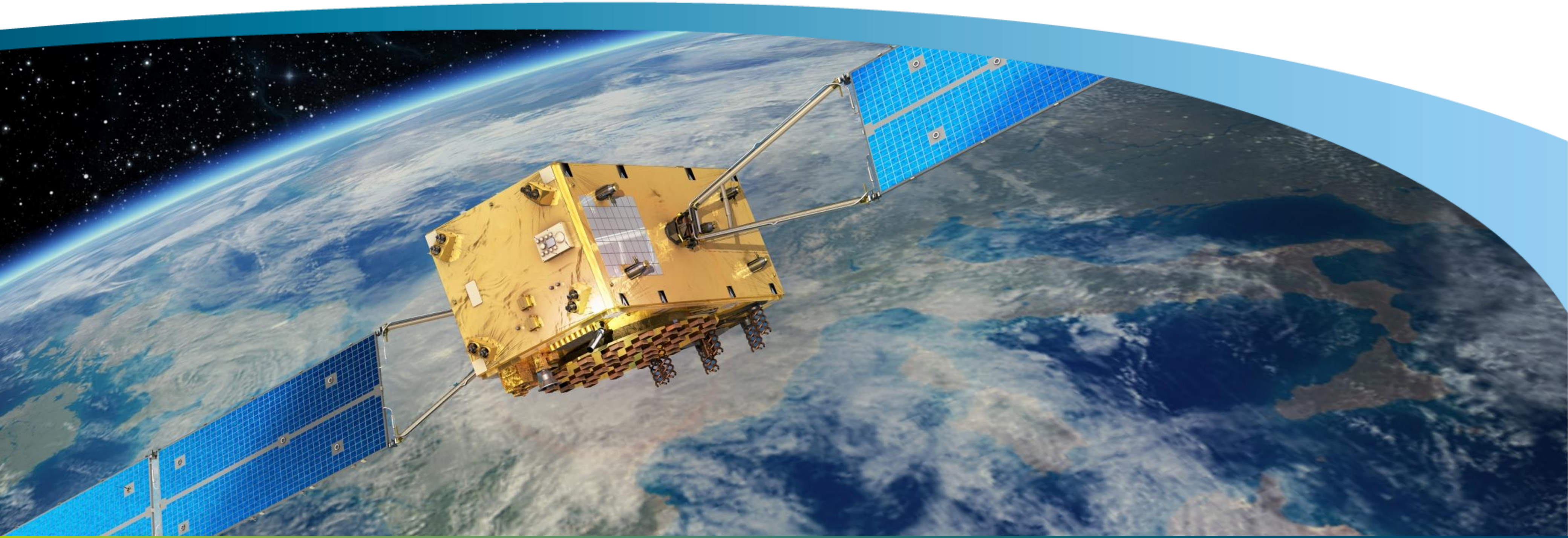
30.04.2014, Teleconference



SPACE SYSTEMS

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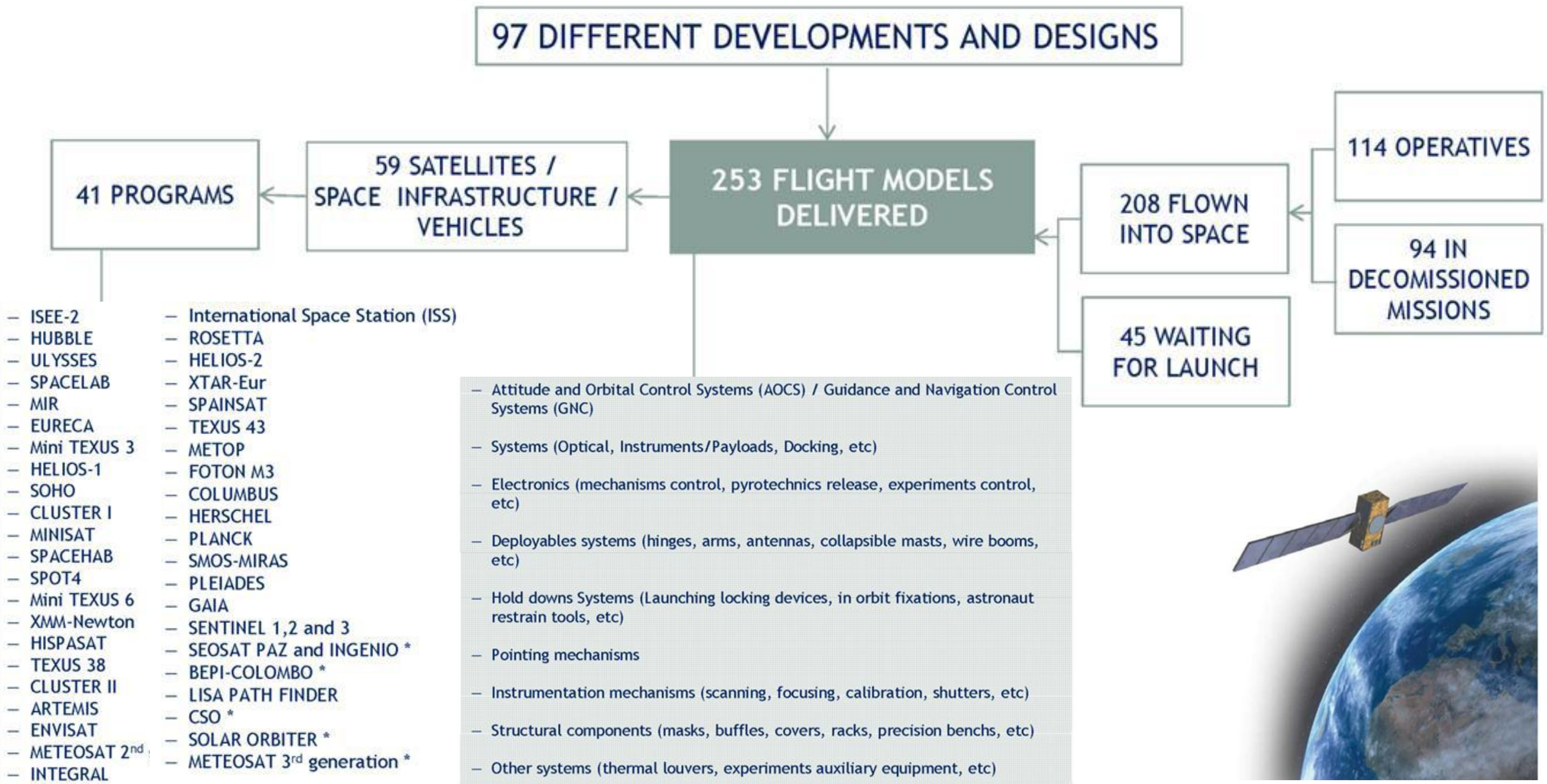
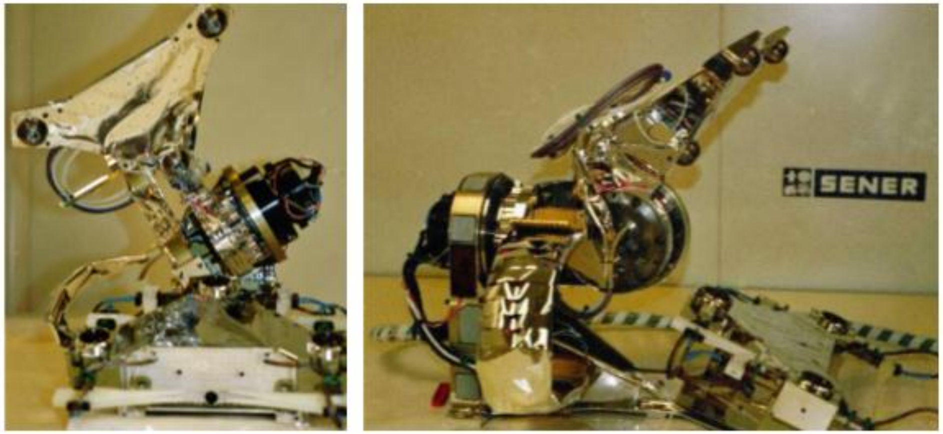
Study Team – SENER Ingeniería y Sistemas

SENER develops and manufactures structures and mechanisms including electronics, control and soft.

SENER participates in most of ESA programs, from engineering and technology development to main contractor of on-board Assemblies and Sub-Systems for space applications.

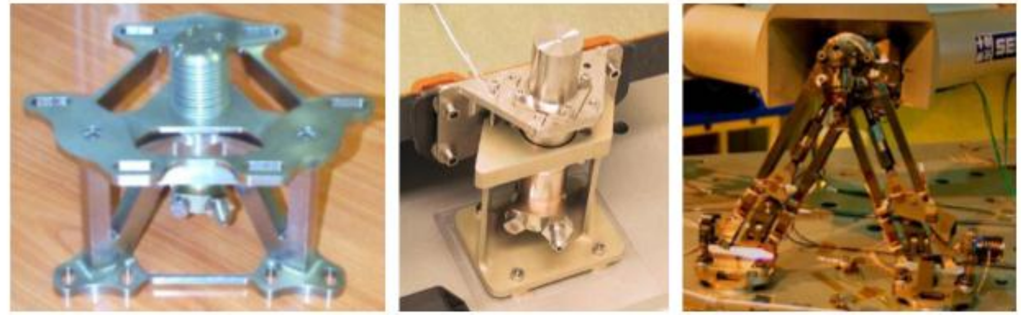


Study Team – SENER Ingeniería y Sistemas

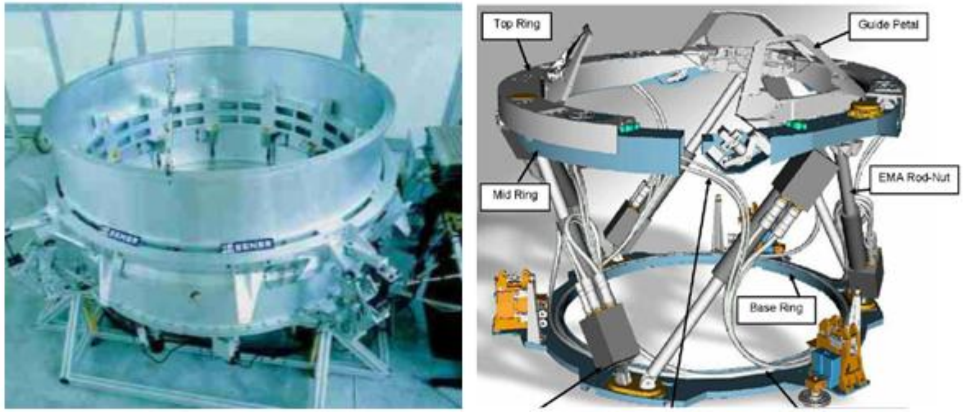


SOHO High Gain Antenna Pointing Mechanism (APM).

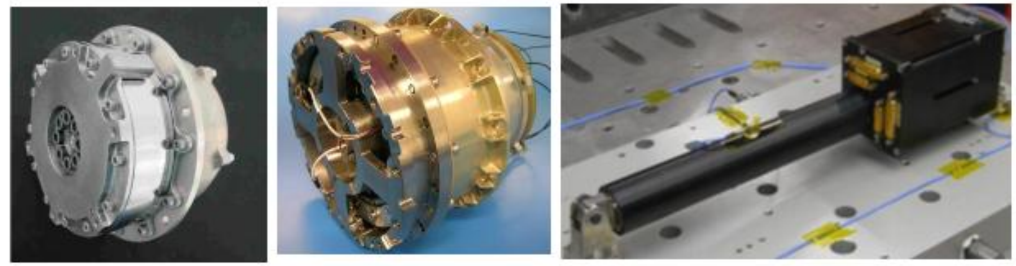
Envisat Polar Platform deployable boom



METOP ASCAT HRM, METOP GAVA HRM, and SILEX GEO HDRMs



Docking/Berthing (COLUMBUS/HERMES);
International Docking & Berthing Mechanism (IBDM).



SENER Rotary and Linear Actuators

LEMA IBDM Active Attenuation

The Active attenuation with IBDM LEMA. Alternatives:

- Hinged panel, adequate for supporting cylindrical targets
- The direct action in the z axis of the LEMA seems to be the preferred option:
  - Induce less sliding
  - Provide the preload of 400N
  - Has enough stiffness
- LEMA can be back-driven when unpowered, and therefore to maintain preload during de-orbit an additional system is required:
  - Over-centre mechanism
  - Brake
  - Latch

Passive attenuation would be possible for Option B and Option E if the rotary actuators were able to provide the specified preloads.