FLUIDIC MANAGEMENT SYSTEM FOR HEMPT-NG

EPIC WORKSHOP FOR ELECTRIC PROPULSION LONDON 2018

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Project description

Fluidic Management System (FMS) is a **subsystem** of the Highly Efficient Multistage Plasma Thruster - Next Generation (HEMPT-NG) electric propulsion system

Top level objective

- Development, assembly and testing of next generation Fluidic Management System for HEMP-T

Industrial Consortium

- The execution of the subsytem activites are perfomed by:
  - Thales Alenia Space in Germany &
  - Thales Alenia Space in UK,
  - with AST Space as key supplier.

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Project major objectives

Major objectives

- Foster innovation: Provide innovative concept, beyond state-of-the-art
  - → Usage of **miniature fluidic components**
  - → Design having **reduced complexity**
- Create competitive product:
  - → **Mass production capability** with reduced manual production steps
  - → **Generic products** for several HEMP types
- Increase European non-dependence
  - → Development of components with **European origin**

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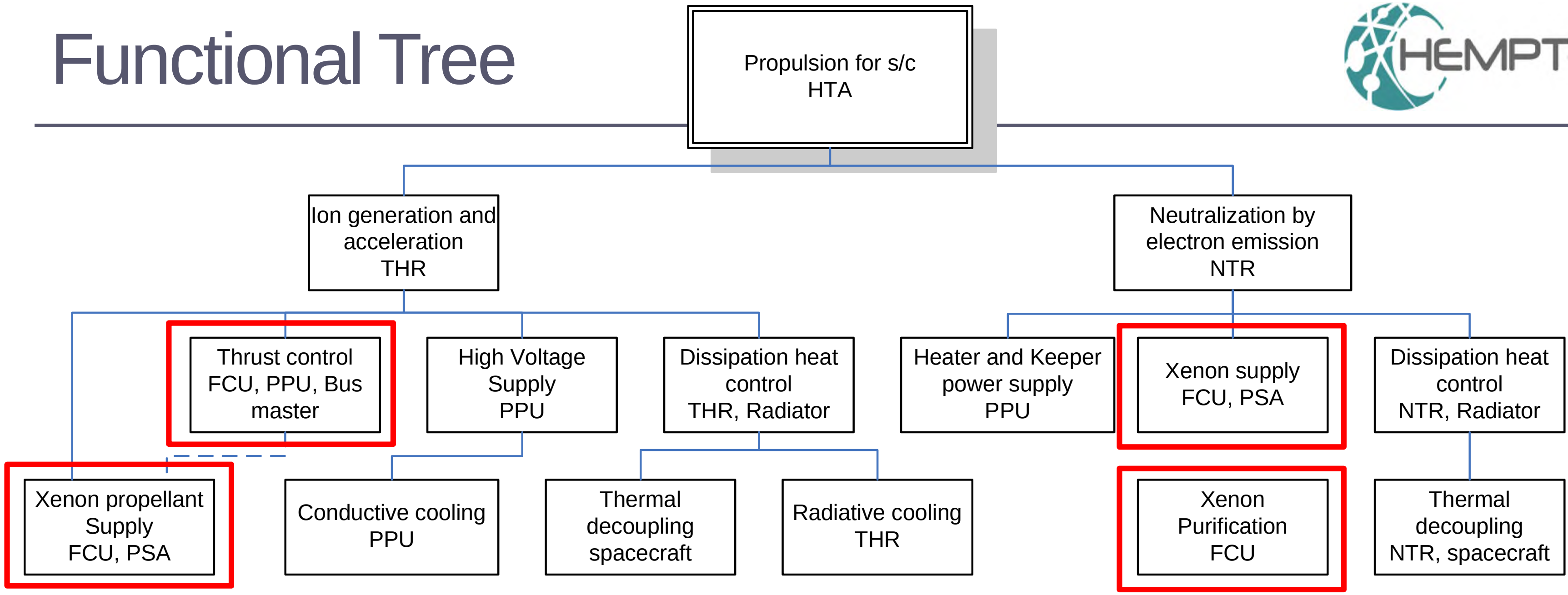
Functional Tree



Needed functions

- Provide Xenon to Thruster and Neutralizer
- Provide means of controlling thrust
- Provide purified gas to neutralizer

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Trade-off analysis: Combining PSA and FCU?

HEMPT-NG

PROs	CONs
Only **one equipment** needed **to be tested** and qualified	**Routing** of tubing **problematic**, since either long high pressure lines or 2 times low pressure tubes lengths
Only **one electronics** for PSA/FCU control needed	**No** high flow for **cold gas** support possible
Reduced complexity	**Less flexibility** since only one PSA/FCU per thruster

Summary

- In a **radical low cost approach**, the **combination** could make sense. Cold gas is not supported therefore different redundancy concept is needed.
- For **complex architectures** and different amounts of thrusters, the **separation** of PSA and FCU is beneficial

Conclusion

- Since cold gas support is identified as needed in the HEMPT-NG requirements and flexibility (cross strapping) for redundancy is to be used, a **separation of FCU and PSA** is the logical choice.

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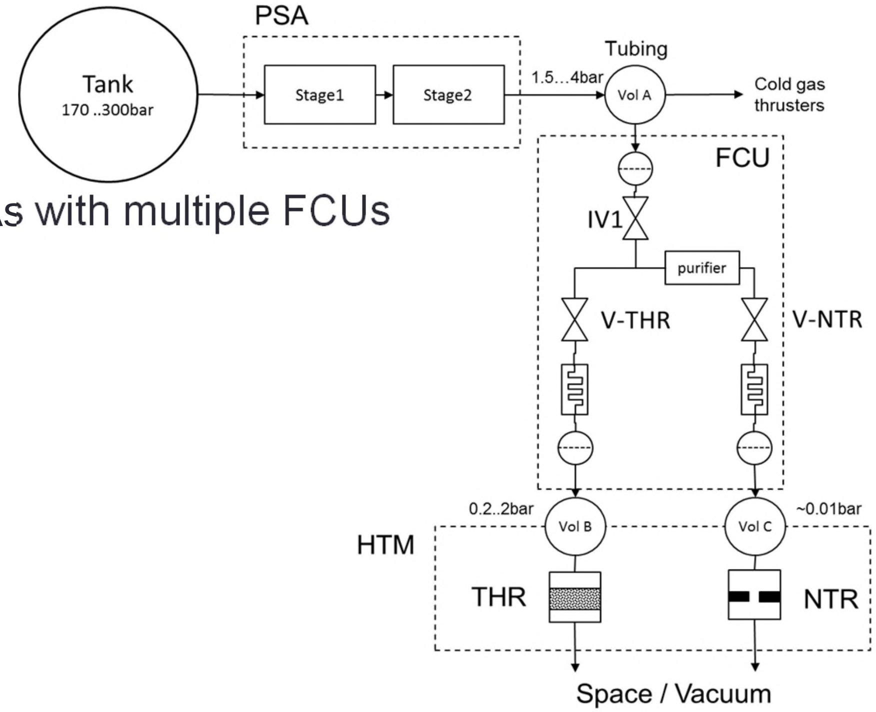
Design of gas feeding system

Key features

- Designed for **Xenon** or **Krypton**
- Supports **cold gas** thruster
- Supports **cross strapping** of multiple PSAs with multiple FCUs



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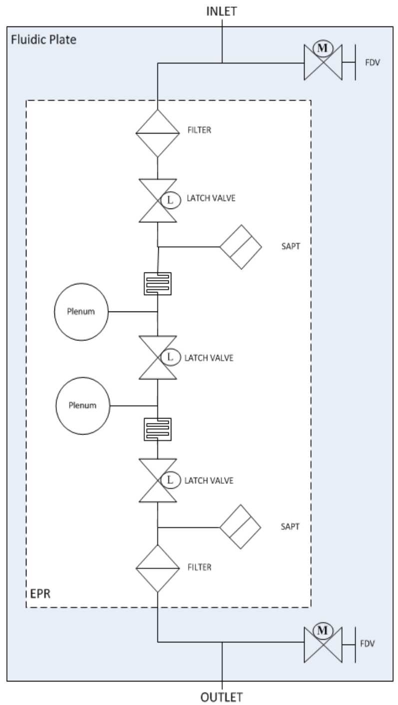
Propellant Supply Assembly (PSA)

Purpose

- The PSA controls the gas flow from the high pressure side to the low pressure side to adjust the outlet pressure to a set value.

Design

- 1 Electronic Pressure Regulator, made up of:
  - 1 inlet filter,
  - 3 consecutive isolation valves,
  - 2 pressure sensors,
  - 2 plenums,
  - 2 ‘mazes’, integrated into the Flow Path Board, that act as orifices
  - 1 outlet filter.
- 2 Fill and Drain Valves (FDVs),
- 1 set of Titanium tubing,
- 1 Fluidic plate with all equipment integrated on it.



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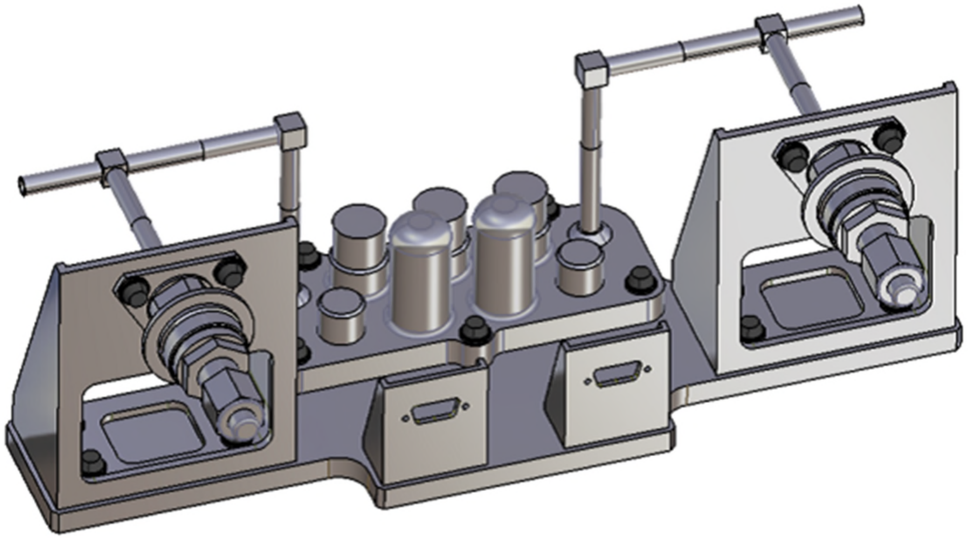
PSA – CAD model



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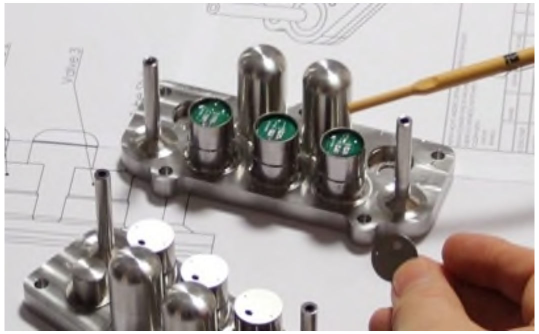
PSA – Key performance data

HEMPT-NG

Key features

- **Two stage** pressure regulator (Bang-Bang regulation)
- **Triple barrier** against propellant loss

Parameter	Specified performance
Inlet pressure (MEOP)	200 bar Xe, 350 bar He
Flow range	0...40 mg/s (Electric propulsion)
	0...400 mg/s (Cold gas)
Outlet pressure range	0...5 bar
Accuracy / ripple	1.5% (200 mbar / 100 mbar)
Qualification temperatures	20…50 °C (Xenon shall not liquify)
Power consumption	Max. 34.5 W (Typ. <3.6 W EOL)
Internal/External leakage	$<10^{-5}$ scc/s GHe / $<10^{-8}$ scc/s GHe
Gas compatibility	Xe, Kr, Ar, He, dry air, N2
Mass	~1.8 kg



Courtesy of AST Space GmbH

Courtesy of Nammo UK

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AEROSPAZIO AIRBUS ERNST MORITZ ARNDT UNIVERSITÄT GREIFSWALD OHB THALES ThalesAlenia Space European Commission

PSA – Verification Test Sequence for EM

HEMPT-NG

Step #	Verification Test Sequence
1	Initial Inspection and Examination
2	Physical Properties (mass, COI, COG…)
3	Cleanliness and Dryness Verification
4	Proof Pressure
5	Pressure Measurement Calibration Verification
6	Internal & external leakage Tests
7	Evacuation Tests (Venting)
8	Functional Tests
9	Electrical Check-Outs
10	Final examination

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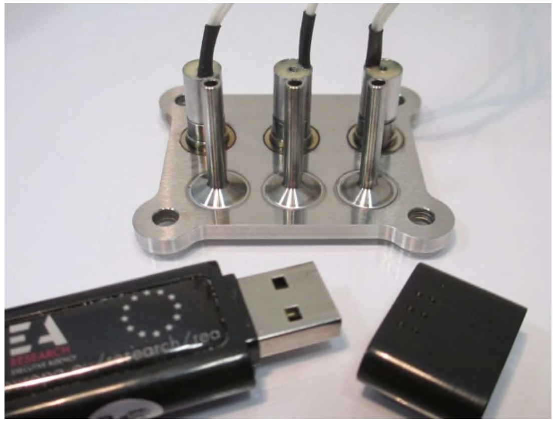
Flow Control Unit (FCU)

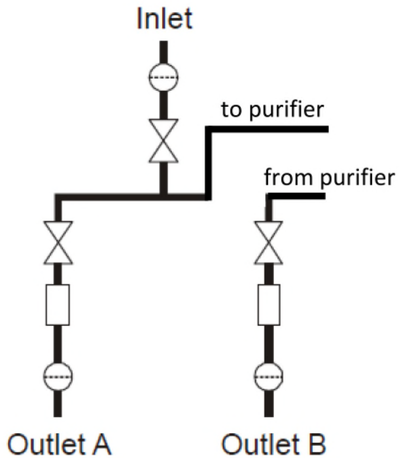
Design and architecture

- Includes modified µFCU with miniaturised components
- Controlled by three valves of one type
- Includes 5 µm particle filters at inlet & outlet
- ‘Mazes’, integrated into the Flow Path Board, that act as flow restrictors
- Gas flow to Neutralizer is routed through a gas purifier



Courtesy of
AST Space GmbH

Courtesy of
SEAS Getters



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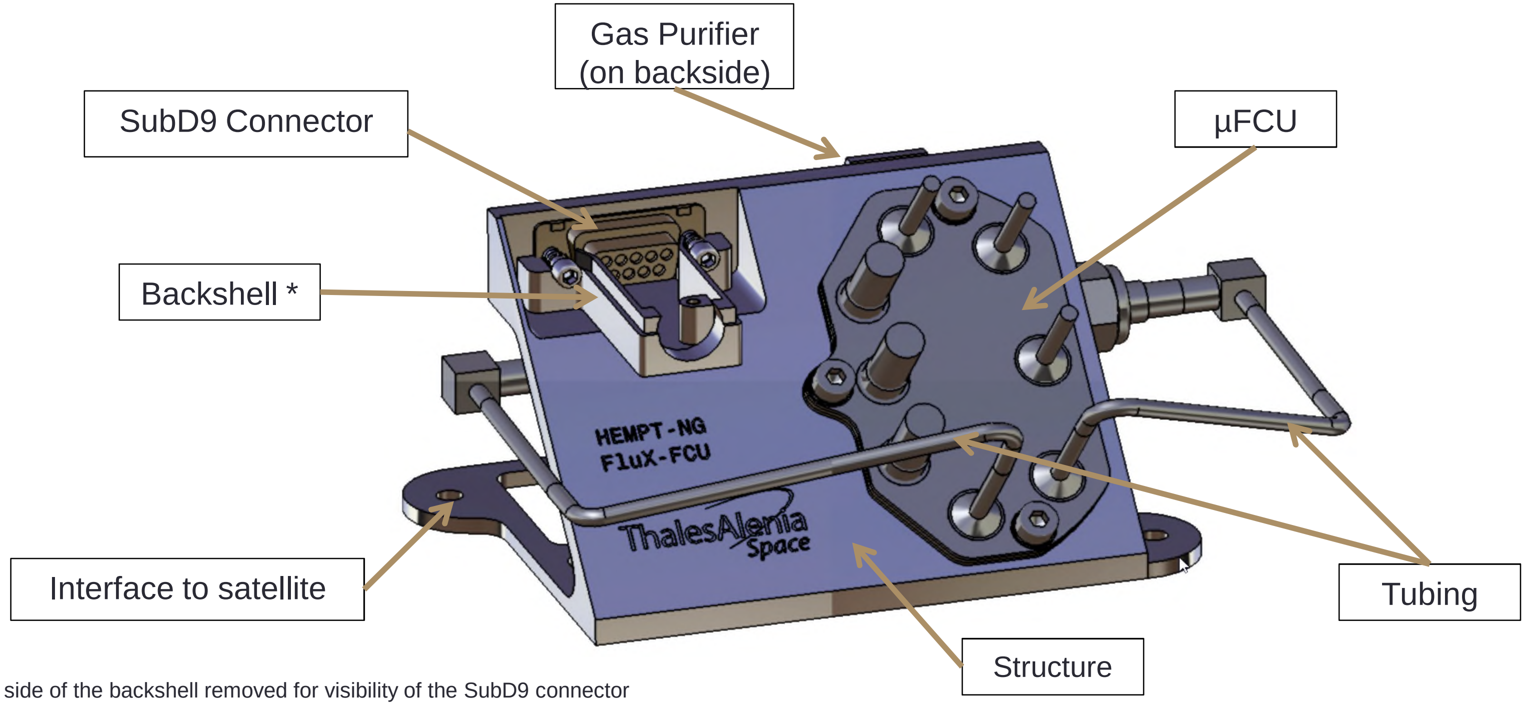
FCU – CAD model overview



* Top side of the backshell removed for visibility of the SubD9 connector
Harness not shown in figure

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FCU – Key Performance Table

Parameter	Specified/expected performance
Inlet pressure (MEOP)	2…4 bar (7 bar)
Thruster flow	0,2…2 mg/s (Type LEO)
	2…20 mg/s (Type MEO/GEO)
Neutralizer flow	0,1…0,3 mg/s
Qualification temperatures	-25…90 °C (operating)
Power consumption	Max. 5 W (Typ. <1.5 W)
Internal leakage	$<10^{-5}$ scc/s GHe
External leakage	$<10^{-8}$ scc/s GHe over lifetime
Gas compatibility	He, Kr, Xe, N_2
Mass	~800 g (± 10%)

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FCU – Verification Test Sequence for EM

HEMPT-NG

- ***Inspection and Examination***
  - As-built Status & Documentation
- ***Physical Characterization Test***
  - Mass & Envelope
  - Interface position and dimensions
- ***Electrical Characterization Test***
  - Isolation
  - Coil resistance
  - Power consumption
- ***Pressurization Test***
  - Leakage
  - Proof Pressure
- ***Functional Performance Test***
  - Flow performance at Inlet pressure extremes
  - Mapping of flow rate as a function of valve duty cycle and frequency adjustment
- ***Vibration Test***
  - Resonance search
  - Sine vibration test
  - Random vibration test
  - Mechanical Shock
  - Resonance search
- ***Thermal Vacuum Cycling***
  - Non-operational thermal vacuum environment
  - Operational thermal vacuum environment
- ***Final Inspection and Examination***
  - As-built Status & Documentation

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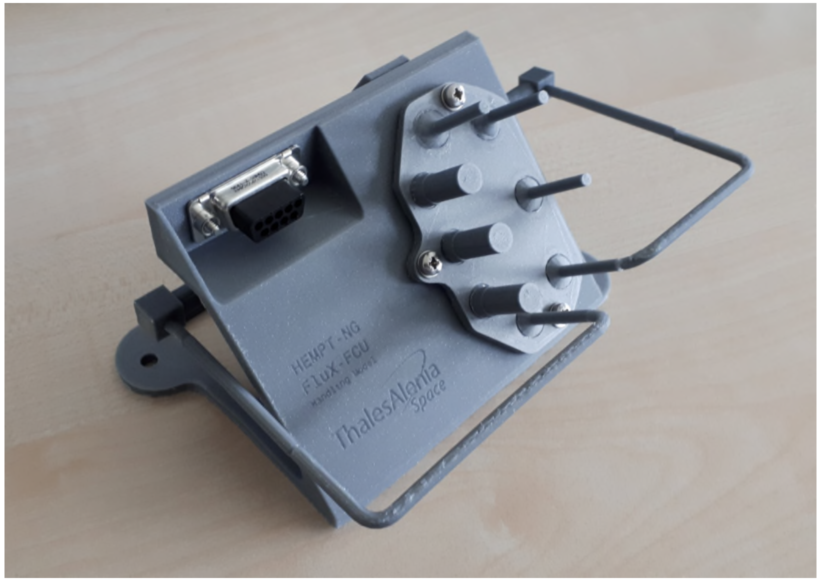
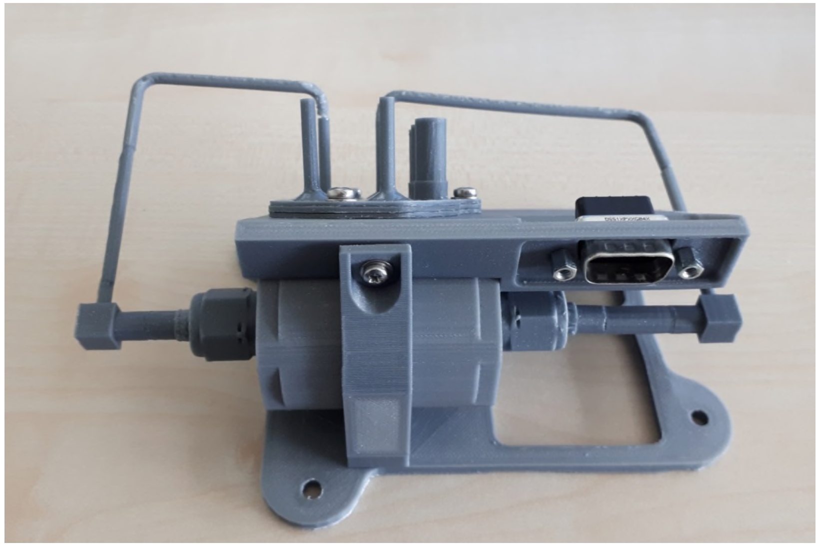
FCU – Handling Model

- Check of assembly and handling constraints
- Check of cable lengths and routing





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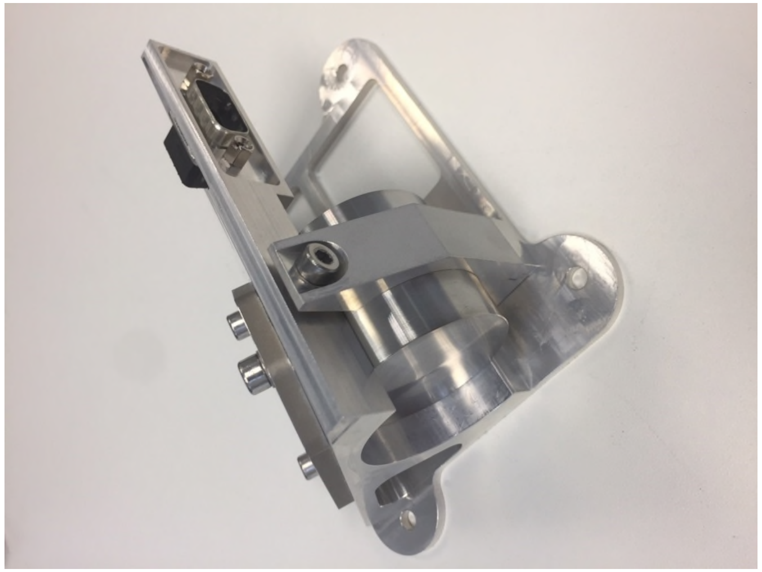
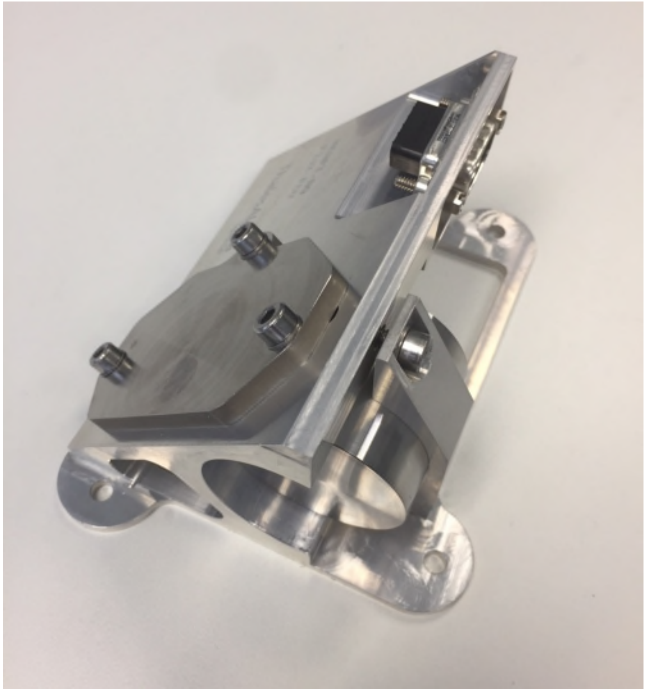
FCU – Structural Model

- Check of piece parts tolerances
- Check compatibility with mechanical environment





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