First results of the development of a MEMS-based µ-Chemical Propulsion System

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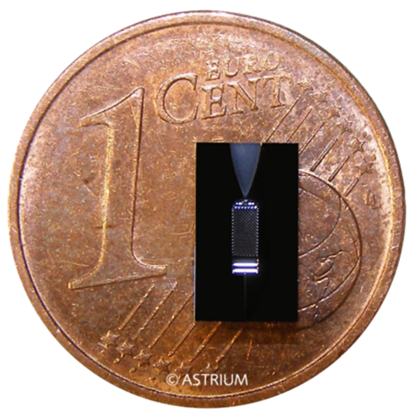
PRECISE – General Overview

- Funded by the European Commission within the 7th Framework Programme
- 7 partners out of 6 countries
- Duration: 2 years (02/2012 – 02/2014)
- 214.3 Man Months ≈ 18 Man Years

- Total: 2,830,429 €
- Requested EC funding: 1,829,367 €

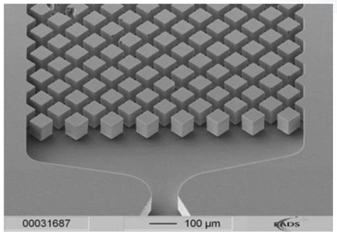
Primary objective

Development of a MEMS-based modular μCPS for highly accurate control of satellites



ASTRIUM AN EADS COMPANY
cnrs
DLR
NanoSpace Swedish Space Corporation Group
JOINT STOCK COMPANY MILITARY-INDUSTRIAL CORPORATION NPO MASHINOSTROYENIA
UNIVERSITY OF SURREY
University of Twente The Netherlands

Chemical Micropropulsion

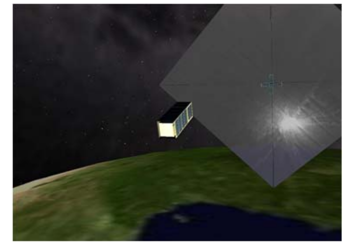


ASTRIUM µThruster

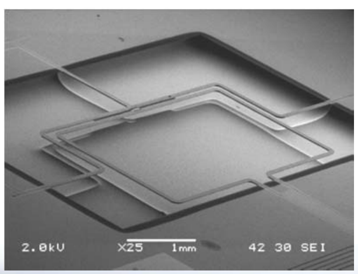
- MEMS-based (Micro Electro Mechanical Systems)
  - Very compact, lightweight and modular architecture
- Thrust levels in the order of < 0.1 micro-Newton up to several milli-Newton
- Thrust is generated by chemical or kinetical energy of the propellant

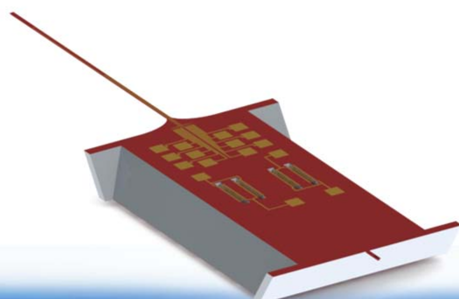
- Suitable for
  - Micro and Nanospacecraft
  - Larger spacecraft with stringent requirements on precision and stability (e.g. formation flying, rendezvous and docking)

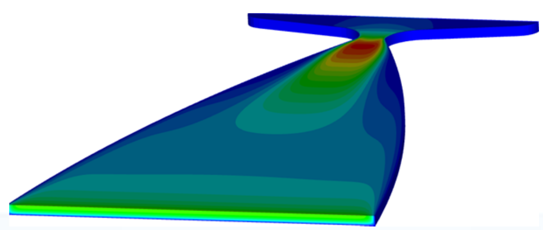
Major research topics of PRECISE



- *Mission Design*
  - Formation flight of solar sail and inspector satellite
- *Material, Components & Technology Research*
  - Nano coatings, µCatalyst, µValves, µHeater, µDiagnostic Tools
- *Development of numerical tools*
  - DLR TAU code and DSMC
- *Development & setup of test capabilities*
  - Infrastructure (vacuum chamber, DAQ, Control System)
  - Measurement techniques (thrust balance, mass flow and plume sensors)
- *Assembly and demonstration firings with hydrazine*

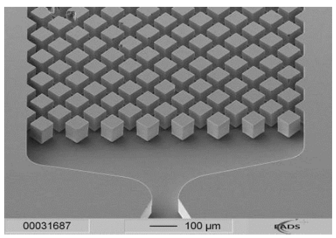






µPropulsion Subsystem

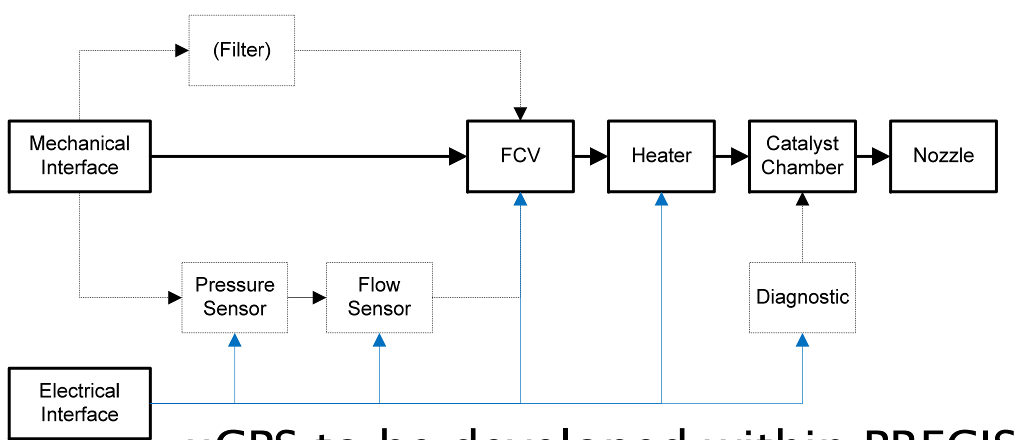
- Incorporate all the components of a classical chemical subsystem



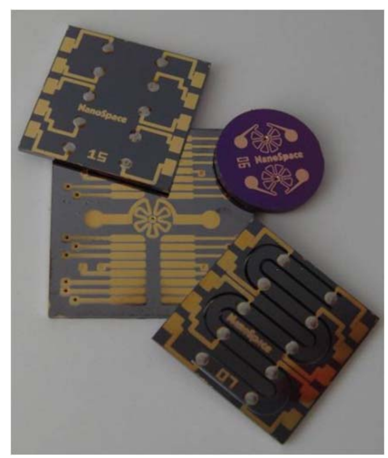
ASTRIUM µThruster

Nanospace cold gas thruster pod as used on PRISMA

$F = 1\text{–}10\,\text{mN}$
$I_{sp} = 180\,\text{s}$ (Minimum)
Hydrazine $\dot{m} \approx 6$ mg/s per thruster

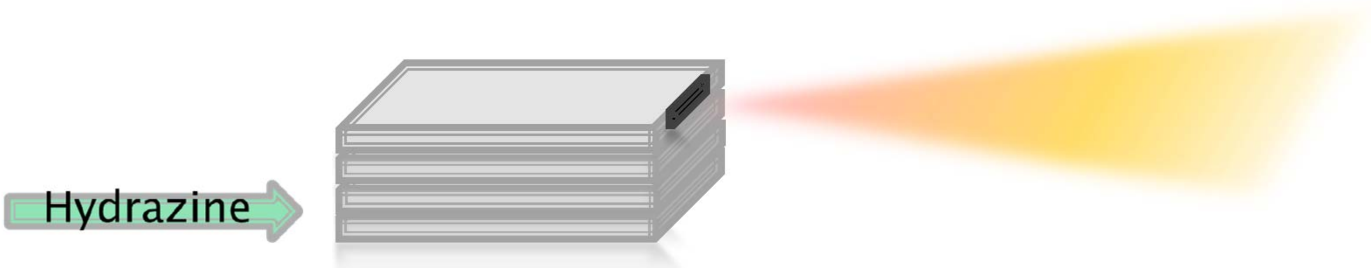


µCPS to be developed within PRECISE



µThruster design approach within PRECISE

- Stackwise layout of the µCPS
- High modularity and thus flexibility
- Interchangeability to test different designs of e.g. µHeater, µValve or µCatalyst

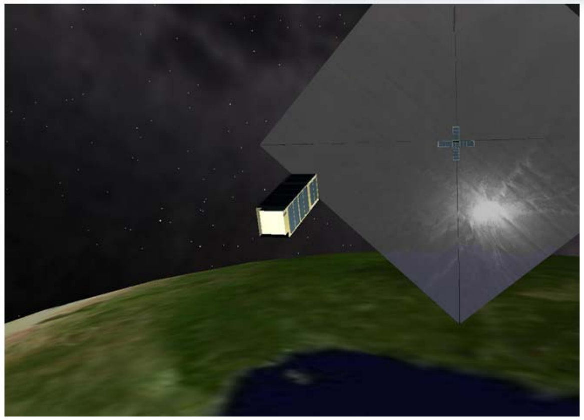


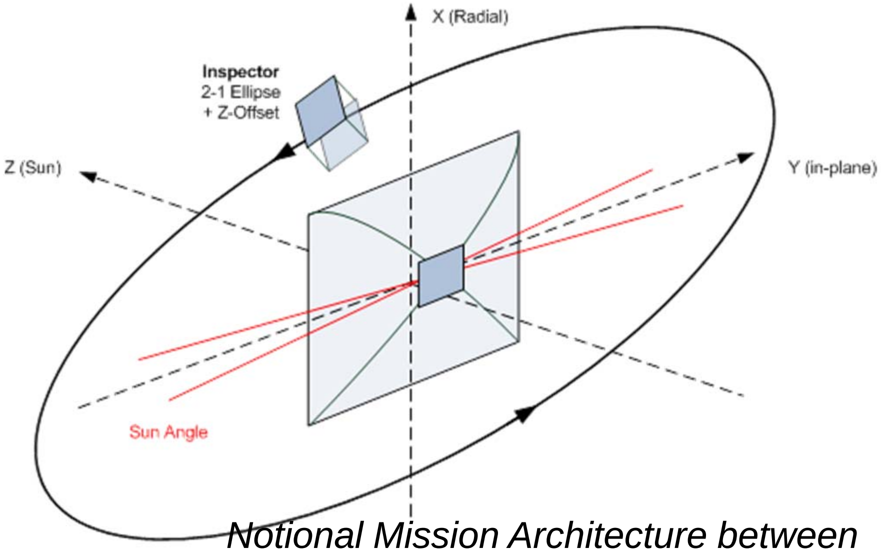
Model Mission

Relative Formation Flying:

- Sun-synchronous Orbit (12/12)
- Altitude ≈ 1600 km
- String-of-Pearl & 2-1 Ellipse Orbit
- Mission delta-v requirement for the inspector sat ≈ 27m/s

- µCPS is usable for:
  - Relative Manoeuvres
  - Momentum Dumping
  - Drag Mitigation
  - SRP Mitigation
  - Station Keeping

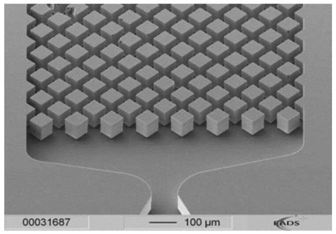




Notional Mission Architecture between GOSAMER-1 & InspectorSat

Propulsion research and catalyst development

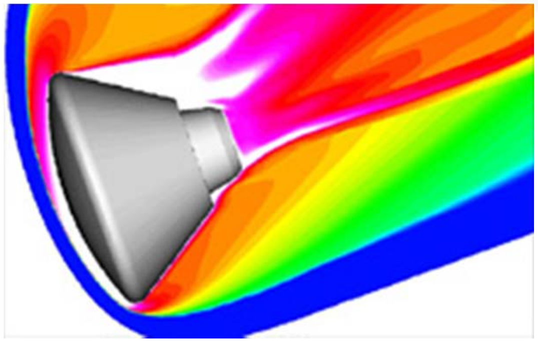
- Micro Fluidics
  - Super-hydrophobic internal wall: reduce pressure drops
  - Super-hydrophilic catalyst surfaces: increase catalytic activity
  - Optimized catalytic and thermal decomposition

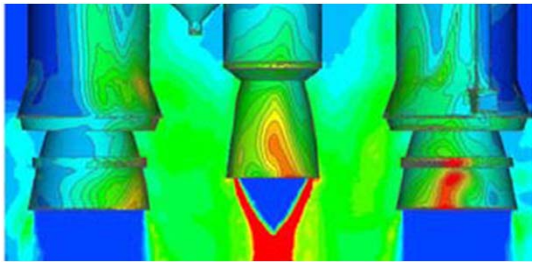


- Micro Catalyst
  - Design of the decomposition chamber (pillars, channels)
  - surface treatment and coating techniques
  - Identification of a layer design (porous layer + catalytic coating + etc.)
  - material identification and testing
  - Manufacturing, characterization and lab testing

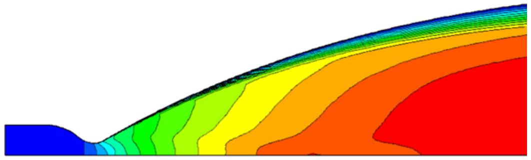
The DLR TAU Code

- TAU Applications
  - Reentry
  - Rocket base buffeting
  - Scramjet supersonic combustion
  - Reactive nozzle flow

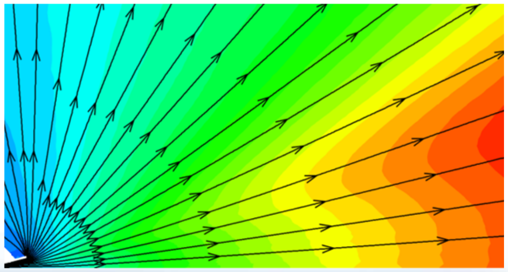




- Boundary layer flow



- Expansion into vacuum
  (with DSMC code)

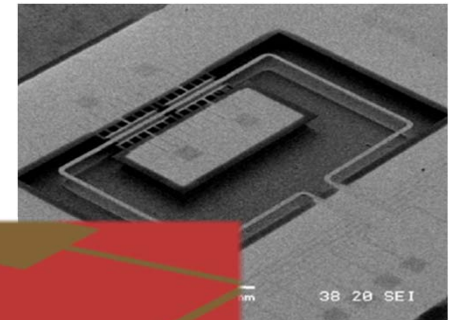


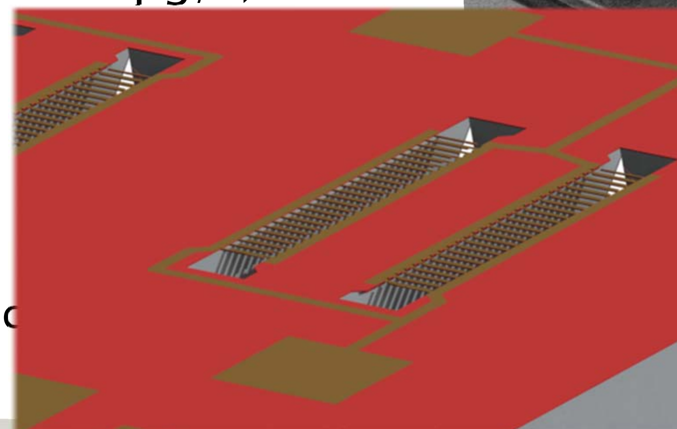
Mass flow and plume sensors

- Micro Coriolis mass flow sensor
  for hydrazine flow measurement ($\dot{m} < 1 \mu g/s$)

- Plume measurement

- Surface channel technology
  - low pressure drops due to the near c
  - 1µm thin slicone nitride wall





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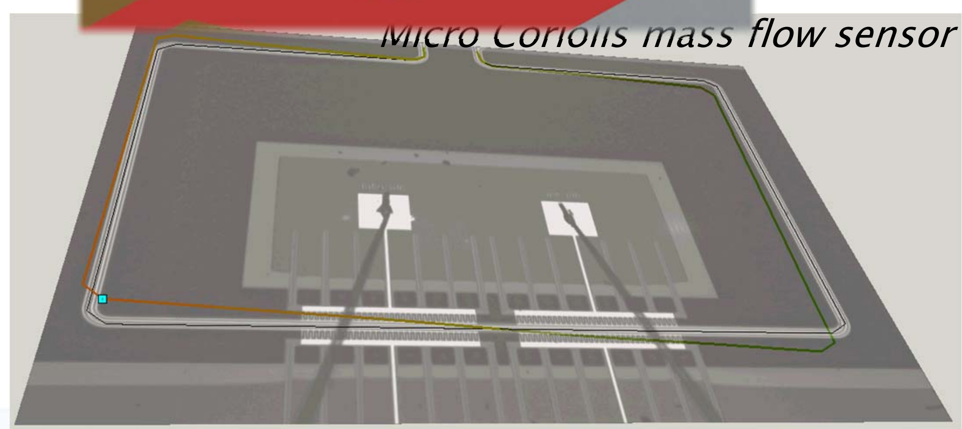
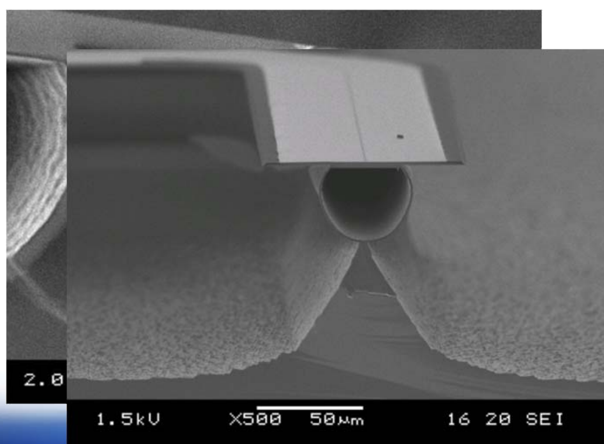
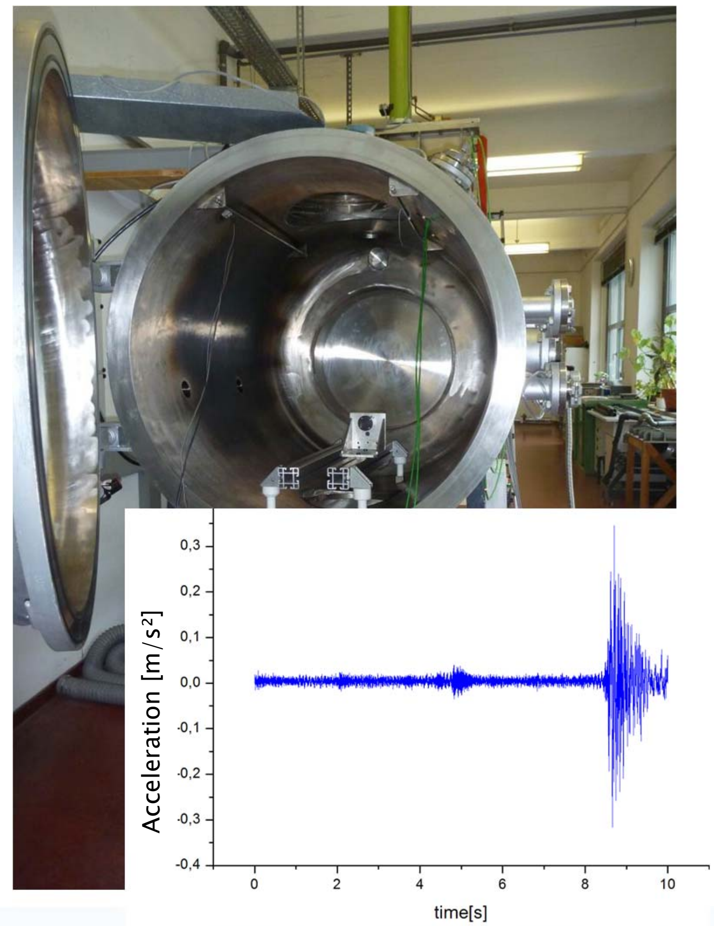


Micro Coriolis mass flow sensor



Test facility STG-MT

- Stainless steel chamber
  - Volume 1000l
  - Good accessibility for installation of measurement equipment + thrust stand
- Several pumps incl. liquid helium cryo pump maintain a pressure of 10^{-9} bar
- 1 bar → 10^{-9} bar: 2,5h
- Essential: minimisation of ground vibrations
- Highly sensitive thrust measurement balance necessary



Acknowledgements

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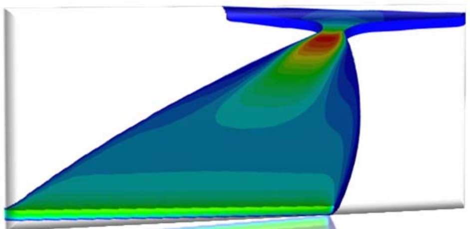

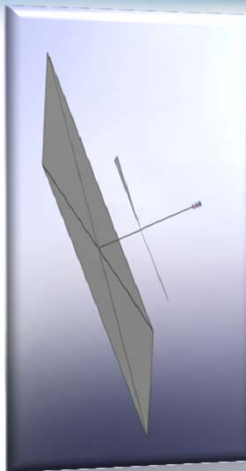

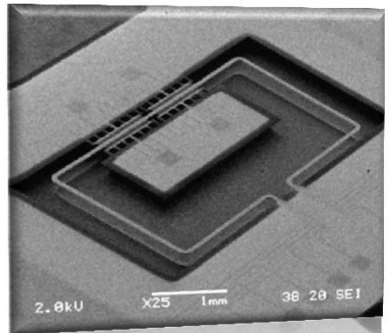

Any questions?

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