FLIGHT DEMONSTRATION OF NEW THRUSTER AND GREEN PROPELLANT TECHNOLOGY ON THE PRISMA SATELLITE

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Introduction and Outline

- Objectives
- PRISMA Mission
- HPGP Propulsion System Description
- Research & Development
 - Propellant
 - Thruster
 - System
- Assembly, Integration & Test
- Conclusions
- Acknowledgments



Objectives "High Performance Green Propellants" (HPGP)

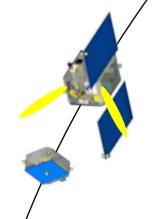
- The objective in 1997 was to develop (within 10 years) a new storable monopropellant, thrusters and system for small satellites which compared to Hydrazine:
 - has significantly better performance
 - is "Green" i.e. significantly less hazardous and environmentally benign
 - reduce the overall mission cost
- The objective for the first flight demonstration of the HPGP technology is to reach TRL 7
 - The mission also offers the opportunity to perform Back-to-back comparison with a comparable hydrazine system





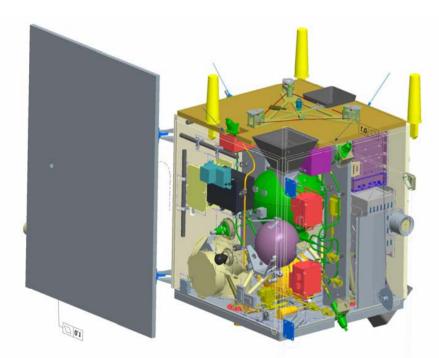


- Prime Contractor: Swedish Space Corporation
- Contributions from DLR and CNES
- Autonomous Formation Flying
- Homing and Rendezvous
- Proximity Operations
- Flight Demonstrations of 2 New Propulsion Technologies
 - HPGP ECAPS
 - Micropropulsion Nanospace
- Main Satellite: Wet Mass:150 kg, Dim: 1 x 0.7 x 0.7 m
 - ΔV Capability >150 m/s
- Target Satellite: 50 kg
- Orbit 900 km
- Launch scheduled for 2009

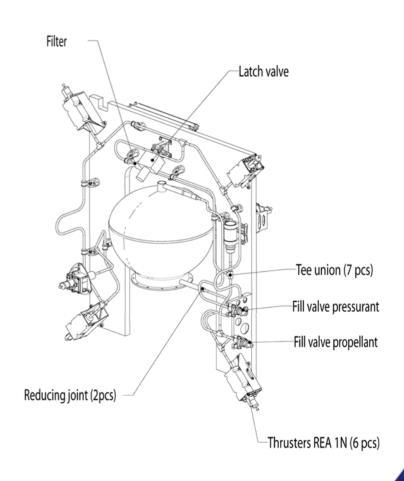




PRISMA Propulsion Systems



- Hydrazine RCS
- HPGP RCS
- Micropropulsion (MEMS)





PRISMA HPGP Propulsion System Design

Conventional Hydrazine System Architecture

- Operation in Blow-down mode
- All Fluid Components are COTS with extensive flight heritage

Novel Propellant and Thruster Technology

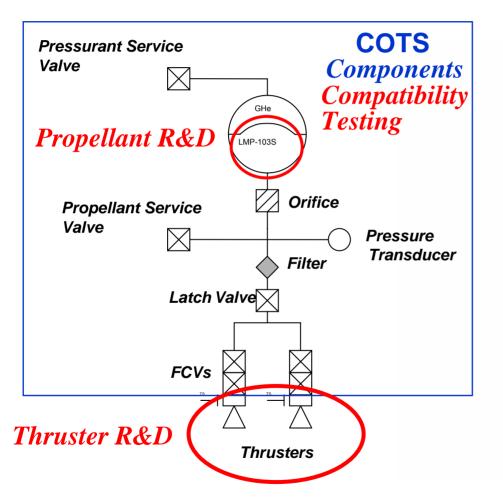
- 2 x 1 N HPGP Thrusters
- Propellant load is 5.5 kg of LMP-103S

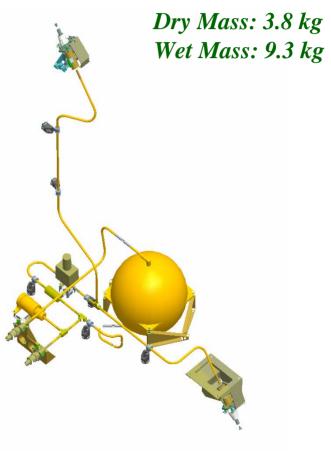
ECAPS holds patents worldwide for a family of ADN-based Propellants, Catalyst, Thruster Design and Manufacturing Methods



PRISMA HPGP Propulsion System

Hydraulic Schematic & Lay-out







PRISMA HPGP Propulsion System Propellant LMP-103S

- Formulation & Performance
- Classification & Safety
- Storability & Compatibility
- Propellant Manufacturing
- Fuelling



Formulation and Performance

- LMP-103S is a storable monopropellant consisting of a blend of ADN (NH₄N(NO₂)₂), Water, Methanol and Ammonia
- LMP-103 has 6 % higher theoretical specific impulse and 24 % higher density as compared with hydrazine, thus improving:

Density Impulse up to +30 %

- The performance improvement has been verified by firing tests
- Higher performance has been demonstrated by tuning the composition



Classification & Safety

- LMP-103S has been approved for transport to according to <u>UN Class 1.4S</u>
- LMP-103S has <u>UN No: 0368</u>
- LMP-103S is classified as an <u>1.3 Substance</u> explosive hazard
- Moderate toxicity. Vapour toxicity (due to (ammonia and methanol) is 2500 times less than for hydrazine



Propellant LMP-103S Storability

LMP-103S has short term stability from:

LMP-103S has long term stability from:

 Accelerated propellant storability test (STANAG 4582) indicates:

> 20 years of storage life

 LMP-103S is not sensitive to radiation of 100 kRad (Cobalt 60)



Compatibility





Compatibility Issues:

- General Corrosion
- Galvanic Corrosion
- Redox Potential
- Stress Corrosion
- Leaching
- Diaphragm Integrity
- Hydrogen Embrittlement





Storability & Compatibility End-to-End Test



Storability & Compatibility End-to-End Test with COTS Components:

- > 2 year duration
- > 20 000 valve cycles
- Pressure & temperature monitoring
- Temperature range +10 to +50°C
- Regular propellant sampling & Analysis

Results after 18 months:

- No pressure build-up
- No corrosion
- Insignificant leaching of materials



LMP-103S Propellant

Manufacturing

- Manufacturing process has been verified for <u>Flight Quality</u> (High Purity Grade) LMP-103S propellant
- Manufacturing is ongoing for 50 kg of LMP-103S propellant



LPM-103S Propellant Plant at EURENCO, Karlskoga



Fuelling



Fuelling SMART-1 with Hydrazine



ECAPS Fuelling with LMP-103S

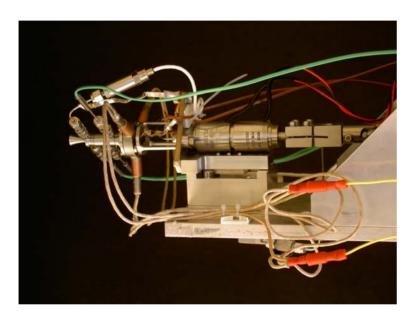
- SCAPE suites are not required
- Unlike Hydrazine, LMP-103S is <u>not sensitive</u> to exposure to air or humidity
- ECAPS has performed >40 fuelling sessions since 1999



LMP-103S fuelling equipment



Thruster Development



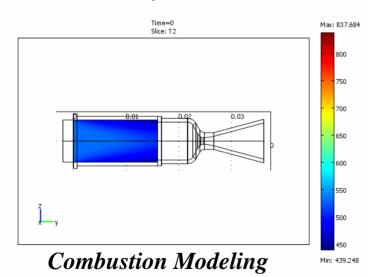
1 N HPGP Development Thruster

- >30 Thrusters (Development, Engineering and Prototype models) have been built and test fired since 1999
- TRL-3 was achieved in 1999
- TRL-6 was achieved in 2007
- PRISMA Flight Thrusters are currently integrated into the propulsion system

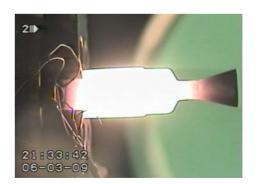


Thruster Design

- Conventional Flow Control Valve
- Un-cooled Rhenium / Iridium Thrust Chamber
- Novel High Temperature Resistant Thermo/Catalytic Reactor









Firing Tests



Firing Test Facility - ECAPS

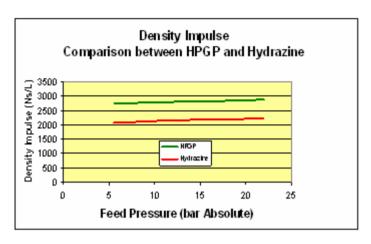


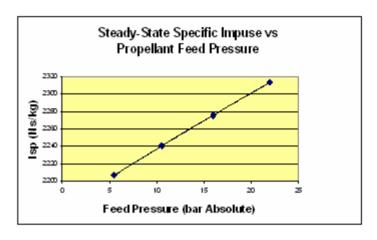


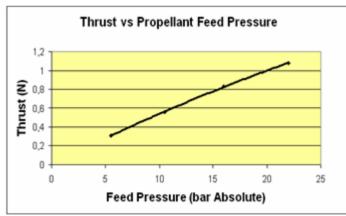
Firing 30 sec

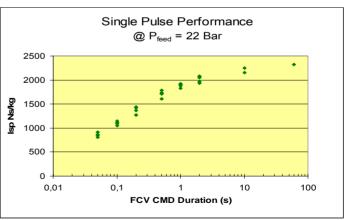


Performance











Life Testing

Parameter	PRISMA "Demonstrated"	ESA Contract "Objectives"
Accumulated Firing Time:	> 5 hours*	> 20 hours
Propellant Throughput:	> 5 kg*	> 20 kg
Number of Pulses:	> 20 000*	> 50 000
Thermal Cycles:	> 500*	> 1000

*No indication of degradation after test



Manufacturing, Assembly and Test



Assembly of Flight Thrusters



HPGP Propulsion System

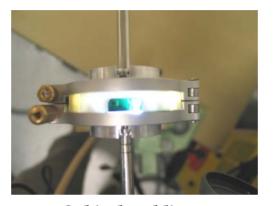
Manufacturing, Assembly & Test



Tube bending



Radiography of weld joints



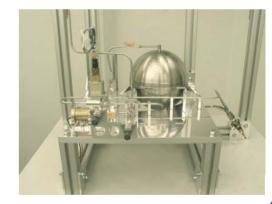
Orbital welding



Pressure and Leak Check



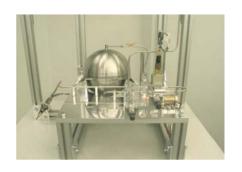
Precision Cleaning



HPGP Flight System



Conclusions



- 10 years after the invention of the HPGP concept the first Flight Propulsion system has been successfully developed, manufactured and verified
 - On time
 - On Budget



PRISMA STM

- The initial objectives for developing the new propellant and thruster technology have been met i.e.:
 - Higher performance
 - Less hazardous and environmentally benign
 - Reduce the overall mission cost
- The required infrastructure to manufacture and test
 1 N HPGP systems is in place, including catalyst and propellant manufacturing

Conclusions



 Life tests will start in 2007 within the ESA contract. The goal is 20 kg of propellant throughput and accumulate firing time of > 20 hours.



 Propulsion Module RFQ for commercial small satellites have been received and proposals have been submitted



 Up-scaling to higher thrust levels and development of a 20 N Thruster has started (Phase 1)



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