9th ESA MNT Round Table
Micro & Nanotechnology for Space Applications

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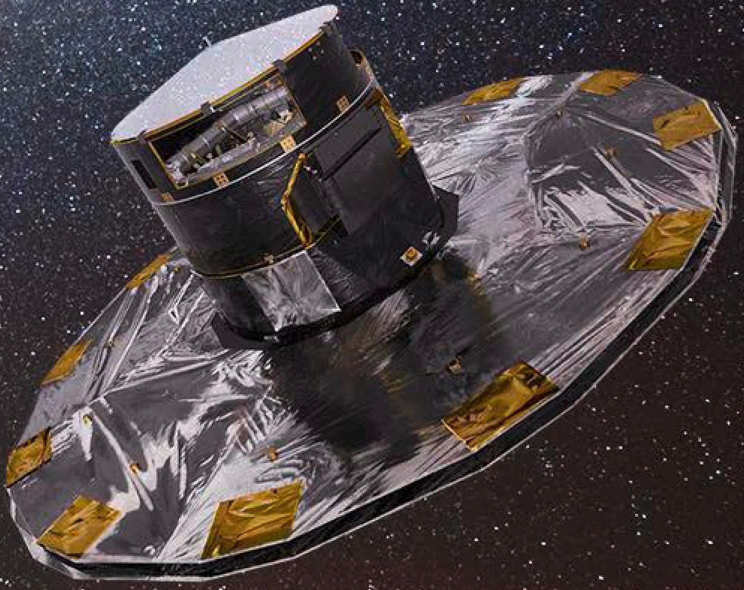
Lausanne 10-13 June 2014



50 YEARS OF EUROPEAN COOPERATION IN SPACE

esa

1964-2014

→ SERVING EUROPEAN COOPERATION AND INNOVATION

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- In 1964, Conventions of the precursors of ESA (ESRO & ELDO) entered into force.
- 2014 is dedicated to addressing the future in the light of these 50 years of unique achievements in space, which have put ESA among the leading space agencies of the world.
- 50 years of European cooperation in space is an anniversary for the whole space sector in Europe, which can be proud of its results and achievements.
- Testimony that, when Member States share challenging objectives and join forces, Europe is at the leading edge of progress, innovation and growth, for the benefit of all its citizens.
- This has been, and continues to be, ESA's mission for the future.

9th ESA MNT Round Table

- ✓ MEMS and ESA Projects
  - GAIA
  - Sentinel 3
  - AEOLUS
  - JWST
  - MEMS Propellant Gauging Systems
- ✓ ESA R&D and MNT
- ✓ 9th ESA MNT Round Table:
  - Figures
  - Acknowledgements
  - ESA 10th MNT Round Table

MEMS and ESA Projects

- ✓ MNT smaller, lighter of course but also **function / mission enabler** and in certain cases allow **European Non-Dependance**

- ✓ **ESA GAIA is flying MEMS** Flow Sensors as Mission Critical Components

- ✓ **ESA S3 MEMS GYRO qualified and ready for flight**

- ✓ **ESA Projects present challenges:**
  - ESA AEOLUS MEMS Pressure Sensors procurement and qualification
  - ESA JWST: finalise FM MEMS shutters procurement and Δ-qualification with NGSC

- ✓ **ESA efforts to integrate European MEMS Pressure transducer in platform Propellant Gauging Systems (Space Qualification expected 2016)**

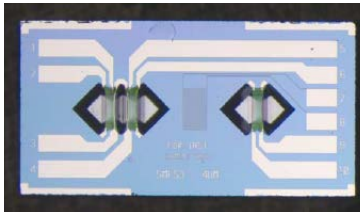
GAIA:
MEMS Flying as Critical Component

ESA Project: GAIA, Propulsion System

In 1993: HIPARCOS Astrometric Accuracy was: 1-10 milliarcs, Gaia will be 20 µarcs

MEMS: Very accurate pointing required => order of µN thrust is mandatory, µN thrust only available with cold gas micro propulsion and need for very accurate (1 µN) and fast time response (10 Hz) flow sensor

The flow sensor is an heritage from medical application



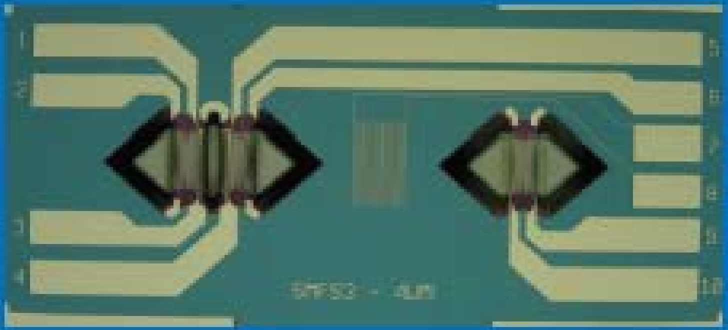
ESA GAIA Satellite

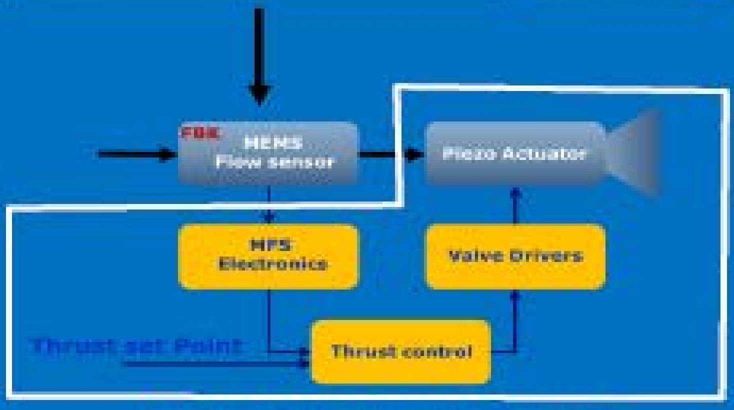
MEMS Mass Flow Sensors for Cold Gas Microthrusters

(Thales Aleania Space (MI), Selex Galileo (FI), FBK (TN))

General Characteristics

- Provides the actual mass flow rate at the MT inlet, strictly related to the generated thrust level.
- Detects the "temperature unbalance" in presence of the gas mass flow, between two thermometers, while a constant amount of power is provided in between.
- Si-Chip technology: a heating element is positioned in between the upstream and downstream temperature sensing elements (thermo-resistors)
- Inside the Si chip, two other temperature sensors are realized for thermal stabilization
- The sensors for monitoring of bulk surface and gas temperature





MT Closed loop operative principle

General Specifications

- MFS Dynamic Range: about 3order of magnitude
- MFS Frequency/Time response: 300 Hz bandwidth

ESA's billion-star surveyor Gaia is now (Jan 2014) in its operational orbit around a gravitationally stable virtual point in space called 'L2', 1.5 million km from Earth.

S3 MEMS GYRO

ESA Project: Sentinel 3, AOCS (Attitude and Orbit Control System)

MEMS Rate Sensor, Motivation for MEMS: **European Non Dependence**

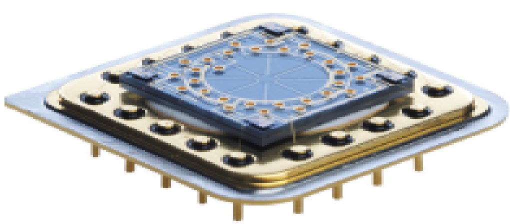
Status: MEMS FM procurement and project qualification completed

Ready for flight, Heritage: automotive

ESA – 9th ESA Round Table on Micro and Nano Systems for Space

SGH15 Capacitive MEMS Gyro

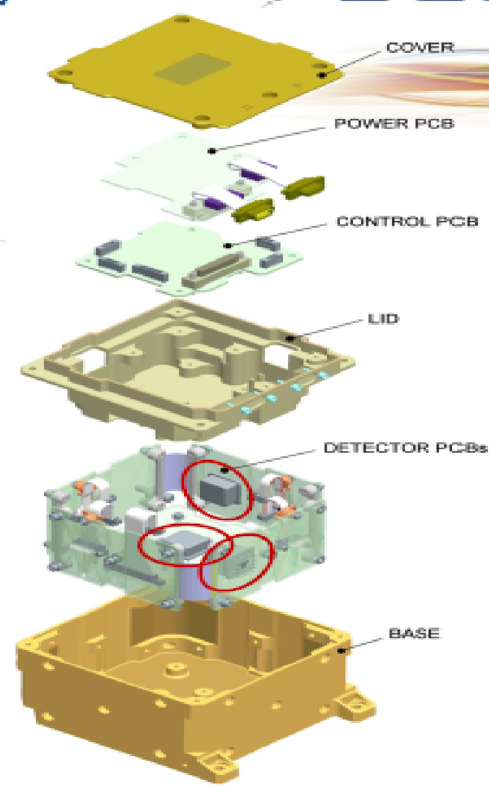
SGH15 MEMS



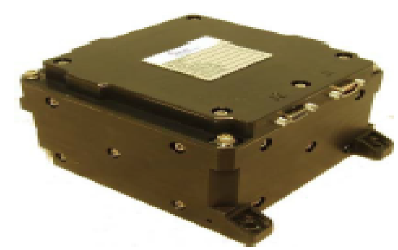
- 8mm Ø ring resonating ring for best performance
- Proven architecture -
  - Glass package
  - Vacuum sealed
  - On chip pick-off amps

SGH15 MEMS Rate Detector

- Hermetically sealed (welded) Kovar base & lid (from VSG3)

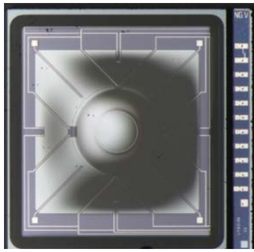


MEMS Rate Sensor



"SGH15 is a unique detector design applicable only to the current space programmes – the latest Inductive VSG3 detector (SGH03) outperforms SGH15 and has a wider commercial market beyond space applications"

Concrete cases:
AEOLUS Pressure sensors



ESA Project: AEOLUS, laser O2 cleaning system

MEMS Pressure Sensors because **Very low pressure Range on < 1 mBar only achievable with MEMS technology**

Status, project procurement and qualification in progress

Heritage: MEMS pressure sensor for oil exploitation and gas sensing

Requirement	*HPT*	*LPT*	*VLPT*
Sensor			
Max. Expected Operating Pressure (MEOP)	200 bar	5.0 bar	150 Pa
Max. Expected Non-Operating Pressure			1.2 bar
Min. Expected Operating Pressure (flight)	0 bar	0 bar	0 bar
Max expected inlet pressure (no degradation of sensor) (MEIP)	1.5 x MEOP 300 bar	1.5 x MEOP 7.5 bar	1.2 bar
Proof pressure	1.5 x MEOP 300 bar	1.5 x MEOP 7.5 bar	1.5 x MEIP 1.8 bar
Minimum design burst pressure	2.5 x MEOP 500 bar	2.5 x MEOP 12.5 bar	2.5 x MEIP 3 bar
Max possible O2 pressure	200 bar	5 bar	150mbar[1]
Analogue output	0 - 5V	0 - 5V	0 - 5V
Max total error band	+/- 0.2%	+/- 0.2%	+/- 3%
Max mass	300g		

Concrete cases:
ESA

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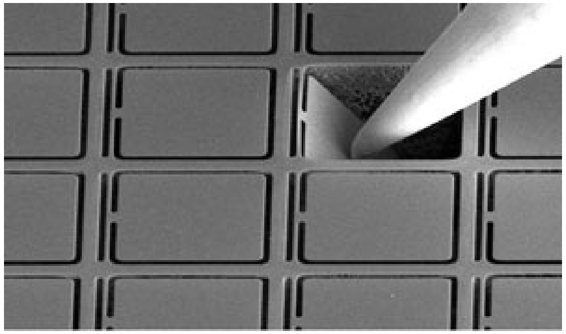
ESA Project: JWST James Webb Space Telescope, NIR-Spec: Multi-image Near InfraRed Spectrometer

Reasons for MEMS: Capable of 100 images observations at one time, significant, improvement on the current technology capability (only one object at a time) & 171 X 365 shutters arrays,

4 arrays, all individually addressable and programmable => Extremely flexible

Status: MEMS Project qualification completed

Heritage for NGSC:
MEMS bolometers



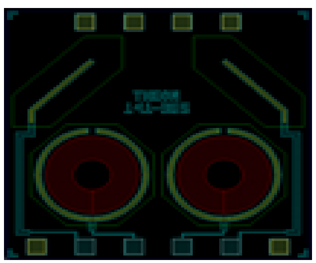
Pressure Transducers

european sensor systems

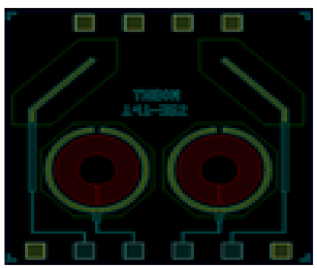
- THEON (ESS) is the contractor and THALES ALENIA SPACE the end user
- Develop a family of ITAR free Pressure Transducers for measuring the remaining propellant medium in the propulsion subsystem

	MPS LEO	PPS	UPS
Functional Performance			
Operating fluid	N_2H_4	Gaseous Xenon (GXe)	GHe, MON-1, MMH
Operating pressure	0-27 bara	High pressure: 0-150 bara Low pressure: 0-7 bara	High pressure: 0-310 bara (GHe) Low pressure: 0-24 bara (MON,MMH)

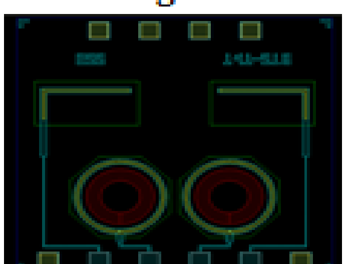
MEMS Pressure sensors (fabricated)



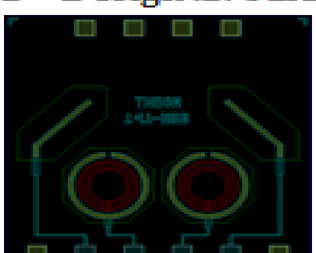
1st Design :7bara



2nd Design :27bara

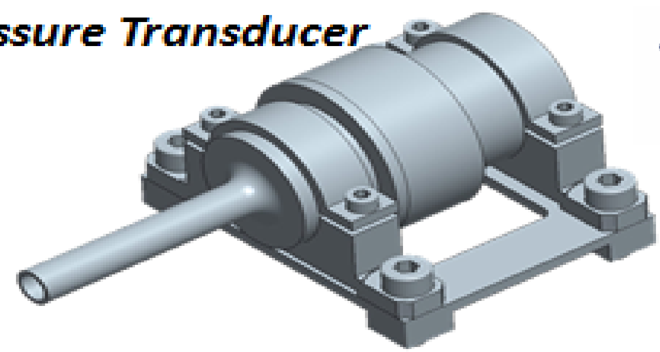


3rd Design :150bara



4th Design :150bara

Pressure Transducer



ThalesAlenia Space

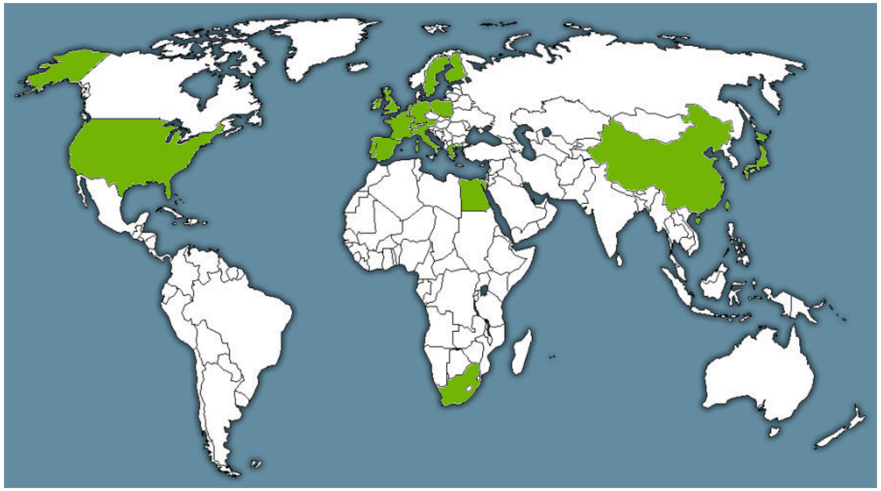
- Status : PDR & MPCB were successfully implemented
  CDR is planned for Q4 2014
- Early prototypes of MEMS pressure sensors and CMOS ASICs were fabricated and their functionality was proved

ESA R&D and MNT:

- ✓ MEMS now proposed as part of European Component Initiative
    - Main focuses: RF MEMS
    - MEMS reliability
- ✓ Major on-going MEMS Activities at ESA:
    - RF MEMS benchmarking and selection
    - MEMS Magnetometer
    - MEMS IMU
    - MEMS pressure transducers
    - MEMS Fabry Perot Interferometer
    - etc
- ✓ Nanotechnologies, ESA initiated activities dealing with:
    - CNTs
    - Graphene (Antenna, RF MEMS, epoxies, ...)
    - 3D/Additive Manufacturing
    - etc

9th ESA MNT Round Table: Figures

- ✓ 54 presentations over 13 sessions
- ✓ 13 posters
- ✓ 120 participants from 21 countries:



Thank You

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- ✓ Thank you to all of you for making this round table a success!
- ✓ Thanks to the Swiss Space Center and Swiss Space Office for their help and support in the organization of this event
- ✓ Thanks to ESA conference bureau for helping us keep the deadlines
- ✓ Thanks to our sponsors:

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EMPA Materials Science & Technology

Media partner: NIA Nanotechnology Industries Association

10^{th} ESA Round Table on Micro and Nano Technologies for Space Applications

2016

In ??