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Space Presentation

Agenda

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1
About InnaLabs
- Our Business
- Our People
- Leadership Team

2
Heritage
- Space Timeline
  Milestones

3
Technology
- Technology Overview
- Technology Roadmap
- Space Products Overview

Our Business

- **About InnaLabs**
  - Established in October 2011, in Dublin, Ireland.
  - At its core, InnaLabs is a ***Developer*** and ***Manufacturer*** of Coriolis Vibratory Gyros (CVG), navigation and tactical grade fused quartz accelerometers, tactical grade IMUs.
  - Privately owned Irish company, which is also supported by Enterprise Ireland as a "*High-Potential*" SME of Global Appeal.
- **Technology**
  - Strong IP Portfolio: 15 patents, with additional pending.
  - World Class suite of experts.
  - 6000m2 Class 7 state of the art clean-room capable of producing 12,000 tactical grade CVGs and 6,000 navigation and tactical grade accelerometers per annum.
- **Quality**
  - ISO 9001:2015 certified; InnaLabs has successfully passed many prime audits and customer validations.

Our People

Over **70%** of our Engineering team have a **Master's degree**

There are **21 Nationalities** in our team

Strong combination of **Inertial Scientists** and experienced **Industrialists**

Developing high-trust work culture with Great Place To Work.

Our Leadership Team

John O'Leary, CEO

- Founded the Irish Operation in 2012.
- Hired world class team from different countries.
- Develop an Irish Hi Tech sensor company that will compete and win on a global scale.

Jose Bietia, CTO

- World class subject matter expert on Inertial Sensors & Systems.
- Designed market leading gyros
- Formed and trained a team of experienced Engineers that deliver high-quality products.

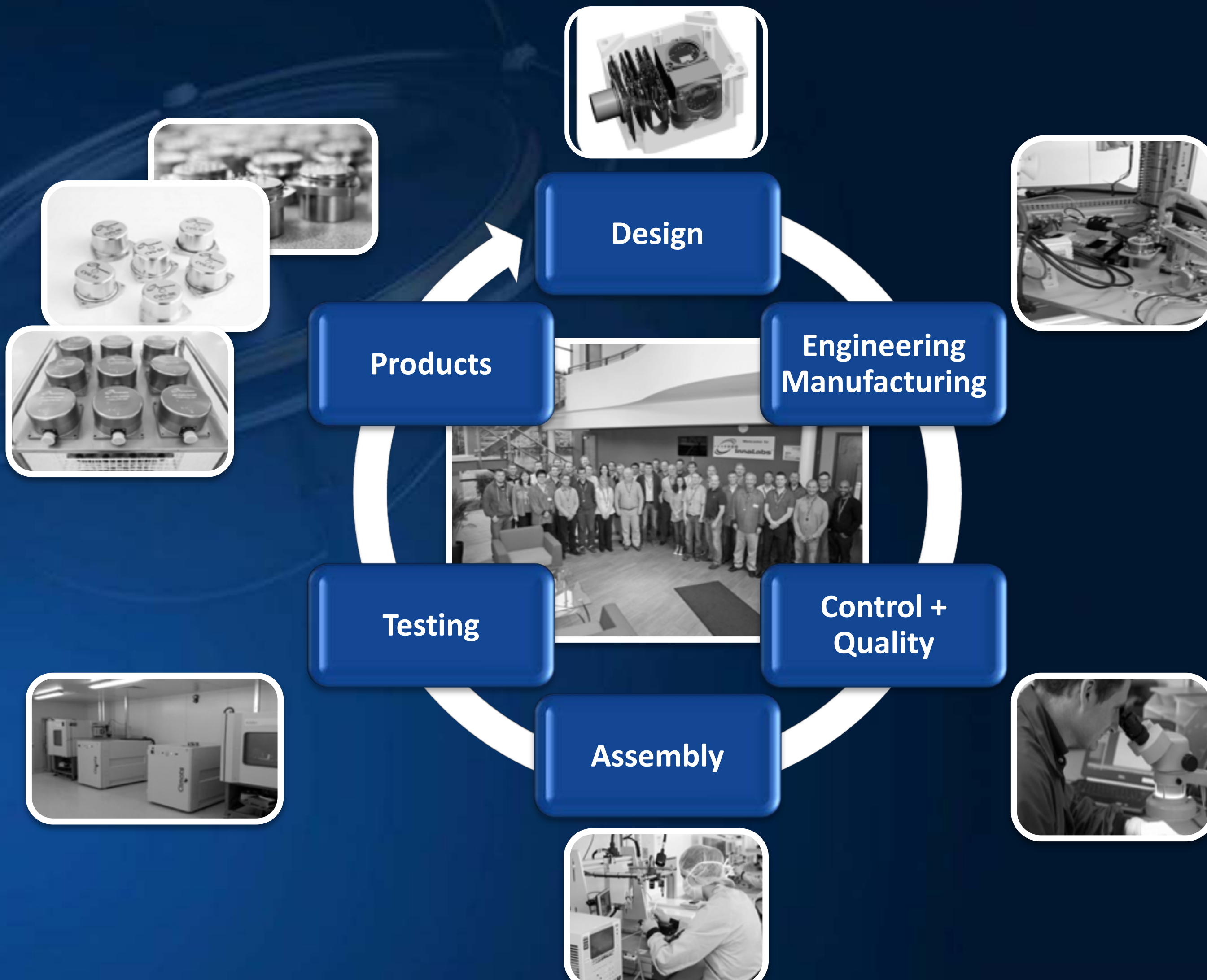
David Fairbrother, CFO

- Extensive experience in Finance and Banking
- Specializing in maximizing profit and growth opportunities
- Key member of the leadership team preparing the company for scaled global growth

James Coburn, VP of Compliance

- Implemented QMS Quality Management System for the company
- Qualified Lead Auditor for the company
- Responsible for our systems and standards of control

Complete Ownership of Development Cycle

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InnaLabs Space Heritage

Timeline

2016	InnaLabs established its space heritage	We established space heritage with successful delivery and operations of gyroscopes for a LEO constellation. By April 2020, we had accumulated more than 1,000,000 operating hours (with no failures or performance degradation) using more than 50 gyros on board 13 satellites in orbit.
2018	InnaLabs® awarded ARIETIS space Gyro Contract	InnaLabs® was awarded the contract to develop the ARIETIS Rad-Hard Space Gyro by the European Space Agency.
2019	InnaLabs® awarded Aquila Space Accelerometer Contract	InnaLabs® was awarded the contract to develop the Aquila Rad-Hard Space Accelerometer by the European Space Agency.

Off-the-Shelf Land stabilisation gyro in LEO, 1,000,000hr in space since 2016 (13 satellites, 52 × 1-axis gyros, 500km SSO)

High-resolution color photograph


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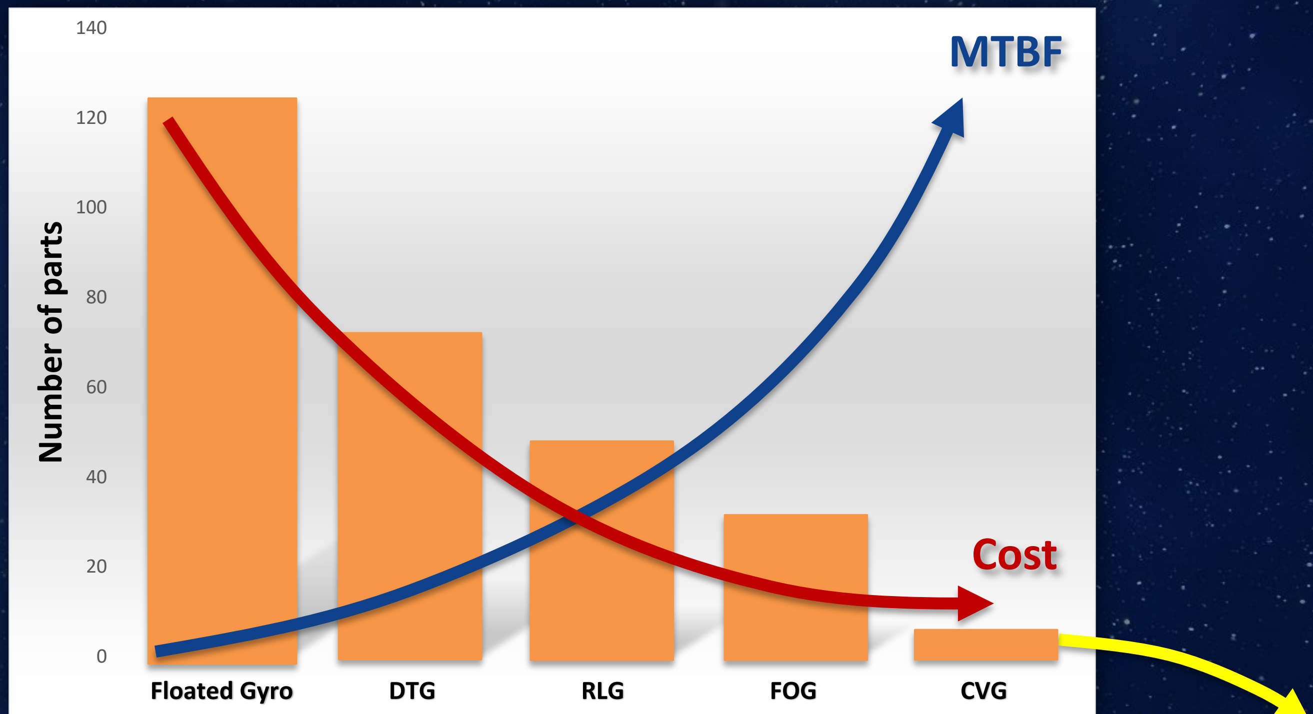
Gyroscope Technology Rationale
Comparison of Gyros



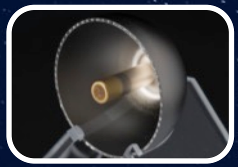
Floated gyro (from ’50s)

DTG (from ’60s)

RLG (from ‘70s)

FOG (from ’70s)

HRG (from ’60s)



CVG (from 2011)

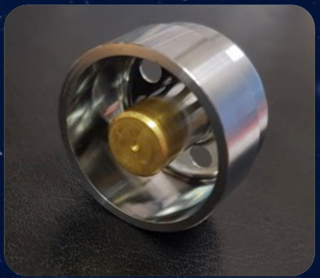
InnaLabs

InnaLabs CVG Technology

- **Start Marconi**
  - First use of a metal cylinder structure was the START (Marconi, 1982) with 1 ° /s performance.
- **Northrop Grumman's HRG**
  - Hemispherical gyro has demonstrated navigation grade performance (**< 0.01 °/hr***) thanks to silica with extremely high Q-factor, high vacuum and electrostatic drive and detection.
- **InnaLabs CVG**
  - Has focused effort on high Q-factor metal cylinder resonators, seeking for a harmonious blend of HRG and START to achieve **1 to 10 °/hr** at **very low cost**

START
GEC Marconi, UK

HRG
*Northrop Grumman**



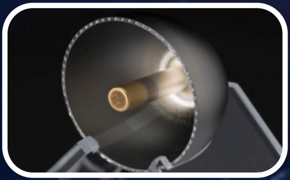
High-Q metal cylinder
Innalabs Ltd

*http://www.northropgrumman.com/Capabilities/HRG/Documents/hrg.pdf

InnaLabs CVG: A Low Cost HRG

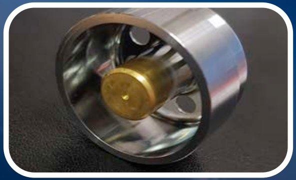
Technology Comparison

Technology	Design	Size	Cost
HRG	• Silica • Hemispherical	--	–
	• Electrostatic • High drive voltage • Gaps of few um	–	✗
	• High vacuum • Getter requires	✗	–
CVG	• Metal • Cylindrical	--	✓
	• Piezoelectric • 5 V	✓	✓
	• Medium Vacuum	✓	✓



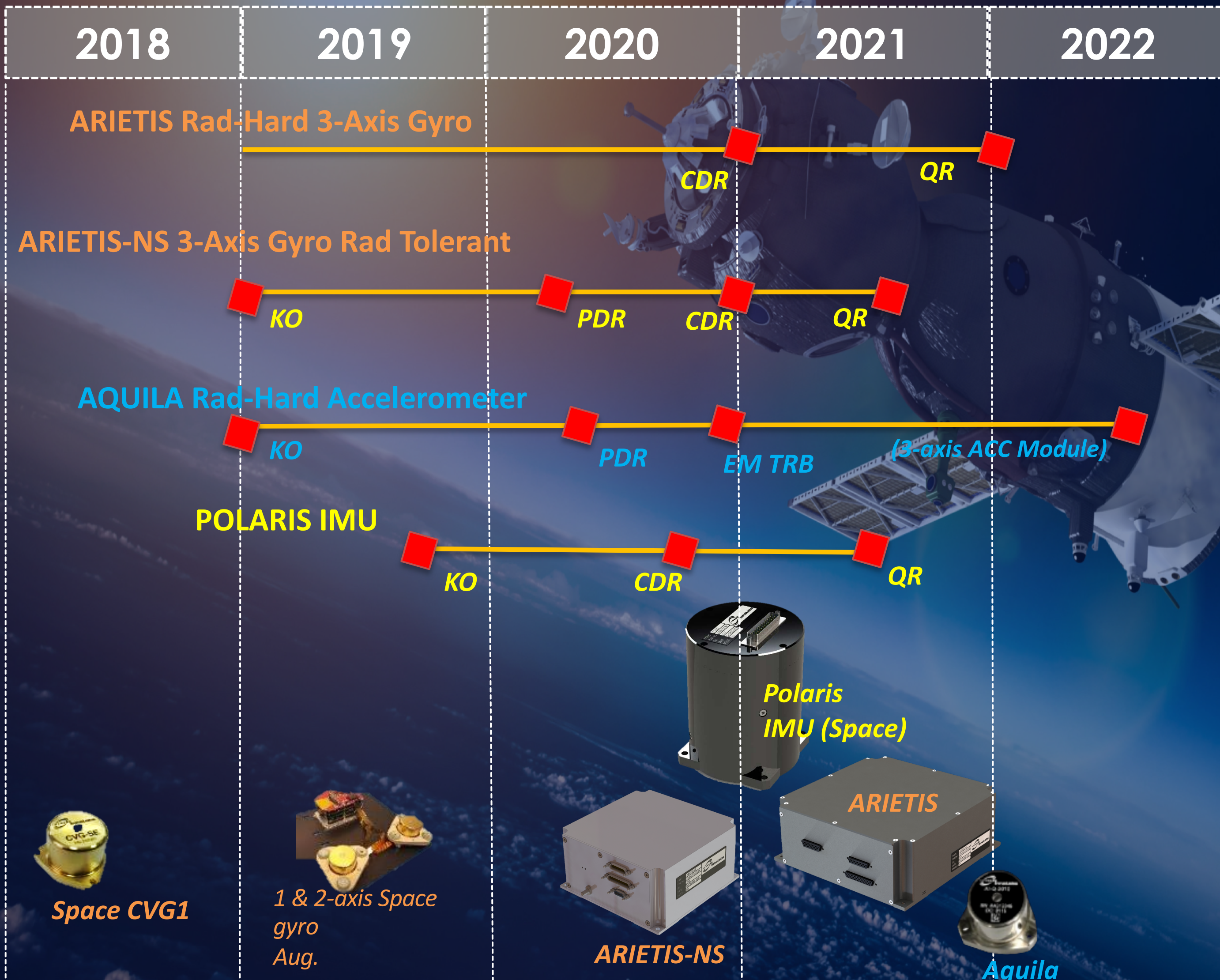
HRG

✓ Good ✗ Poor – Okay



CVG (InnaLabs)

Space Technology Roadmap



Gyros   Accel   Systems

4

Contracts with ESA

$>10^6$ hr

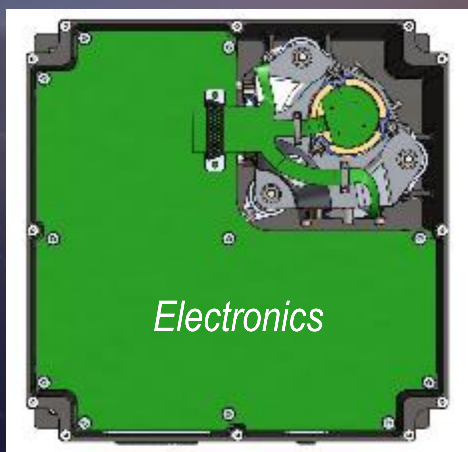
In Space in LEO

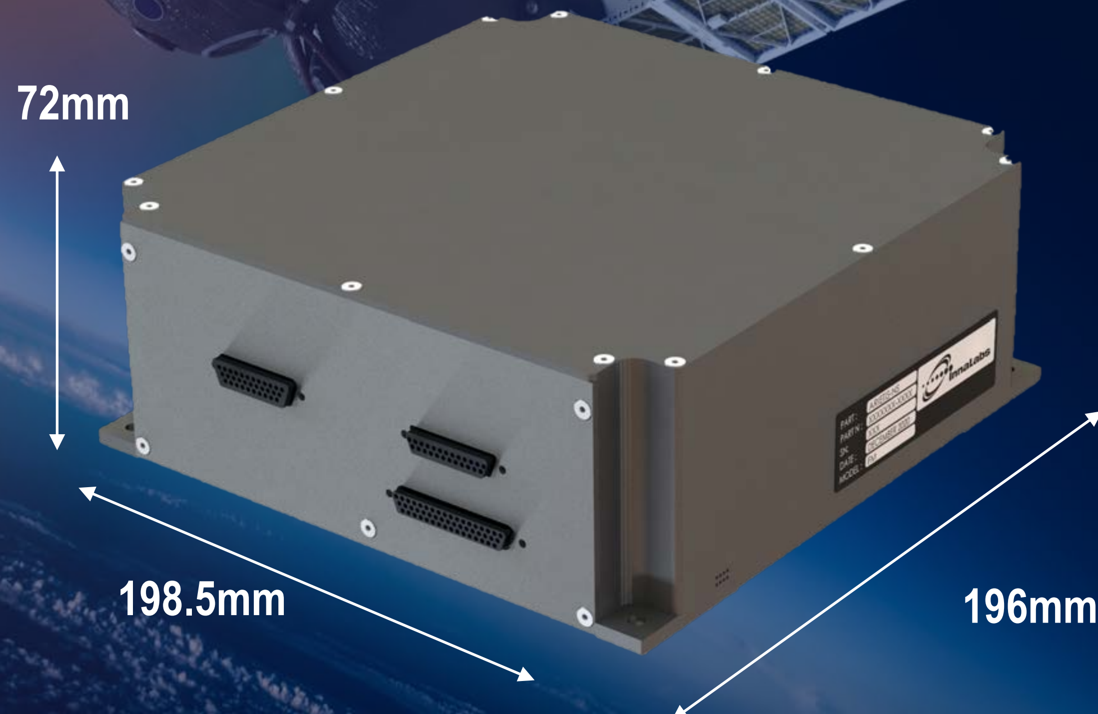
4

Space Programs

ARIETIS: Rad-Hard Gyro

A 3-axis Rad-Hard Gyro meeting ESA ECSS standards for Science missions and Telecom GEO (ARW ≤ 0.005 °/√h, Bias errors EOL ≤ 5 °/h max, ≤ 3kg, 500 FIT, 8.5W). It is compliant to both ESA Science Missions as well as commercial telecom requirements in both performance, design and quality.





CVG2
Gyro Sensing Element

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ARIETIS: Rad-Hard Gyro

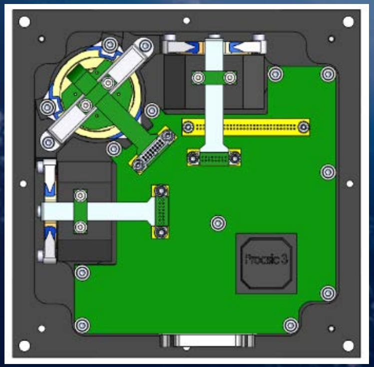
Performance Parameters	Value
Measurement range	3°/s (full performance) 48°/s (coarse performance)
Switch-on response time	$\leq$ 6s
ARW	$\leq$ 0.005°/√hr (up to ±3°/s)
Bias stability over 24hr (steady temperature)	$\leq$ 1.5°/hr (1σ)
Bias stability over 1hr (steady temperature)	$\leq$ 0.3°/hr (1σ)
Bias errors (all effects, EOL)	$\leq$ 5°/hr (max)
Scale Factor repeatability errors (all effects, EOL)	$\leq$ 700ppm (1σ)

ARIETIS: Rad-Hard Gyro

Key Features	Value
Output	Inertial angle increments of rotations about three orthogonal axes
Data Interface	RS422 Data Interface (RS485, CAN BUS optional)
Reliability	$\leq$ 500 FIT at 30°C
Mass	~3 kg
Power consumption	$\leq$ 8.5W
Radiation	Designed for long life-time GEO missions of more than 15 years
Power Interface	28VDC nominal (regulated and regulated) 50VDC or 100 VDC optional
In-orbit calibration functionalities	Yes
Temperature range	Qualified to a temperature range of -40°C (-40°F) to +70°C (+158°F)
Vibration profiles during launch	26 grms, 22g sinusoidal

ARIETIS-NS: Rad Tolerant 3 Axis Gyro

- **3-Axis Rad-Tolerant Gyro**
  - Meeting New Space Approach for LEO and Telecom GEO (ARW ≤ 0.005 °/√h, Bias errors BOL ≤ 1 °/h, 1000 FIT, 6.5W).
  - Comes in two different versions:
    - LEO (Lower Mass)
    - GEO (Higher mass to withstand 15+ years in GEO)
  - COTS EEE parts used. All active and discrete go through radiation Lot Acceptance Tests (both TID and SEE).



CVG2
Gyro Sensing Element

ARIETIS-NS: Rad Tolerant 3 Axis Gyro

Performance Parameters	Value
Measurement range	10°/s (full performance)
Switch-on response tie	≤ 6s
ARW	≤ 0.005°/√hr (up to ±10°/s)
Bias stability over 24hr (steady temperature)	≤ 1.5°/hr (1σ)
Bias stability over 1hr (steady temperature)	≤ 0.3°/hr (1σ)
Bias errors (over temperature, BOL)	≤ 1°/hr (1σ)
Scale Factor repeatability errors (all effects, BOL)	≤ 1000ppm (1σ)

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ARIETIS-NS: Rad Tolerant 3 Axis Gyro

Performance Parameters	Value
Output	Inertial angle increments of rotations about three orthogonal axes
Data Interface	RS422 or RS485 (CAN BUS optional)
Reliability	≤ 1000 FIT at 30°C
Mass	~1.25 kg for LEO version ~2.2 kg for GEO version
Power consumption	≤ 6.5W
Radiation	LEO: 7+ years in LEO GEO: 15+ years in GEO
Power Interface	28VDC nominal (regulated and regulated)
Temperature range	Qualified to a temperature range of -40°C (-40°F) to +70°C (+158°F)
Vibration profiles during launch	20 grms

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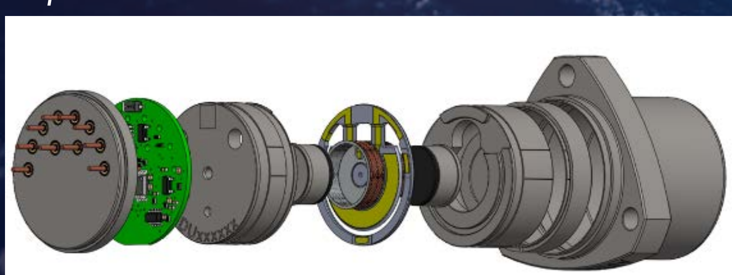
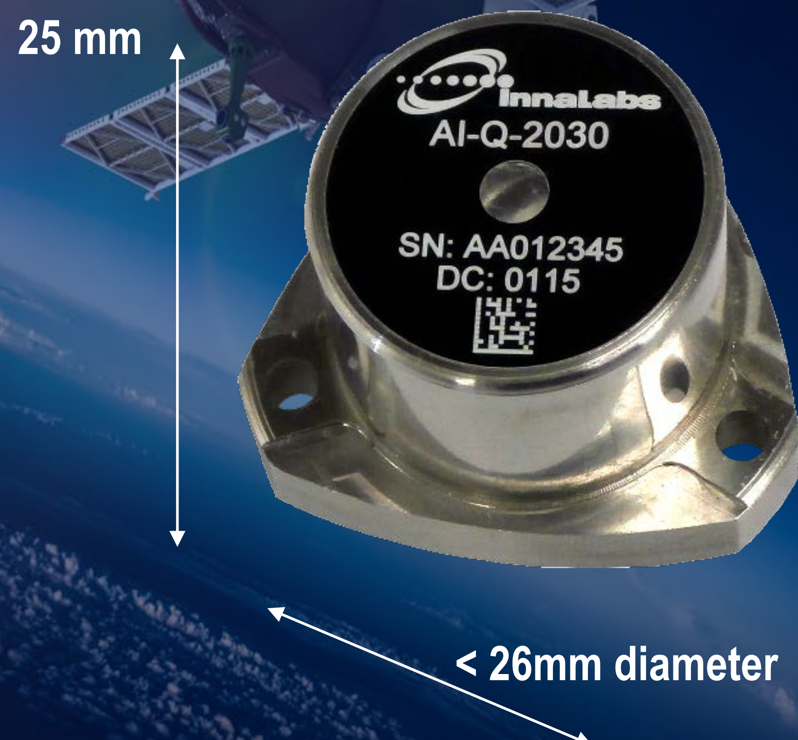
AQUILA: A Navigation Grade Accelerometer

Rad-hard navigation grade **accelerometer** meeting ESA ECSS standards for any **Space platforms** (20g MR, 20μg, 25ppm, 100krad)

Pendulum

Exploded view





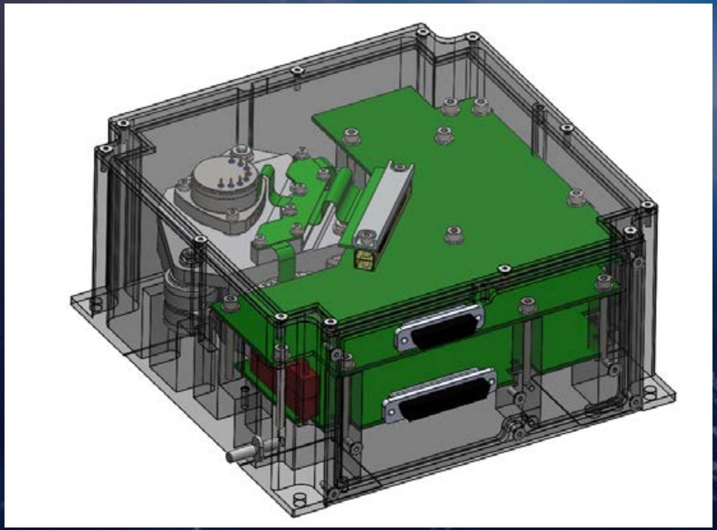
AQUILA: A Navigation Grade Accelerometer

Performance Parameters	Value
Measurement range	±20 g
sensitivity	<1 µg
Bias	≤ 4 mg
Bias one year repeatability	80 µg
Bias temperature sensitivity	20 µg/°C
Scale factor	1.20 - 1.46 mA/g
Scale Factor one year repeatability	100 ppm
Scale Factor temperature sensitivity	120 ppm/°C
Vibration	14 grms, 15g sinusoidal

3 Axis Accelerometer

Rad-hard 3-axis **accelerometer** equipment meeting ESA ECSS standards for any **Space platforms** (uses 3x AQUILA, 100krad TBC)

Exploded view



3 Axis Accelerometer – IF specification

Key Features	3 axis acceleration Unit
Axis	3 axes detection (orthogonal)
Output rate	10 Hz (TBC)
Reliability (baseplate temperature of 30°C)	1000 FIT
Communication Line	RS422
Mass	2 kg (with ECSS margins), to be further optimised and reduced
Volume	166 mm x 166 mm x 72 mm, to be further optimised and reduced
Power line	28V unregulated
Nominal Power dissipation	8W, to be further optimised and reduced. Power for 1g operation expected to be lower.

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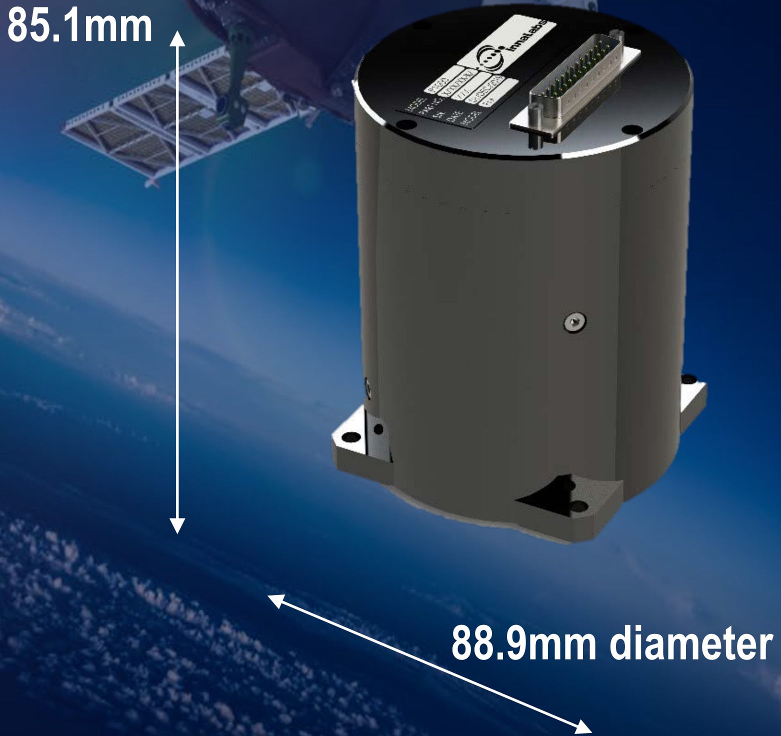
POLARIS IMU

6-axis Rad-Tolerant Inertial Measurement Unit (IMU) meeting ESA ECSS standards for µlaunchers, landers, etc. (ARW ≤ 0.01 °/√h, Bias errors ≤ 1 °/h, 0.3mg, 1kg, 8W)

InnaLabs Fused Quartz miniature Accelerometer

CVG2 Gyro Sensing Element



Thank you!

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