# Pushing the known performances boundaries of space Gyros

## An introduction to the ASTRIX 200+ Development

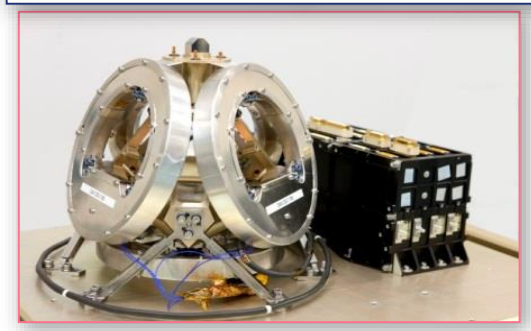
DEFENCE AND SPACE

2022/10/26

AIRBUS

# The large Astrix Product Line

**Targeted for Science & EO missions**



**ASTRIX® 200**

**4 axis (accelerometers as an option)**

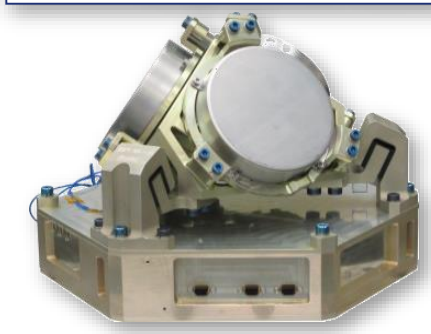
**Flight Proven**

**ASTRIX® 120**

**4 axis (accelerometers as an option)**

**Flight Proven**

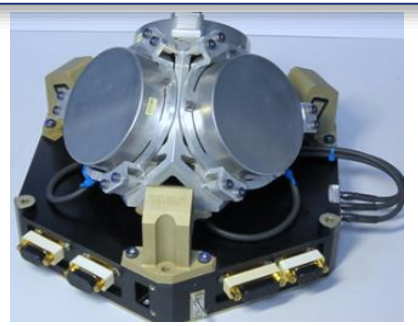
**Targeted for GEO Telecom / Safe Mode sat / Probe missions**



**ASTRIX® 1120 (A)**

**3 axis (accelerometers as an option)**

**Breadboard Stage**



**ASTRIX® 1090 (A)**

**3 axis (accelerometers as an option)**

**Flight proven**

**ASTRIX® NS**

**3 axis**

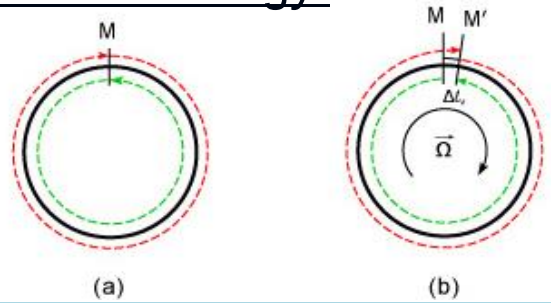
**EQM Stage**

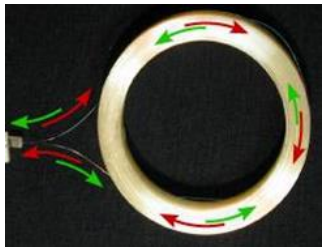
**15 years life time permanently ON**

| 0,0001°/h class | 0,001°/h class | 0,001°/h class | 0,01°/h class | 0,01°/h class, COTS-based |
|---|---|---|---|---|

# FOG is the best solution for space Applications

Fiber Optic Technology uses the Sagnac Effect to measure the satellite rotation rates



$$\Delta\varphi_{Sagnac} = \frac{2\pi LD}{\lambda c}\Omega$$

L: fibre length
D: fibre coil diameter
$\lambda$: wavelength
C: light velocity
$\Omega$: rotation rate

| MAIN ADVANTAGES | |
|---|---|
| Full solid state (no mechanical perturbation, no lifetime limitation) | FOG Technology |
| Compatible with high angular rate system (eg. CMG-controlled) | |
| Outstanding noise performance (pure ARW noise) | |
| Very high bandwidth (above 500 Hz) for image post processing | |
| Very good scale factor stability for image location improvement | |
| Sensing element not dissipating (can be put close to optical instrument) → very accurate image location | ASTRIX design Advantages |
| Coil size can be changed to address different performance requirement | |
| Same electronics functions for all products | |



AIRBUS

# Astrix

## Airbus Gyroscopes Heritage

A reliable heritage on inertial measurement units proven by:

- Performance & versatility
- 43 Satellites flying Astrix
- 63 Astrix units in orbit
- 256+ years in flight & 166 years switched ON
- No anomaly in flight

**Orbit:** L 2 (LEO)

**Gyro / launch:** POINT

- 3 Astrix 120HR / Q1 2013
- *1 Astrix 120 / Q2 2009*

**Orbit:** INTER PLANETARY

**Gyro / launch:**

- 4 Astrix 120HR / Q4 2011 & Q4 2012

**Orbit:** LEO

**Gyro / launch:**

- 2 Astrix 200 / Q4 2011 & Q4 2012
- 2 Astrix 120 / Q3 2012 & Q2 2014
- 2 Astrix 120 / Q2 2014 & Q2 2016
- 2 Astrix 200 / Q2 2015 & Q1 2017
- 2 Astrix 120 / Q4 2017 & Q4 2018
- 1 Astrix 200 / Q3 2018
- 2 Astrix 120 / Q2 2018
- 1 Astrix 120 / Q4 2017
- 2 Astrix 200 / Q4 2018 & Q4 2020
- 1 Astrix 1090 / Q4 2020
- 1 Astrix 200 / Q4 2020

**Orbit:** GEO

**Gyro / launch:**

- 3 Astrix 120 HR / Q2 2010
- 1 Astrix 120 / Q3 2011
- 14 Astrix 1090 / Q3 2018, Q3 2019, Q4 2020, Q2&Q3 2021
- 2 Astrix 1090 / Q2 2019
- 2 Astrix 1090 / Q3 2020
- 8 Astrix 1090 / Q3 2020, Q4 2021
- 4 Astrix 1090 / Q1&Q4 2021

**Orbit:** SUN

**Gyro / launch:**

- 1 Astrix 120 & 1 Astrix 200 / Q1 2020

Jan, 2022

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# Astrix 200 : The Current Best-in-class Gyro

**Key Features**

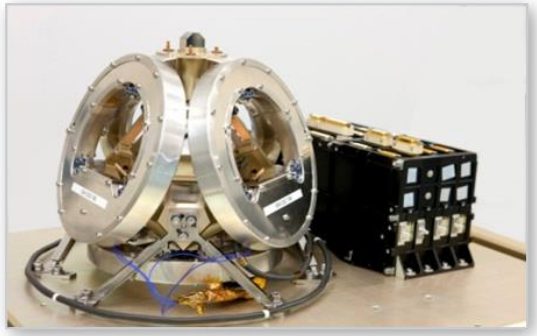
- 4 independent axes (hot redundancy)
- More than 15 years continuous operation (no life limited item)
- High reliability: Probability of success > 0.995 after 5 years continuous operation
- ICU / GEU decoupled
- Accelerometers can be added

**Budgets**

- Mass 12,7 kg (ICU 7,5 kg, GEU 4,5 kg)
- Volume ICU ø330 x h280mm

GEU 295x150x145 mm3

- Power 5,5W per ON channel



**Main Performances (typ)**

- Noise **0.00012** ˚/√h
- Bias stability 0.0005 ˚/h
- Scale factor stability 30 ppm
- Turn-on < 3s

**Interfaces**

- Power bus 22 – 50 V
- Dialog 1553, RS422
- Synchro hardware link for accurate time-tagging, 1553 broadcast or autonomous mode available
- RS422 stimulation for AOCS test

**Environments**

- Thermal -10 to +50 ˚C (full performance)

-20 to +60 ˚C (operation)

- Vibrations 25g sine,

GEU 20 $g_{rms}$, ICU 10 $g_{rms}$

- Shock 1200g over 1200Hz to 10kHz
- SEP tolerant, latch-up immune
- EMI/EMC MIL-STD-461

# Astrix 200+ Development Objective : Be the Best Astrix Ever

***The development of the Astrix 200+ aims to provide the space industry with an outstanding gyroscope***

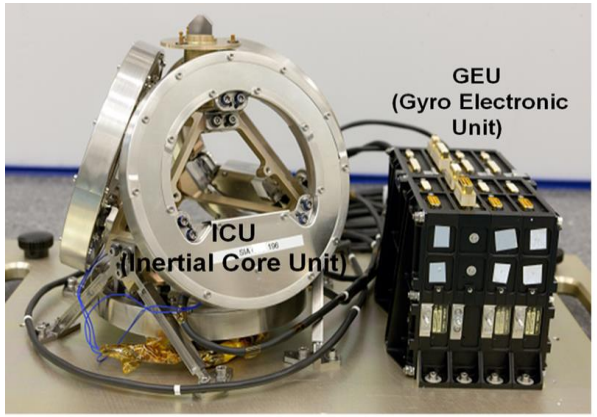
- More specifically:
  - ARW improvement target : $5.10^{-5}$ °/√h, 1σ (<$7,5.10^{-5}$ °/√h guaranteed)
  - Scale factor stability over 1 month: < 30 ppm, 3σ (environment included)
  - Bias stability over 1h : < 0,0004 °/h, 3σ
  - Micro-vibrations **in**sensitivity
  - Use of European components
  - Ease the gyroscope integration into the satellite (volume, mass, ICU and GEU connection)

# A Flight-Proven Industrial Consortium

- Astrix 200+ development is carried out by iXblue and Airbus Defence & Space,
  - on the bases of the current successful partnership for the HiRel Astrix
  - And taken into account the lesson learned from the past developments (Astrix 1090, Astrix 200…)

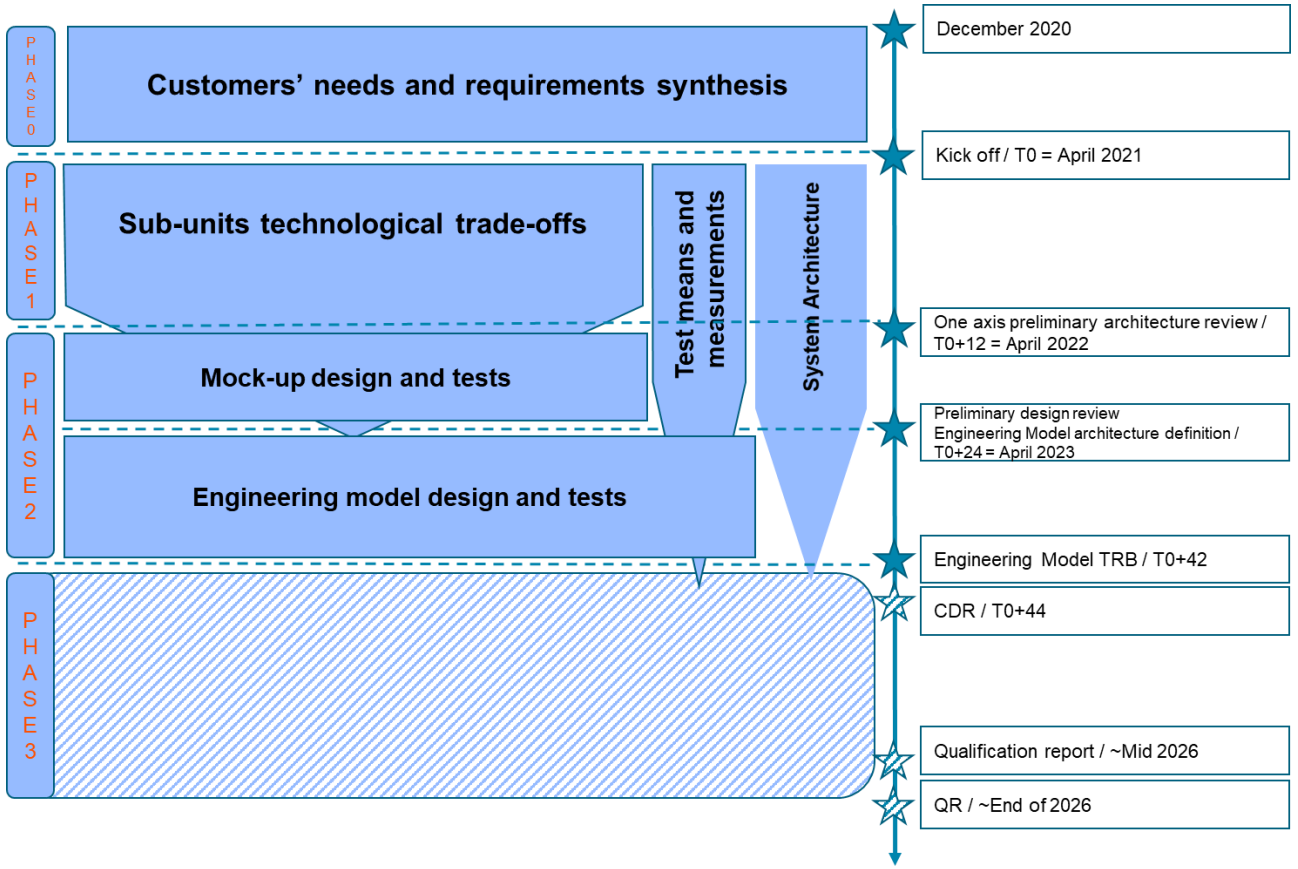
- As a sponsor to the development, CNES is involved in the follow up and reviews of the development

- The main activities are split as follows:
  - iXblue is responsible for the new ICU design (Inertial Core Unit composed by the mechanical structure and the coils),
  - Airbus is responsible for the new GEU design (Gyro Electronics Unit)
  - Airbus is responsible for the equipment-level system synthesis



# Astrix 200+ Robust and Comprehensive Development Plan

- The current development phase is planned for 3,5 years, starting in April 2021:
  - Phase 1: in closure
    - Exploratory phase for several concepts validation
    - One axis architecture review close-out in progress
  - Phase 2: on-going(from May 2022 to November 2023)
    - A mock-up (1 axis) will be produced and tested.
    - An EM (3 or 4 axis) will be produced and tested
- An additional phase (Phase 3, ~2,5 years) should follow with the EQM qualification.
- FM availability by the end of 2026



# An Endeavour about Overcoming Technical challenges

The targeted improvements requires to overcome a number of critical technical challenges:

- Magnetic environment robustness
  The gyro performances are sensitive to the magnetic field. Eliminating the magnetic influence is necessary to achieve the targeted performances. This will be achieve by optimizing the µ-metal shielding and/or compensating its influence.

- Scale factor stability
  Achieving the target stability will require a new design for the optical source architecture, a key unit of the gyro

- Micro-vibrations robustness
  Becoming insensitive to micro-vibrations means changing the structural resonances and modes without degrading the thermal properties. This is a delicate engineering work

- ARW improvement
  The noise performance enhancement is incompatible with the current optical architecture. It will require to implement a RIN (Relative Intensity Noise) reduction functionality

# Astrix 200+ use cases

With a product as performant as the Astrix 200+, the expected gains for the satellite AOCS are as follows

| 200+ target improvements | AOCS Performance gain |
|---|---|
| Lower noise level and spectrum | Better Line of Sight stability (RPE)<br>More accurate post-processing on the ground |
| Higher scale factor stability | Better on-board attitude estimation for agile manœuvres (APE) |
| Larger measurement bandwidth | Better Line of sight stability (RPE) and disturbance rejection |
| Similar volume and mass than existing Astrix | Accommodation from previous plateforms may be re-used |

# Thank you