Astrix NS

The new, space-qualified, compact gyroscope and IMU of the Astrix family

ADCSS 2022 - 26 October 2022

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SPACE ACTIVITIES AT iXblue

A French, independant, high-tech company

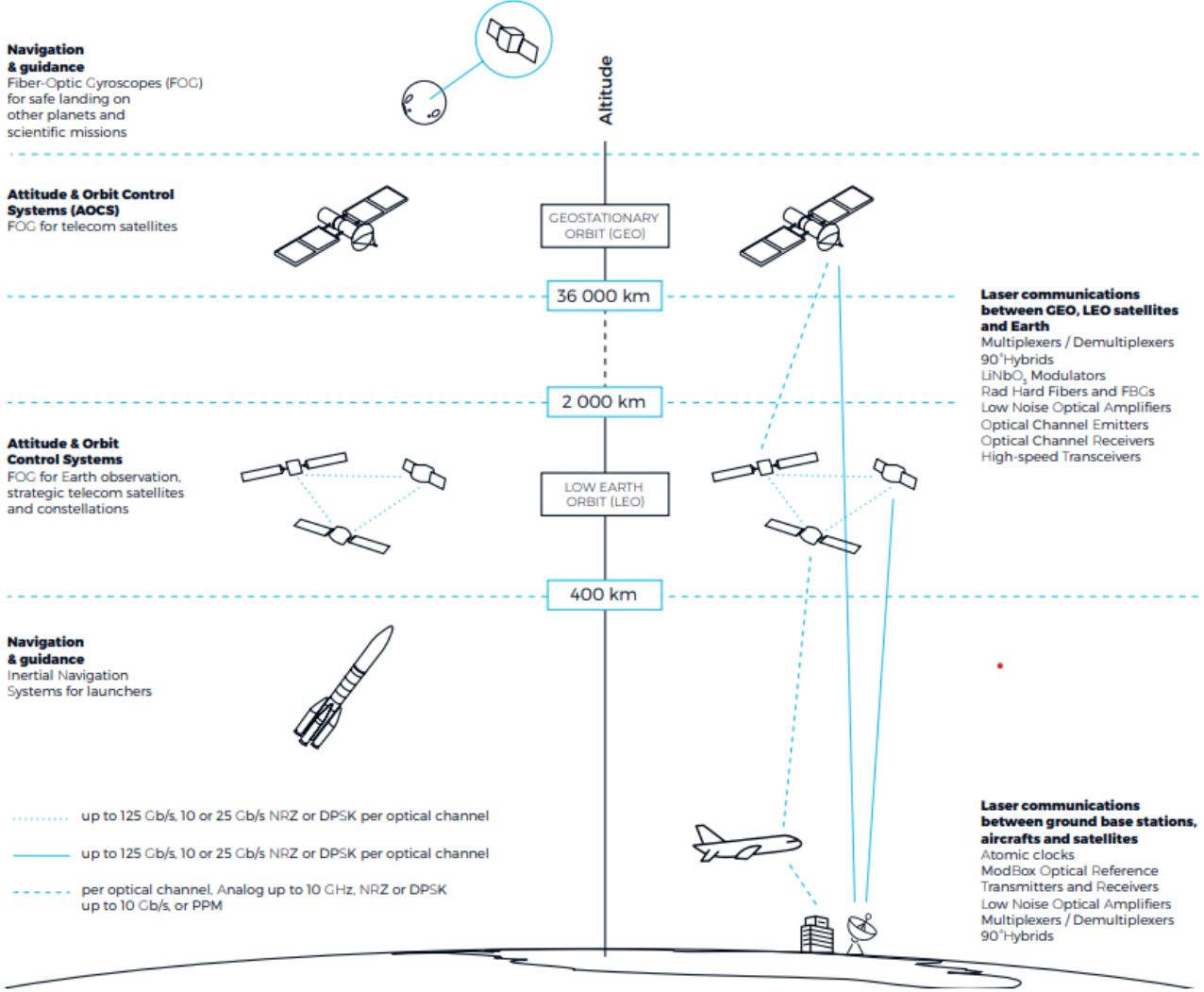
1 500 + people

250 M€ + turnover

20% revenues in R&D

1 000 + navigation systems produced

iXblue space activities

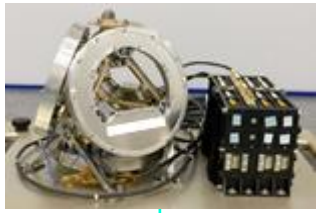


Space qualified inertial systems at iXblue

- More than 15 years of experience and heritage in partnership with Airbus
- More than 6 millions hours of flight without incident
- Know-how in space technologies and space environments.

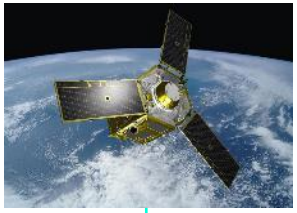
2003

Launch of Astrix 200, a gyro with very high performances



2011

On board Pléiades



2015

First Astrix 1090 produced

2020

On board the launcher Ariane 5

2022

First Astrix NS delivered

Astrix NS main performances

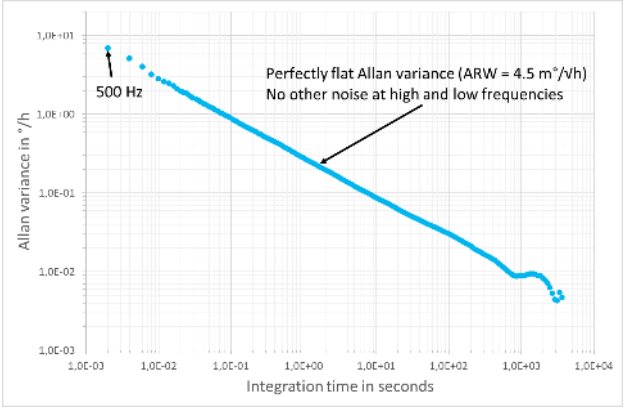
- **General features**
  - Compact : 100 x 100 x 100 mm
  - Low power : 7 W
  - Light : 1.4 kg
  - RS422 / RS485 communication and power supply 20V - 52 V
  - Compatible with LEO and GEO (15 years + 260 days EOR) missions including radiation levels and SEL/SEU
  - Based on space qualified COTS electronics to offer a competitive price while keeping high inertial performances and high reliability

- **Main inertial performances**
  - ARW : 0.005 °/√h and down to 0.0025 °/√h at all frequencies
  - Bias stability over 1 hour : < 0.02°/h (steady temperature)
  - Scale factor : < 200 ppm @3σ
  - Start up and access to relevant data : < 1 s
  - Measurement range at full performance : > 60°/s

Astrix NS applications

- **Perfect choice for telecom missions (GEO/LEO)**
  - Start-up at high angular speed (> 60°/s) and very quickly (< 1s) for safety
  - High reliability with EEE parts space qualified by Airbus for GEO 15 years + EOR
  - Good inertial performances for orbit raising and stabilisation

- **Very well-suited for both Earth observation (LEO) and scientific missions (GEO/LEO…)**
  - High inertial performances with a perfectly flat Allan variance and an ARW down to 0.0025°/√h. For instance, it allows vibration correction at high frequencies, up to 500 Hz.
  - Good bias stability < 0.02°/h
  - No vibrating parts and good thermal behaviour to avoid parasitic effects



- **Constellations that require compact and competitive equipment that can be produced in volume and with short lead time.**

2

ASTRIX NS – NEW SPACE PHILOSOPHY

New space philosophy of Astrix NS

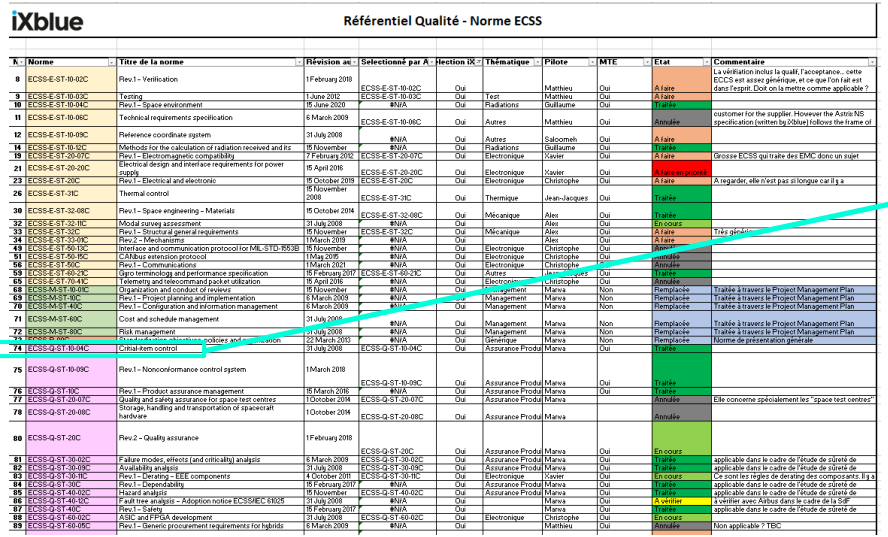
- **New space is a generic concept with products ranging from low to high reliability**

- **A lot of thought was put into defining a New Space philosophy for Astrix NS at the beginning of project**

  - How to ensure a level of quality acceptable for all customers ?
  - How to reduce costs ?
  - How to target high reliability for GEO 15 years + 260 EOR missions ?

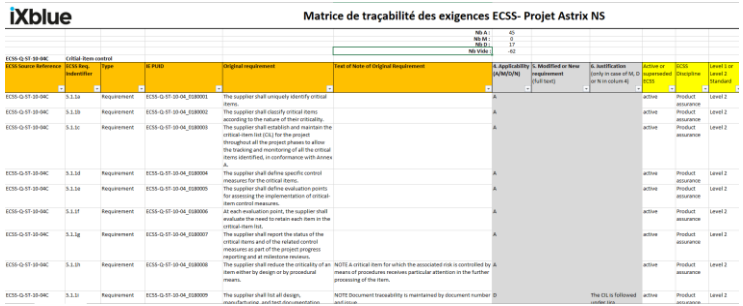
Astrix NS Quality Referential

- For the construction of our Astrix NS quality reference system, we chose to follow the ECSS adaptation method (ECSS-S-ST-00-02C Tailoring). Indeed, we took the exhaustive list of all the ECSS standards, we held meetings with different people from each profession to decide on the selection of standards, according to the technical characteristics of the Astrix NS and the need for the project.
- For each standard retained, we have set up a Requirements Traceability Matrix that each pilot must fill in, with our level of compliance. (≈ 22 000 requirements)


iXblue

Référentiel Qualité - Norme ECSS

N.	Norme	Titre de la norme	Révision au	Selectionné par A	Section IX	Thématique	Pilote	MTE	Etat	Commentaire
8	ECSS-E-ST-10-02C	Rev.1 – Verification	1 February 2018	ECSS-E-ST-10-02C	Oui		Matthieu	Oui	A faire	La vérification inclus la qualif, l'acceptance... cette ECCS est assez générique, et ce que l'on fait est dans l'esprit. Doit on la mettre comme applicable ?
9	ECSS-E-ST-10-03C	Testing	1 June 2012	ECSS-E-ST-10-03C	Oui	Test	Matthieu	Oui	A faire	
10	ECSS-E-ST-10-04C	Rev.1 – Space environment	15 June 2020	#N/A	Oui	Radiations	Guillaume	Oui	Traitée	
11	ECSS-E-ST-10-06C	Technical requirements specification	6 March 2009	ECSS-E-ST-10-06C	Oui	Autres	Matthieu	Oui	Annulée	customer for the supplier. However the Astrix NS specification (written by iXblue) follows the frame of
12	ECSS-E-ST-10-09C	Reference coordinate system	31 July 2008	#N/A	Oui	Autres	Salaomeh	Oui	A faire	
14	ECSS-E-ST-10-12C	Methods for the calculation of radiation received and its	15 November	#N/A	Oui	Radiations	Guillaume	Oui	Traitée	
19	ECSS-E-ST-20-07C	Rev.1 – Electromagnetic compatibility	17 February 2012	ECSS-E-ST-20-07C	Oui	Electronique	Xavier	Oui	A faire	Grosse ECSS qui traite des EMC donc un sujet
21	ECSS-E-ST-20-20C	Electrical design and interface requirements for power supply	15 April 2016	ECSS-E-ST-20-20C	Oui	Electronique	Xavier	Oui	A faire en priorité	
23	ECSS-E-ST-20C	Rev.1 – Electrical and electronic	15 October 2019	ECSS-E-ST-20C	Oui	Electronique	Christophe	Oui	A faire	A regarder, elle n'est pas si longue car il y a
26	ECSS-E-ST-31C	Thermal control	15 November 2008	ECSS-E-ST-31C	Oui	Thermique	Jean-Jacques	Oui	Traitée	
30	ECSS-E-ST-32-08C	Rev.1 – Space engineering – Materials	15 October 2014	ECSS-E-ST-32-08C	Oui	Mécanique	Alex	Oui	Traitée	
32	ECSS-E-ST-32-11C	Modal survey assessment	31 July 2008	#N/A	Oui		Alex	Oui	En cours	
33	ECSS-E-ST-32C	Rev.1 – Structural general requirements	15 November	ECSS-E-ST-32C	Oui	Mécanique	Alex	Oui	A faire	Très générale
34	ECSS-E-ST-33-01C	Rev.2 – Mechanisms	1 March 2019	#N/A	Oui		Alex	Oui	A faire	
49	ECSS-E-ST-50-12C	Interface and communication protocol for MIL-STD-1553B	15 November	#N/A	Oui	Electronique	Christophe	Oui	Annulée	
51	ECSS-E-ST-50-15C	CANbus extension protocol	1 May 2015	#N/A	Oui	Electronique	Christophe	Oui	Annulée	
56	ECSS-E-ST-50C	Rev.1 – Communications	1 March 2021	#N/A	Oui	Electronique	Christophe	Oui	Annulée	
59	ECSS-E-ST-60-21C	Gyro terminology and performance specification	15 February 2017	ECSS-E-ST-60-21C	Oui	Autres	Jean-Jacques	Oui	Traitée	
65	ECSS-E-ST-70-41C	Telemetry and telecommand packet utilization	15 April 2016	#N/A	Oui	Electronique	Christophe	Oui	Annulée	
68	ECSS-M-ST-10-01C	Organization and conduct of reviews	15 November	#N/A	Oui	Management	Marwa	Non	Remplacée	Traitée à travers le Project Management Plan
69	ECSS-M-ST-10C	Rev.1 – Project planning and implementation	6 March 2009	#N/A	Oui	Management	Marwa	Non	Remplacée	Traitée à travers le Project Management Plan
70	ECSS-M-ST-40C	Rev.1 – Configuration and information management	6 March 2009	#N/A	Oui	Management	Marwa	Non	Remplacée	Traitée à travers le Project Management Plan
71	ECSS-M-ST-60C	Cost and schedule management	31 July 2008	#N/A	Oui	Management	Marwa	Non	Remplacée	Traitée à travers le Project Management Plan
72	ECSS-M-ST-80C	Risk management	31 July 2008	#N/A	Oui	Management	Marwa	Non	Remplacée	Traitée à travers le Project Management Plan
73	ECSS-M-10A	Project implementation philosophy, policies and organization	22 March 2013	#N/A	Oui	Générique	Marwa	Non	Remplacée	Norme de présentation générale
74	ECSS-Q-ST-10-04C	Critical-item control	31 July 2008	ECSS-Q-ST-10-04C	Oui	Assurance Produ	Marwa	Oui	Traitée	
75	ECSS-Q-ST-10-09C	Rev.1 – Nonconformance control system	1 March 2018	ECSS-Q-ST-10-09C	Oui	Assurance Produ	Marwa	Oui	Traitée	
76	ECSS-Q-ST-10C	Rev.1 – Product assurance management	15 March 2016	#N/A	Oui	Assurance Produ	Marwa	Oui	Traitée	
77	ECSS-Q-ST-20-07C	Quality and safety assurance for space test centres	1 October 2014	ECSS-Q-ST-20-07C	Oui	Assurance Produ	Marwa		Annulée	Elle concerne spécialement les "space test centres"
78	ECSS-Q-ST-20-08C	Storage, handling and transportation of spacecraft hardware	1 October 2014	ECSS-Q-ST-20-08C	Oui	Assurance Produ	Marwa		Annulée	
80	ECSS-Q-ST-20C	Rev.2 – Quality assurance	1 February 2018	ECSS-Q-ST-20C	Oui	Assurance Produ	Marwa	Oui	En cours	
81	ECSS-Q-ST-30-02C	Failure modes, effects (and criticality) analysis	6 March 2009	ECSS-Q-ST-30-02C	Oui	Assurance Produ	Marwa	Oui	Traitée	applicable dans le cadre de l'étude de zûreté de
82	ECSS-Q-ST-30-09C	Availability analysis	31 July 2008	ECSS-Q-ST-30-09C	Oui	Assurance Produ	Marwa	Oui	Traitée	applicable dans le cadre de l'étude de zûreté de
83	ECSS-Q-ST-30-11C	Rev.1 – Derating – EEE components	4 October 2011	ECSS-Q-ST-30-11C	Oui	Electronique	Xavier	Oui	En cours	Ce sont les regles de derating des composants. Il y a
84	ECSS-Q-ST-30C	Rev.1 – Dependability	15 February 2017	#N/A	Oui	Assurance Produ	Marwa	Oui	Traitée	applicable dans le cadre de l'étude de zûreté de
85	ECSS-Q-ST-40-02C	Hazard analysis	15 November	ECSS-Q-ST-40-02C	Oui	Assurance Produ	Marwa	Oui	Traitée	applicable dans le cadre de l'étude de zûreté de
86	ECSS-Q-ST-40-12C	Fault tree analysis – Adoption notice ECSS/IEC 61025	31 July 2008	#N/A	Oui		Marwa	Oui	A vérifier	à vérifier avec Airbus dans le cadre de la SdF
87	ECSS-Q-ST-40C	Rev.1 – Safety	15 February 2017	#N/A	Oui		Marwa	Oui	Traitée	applicable dans le cadre de l'étude de zûreté de
88	ECSS-Q-ST-60-02C	ASIC and FPGA development	31 July 2008	ECSS-Q-ST-60-02C	Oui	Electronique	Christophe	Oui	En cours	
89	ECSS-Q-ST-60-05C	Rev.1 – Generic procurement requirements for hybrids	6 March 2009	#N/A	Oui		Matthieu	Oui	Annulée	Non applicable ? TBC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Matrice de traçabilité des exigences ECSS- Projet Astrix NS

ECSS-Q-ST-10-04C	Critical-item control								
ECSS Source Reference	ECSS Req. Identifier	Type	M. FUID	Original requirement	Text of Note of Original Requirement	4. Applicability (A/M/D/N)	5. Modified or New requirement (full text)	6. Justification (only in case of M, D or N in column 4)	Active or superseded ECSS	ECSS Discipline	Level 1 or Level 2 Standard
ECSS-Q-ST-10-04C	5.1.1a	Requirement	ECSS-Q-ST-10-04_0180001	The supplier shall uniquely identify critical items.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1b	Requirement	ECSS-Q-ST-10-04_0180002	The supplier shall classify critical items according to the nature of their criticality.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1c	Requirement	ECSS-Q-ST-10-04_0180003	The supplier shall establish and maintain the critical-item list (CIL) for the project throughout all the project phases to allow the tracking and monitoring of all the critical items identified, in conformance with Annex A.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1d	Requirement	ECSS-Q-ST-10-04_0180004	The supplier shall define specific control measures for the critical items.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1e	Requirement	ECSS-Q-ST-10-04_0180005	The supplier shall define evaluation points for assessing the implementation of critical-item control measures.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1f	Requirement	ECSS-Q-ST-10-04_0180006	At each evaluation point, the supplier shall evaluate the need to retain each item in the critical-item list.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1g	Requirement	ECSS-Q-ST-10-04_0180007	The supplier shall report the status of the critical items and of the related control measures as part of the project progress reporting and at milestone reviews.		A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1h	Requirement	ECSS-Q-ST-10-04_0180008	The supplier shall reduce the criticality of an item either by design or by procedural means.	NOTE A critical item for which the associated risk is controlled by means of procedures receives particular attention in the further processing of the item.	A			active	Product assurance	Level 2
ECSS-Q-ST-10-04C	5.1.1i	Requirement	ECSS-Q-ST-10-04_0180009	The supplier shall list all design, manufacturing and test documentation	NOTE Document traceability is maintained by document number	D		The CIL is followed under the	active	Product assurance	Level 2

Qualification at component level

- **EEE parts selection and qualification done and validated by Airbus following their “Next Space” process.**

- **Electronics components are selected from space/rad qualified, automotive or industrial ranges.**
- **Lot acceptance tests are tailored depending on data available from suppliers and based on the following tests**
  - Construction analysis
  - Life test
  - Highly accelerated stress test
  - Temperature cycling test
  - **For radiation, same process as for usual space programs i.e. SEE and TID test for new references**

- **Opto components (fiber, photodiode, laser diode…) qualification is based on Astrix 1090 & 200 process and heritage.**

Astrix NS qualification at system level

Based on ECSS

- Qualification approach is based on a main model
  - The main QM will see most of the qualification and all the environments in a « test as you fly » chronology

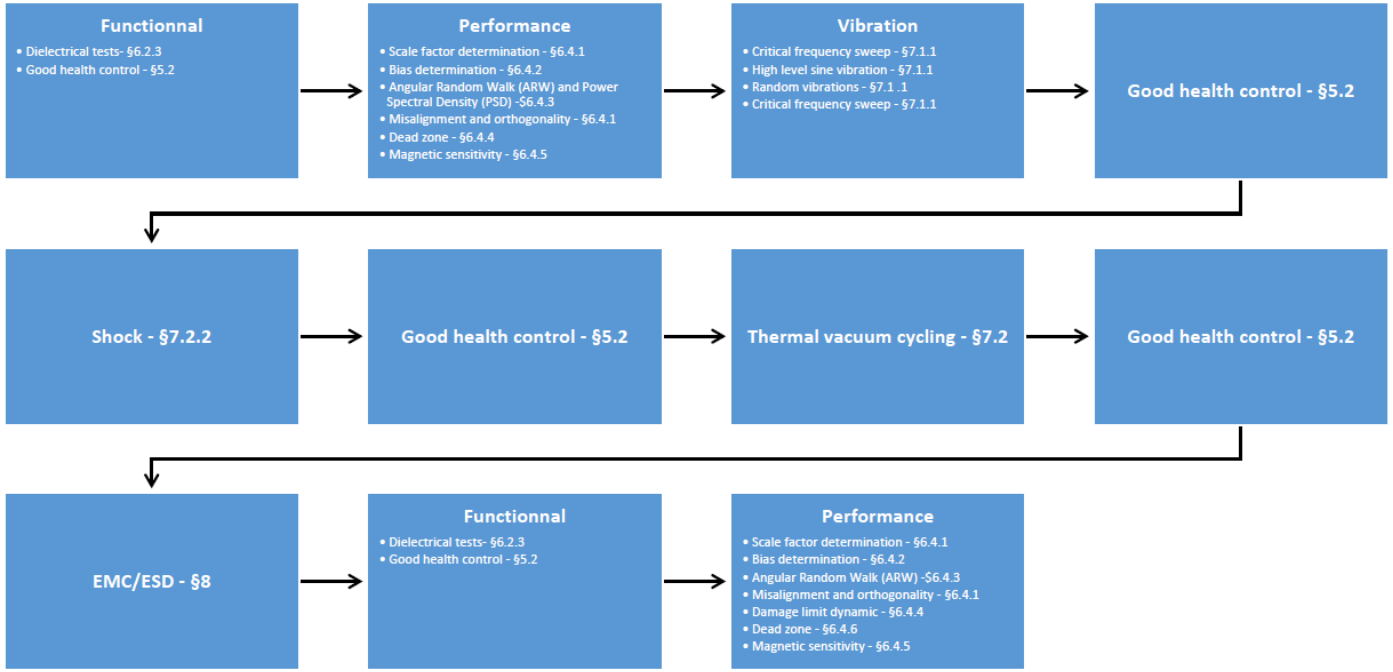


Table 1: Sequence of tests for Astrix NS main qualification model

Operational Safety

- For Astrix NS, we chose to subcontract the operational safety study with **Airbus**.

- The deliverables of this study are:
  - A reliability analysis
  - An FMEA analysis
  - An availability analysis (for QM milestone)
  - A hazard analysis (for QM milestone)

Board	Board Failure Rate (FIT)			
	GEO mission profil 100% ON	GEO mission profil 33% ON	LEO mission profil 100% ON	LEO mission profil 50% ON
Digital	83.6	33.4	91.4	64.4
Interface	176.3	66.4	154.4	88.5
Optoelectronic	35.4	12.8	34.3	23.3
Optoelectronic (LASER diode)	93	40	93	51
ASTRIX NS	**388**	**153**	**373**	**227**

Table 5-2: ASTRIX NS reliability results

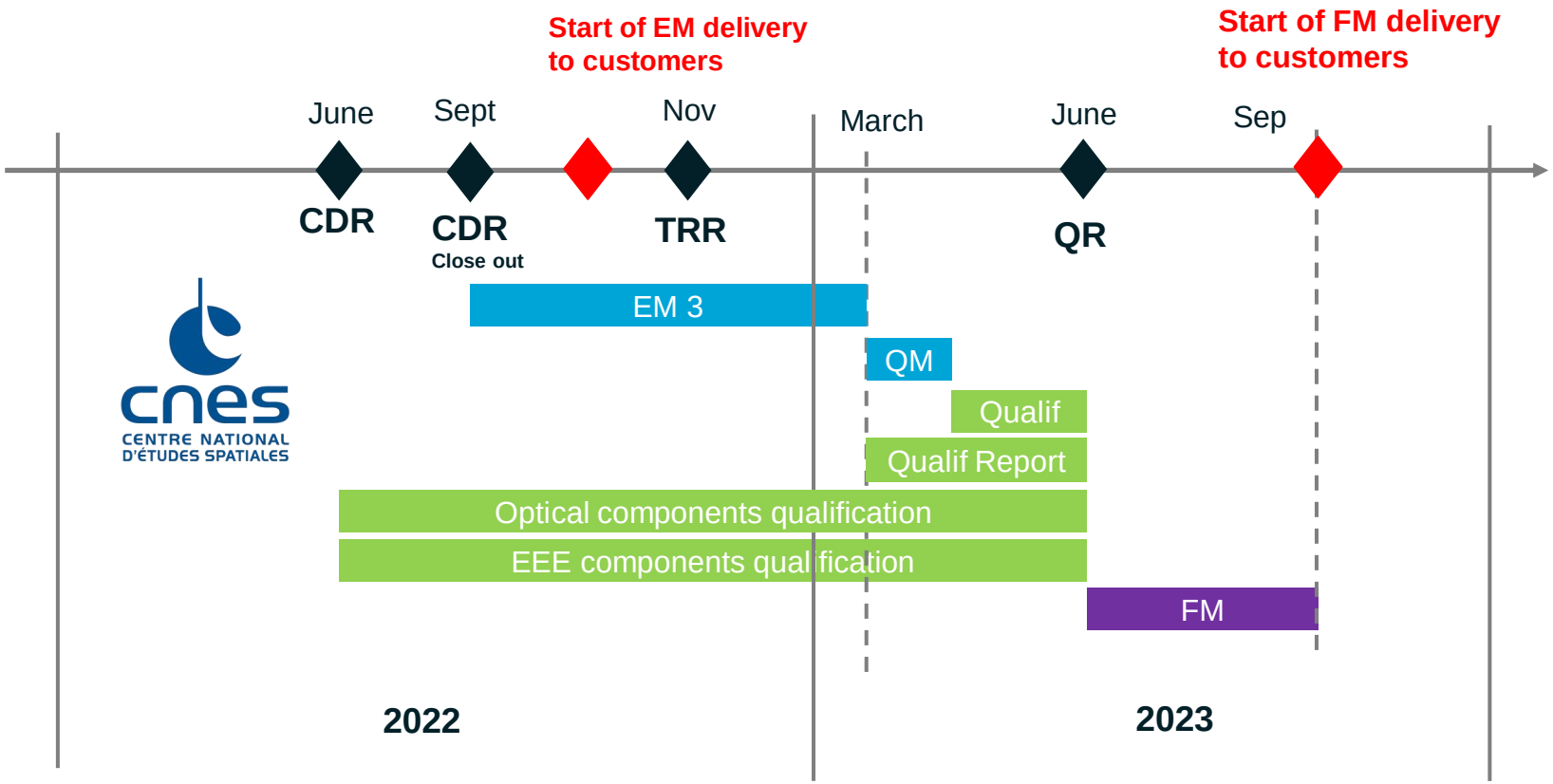
- The applicable standards are:
  Fides 2009 standard and ECSS: ECSS-Q-ST-30C Dependability and ECSS-Q-ST-40C Safety.

- This study is completed by a Part Stress Analysis (PSA) and Worst-Case Analysis (WCA) handled by iXblue.

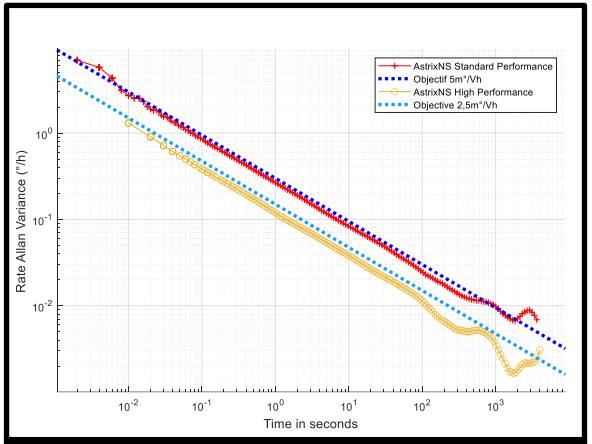
3

ASTRIX NS - DEVELOPMENT UPDATES

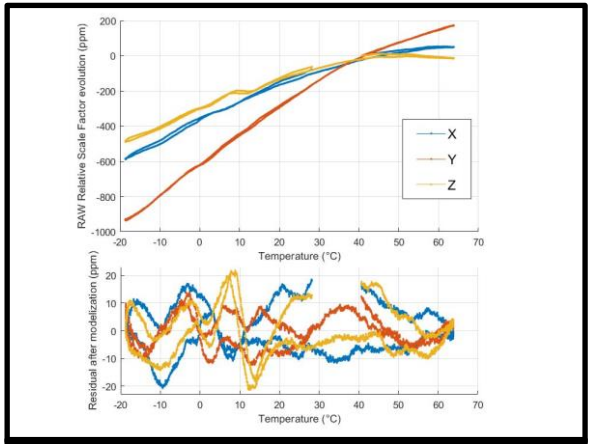
Astrix NS project status



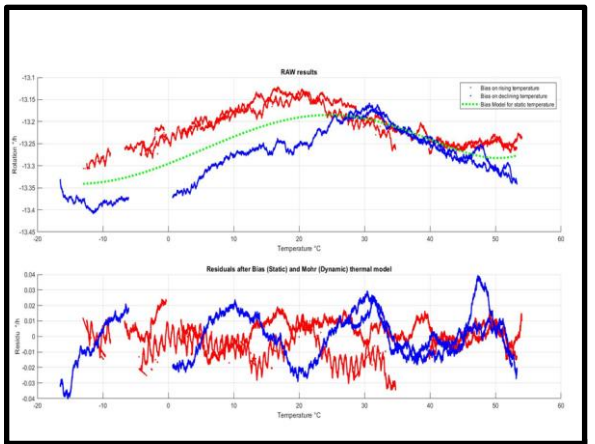
Astrix NS inertial performances



Noise: ARW down to 0,025°/√h



Scale factor thermal sensitivity: under 200ppm

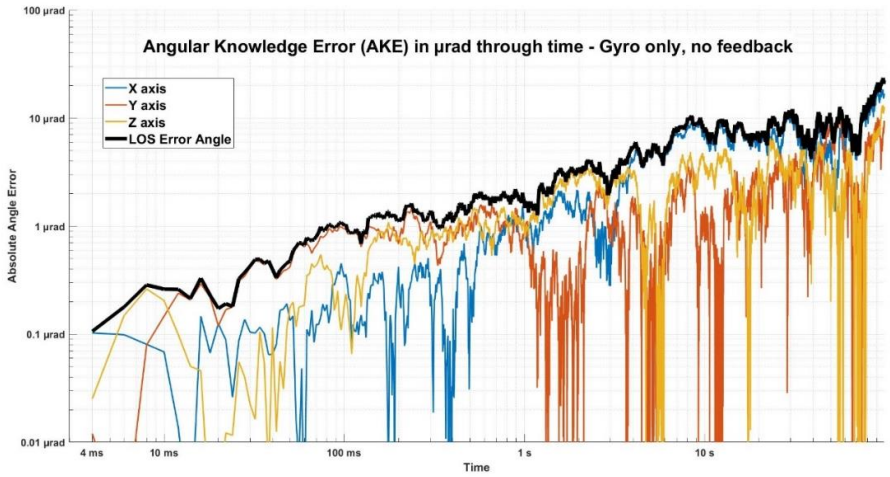


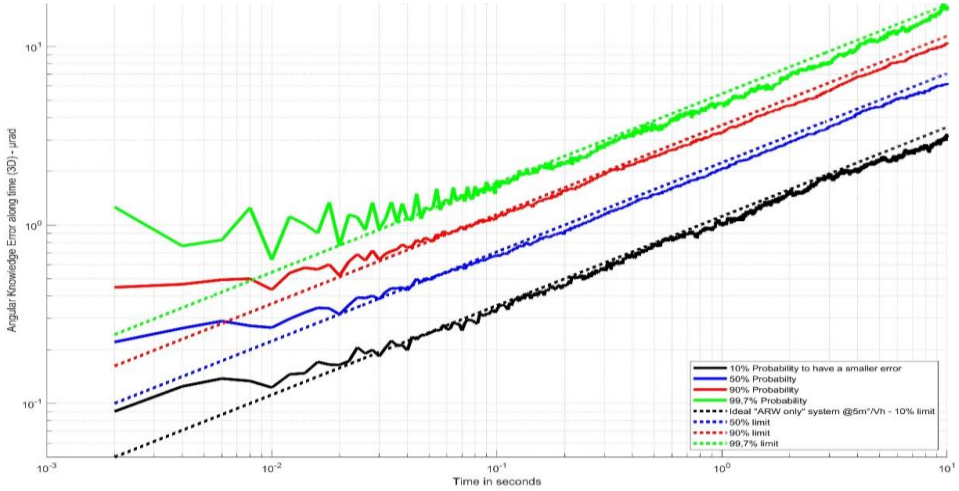
Bias thermal sensitivity : under 0.2°/h

- Performances were confirmed on EM models for both standard and high-performance version.
- All inertial performances are validated on the engineering models for the CDR over the full performance qualification range (-25°C / +65°C).
- Engineering models are manufactured and delivered to customer in 2022.

Astrix NS inertial performances

- Published paper at ICSO 2022 on line of sight and angular knowledge errors.



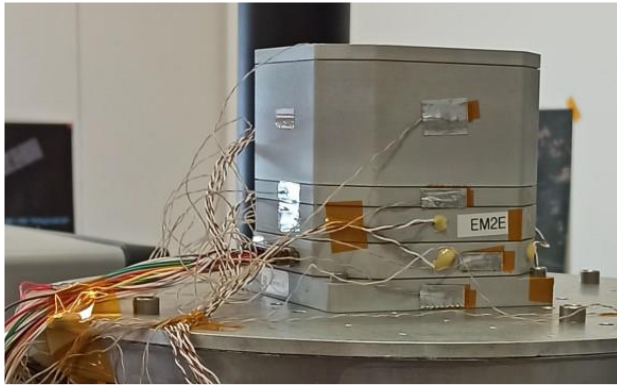


- AKE of 0.3 µrad at 0.1s is demonstrated on the standard performance version
- The noise is a pure ARW without any other contribution

Thermal model and tests

- Vacuum thermal tests have been conducted both at iXblue and CNES

- Both tests confirm Astrix NS good thermal behavior
  - Low temperature increase (below 7°C) for all temperature tested from -20°C to +65°C
  - No problematic warm-up of electronic components regarding reliability, PSA and WCA.
  - Astrix NS thermal behavior is consistent with the thermal simulations: Finite Element model using NX Nastran



Mechanical environment validation

- Mechanical design was validated following CDR with succcessfull test campains in shocks and vibrations.

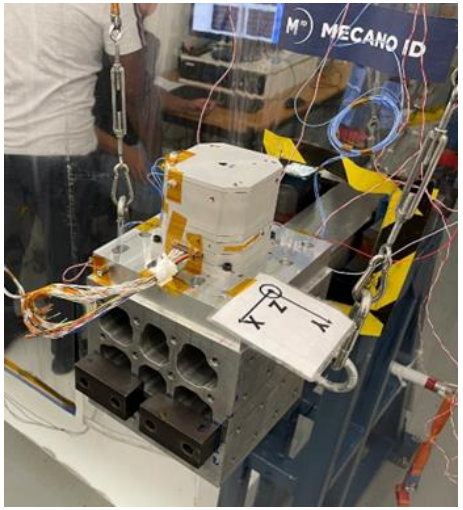
	Frequency [Hz]
STIFFNESS	>900

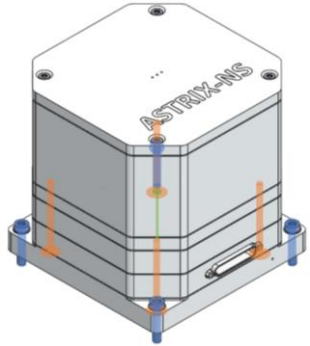
QUASI-STATIC LOADS	25g

	Frequency [Hz]	Amplitude
SINE LEVELS	5 – 20	11mm of displacement
	20 – 100	25g
	100 – 140	12g

	Frequency [Hz]	ASD [g^2/Hz]
RANDOM LEVELS $24.5g_{RMS}$	20	0.23
	60	1
	350	1
	2000	0.03

	Frequency [Hz]	SRS (Q=10) [g]
SHOCK LEVELS	100	50
	1000	2000
	10000	2000





4

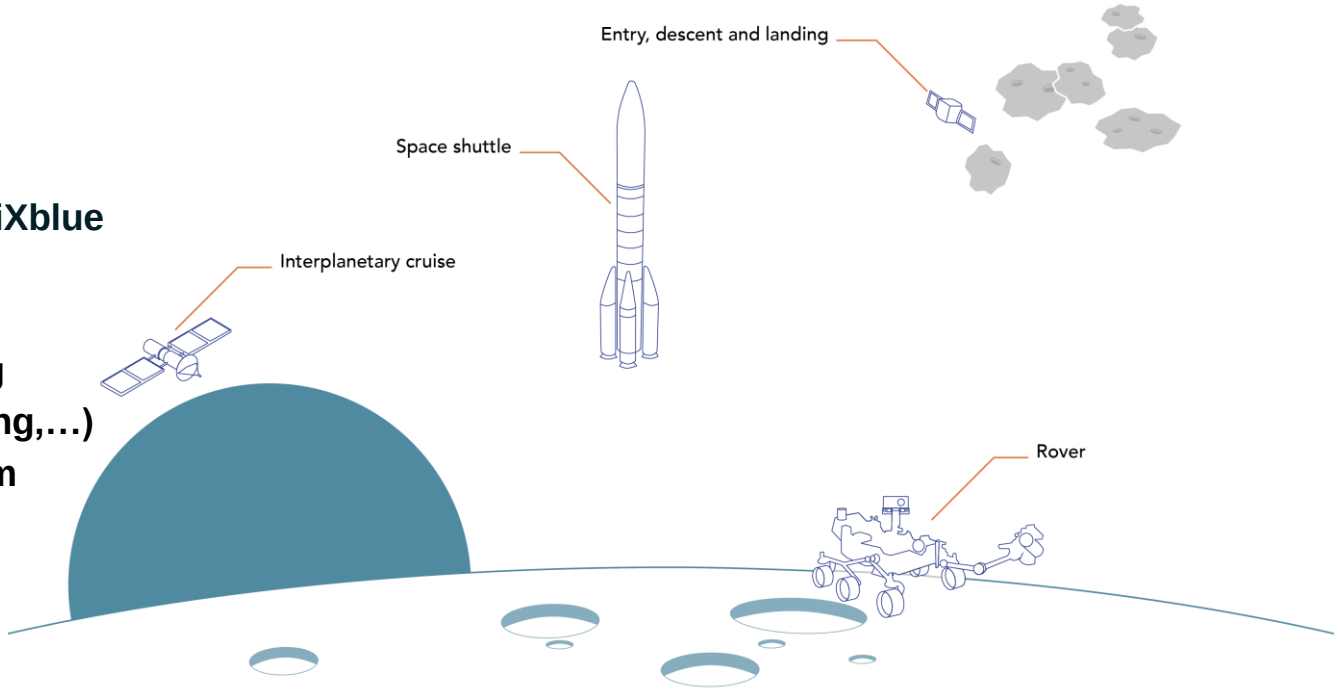
ASTRIX NS – IMU variation

Astrix NS - an inertial measurement unit variation

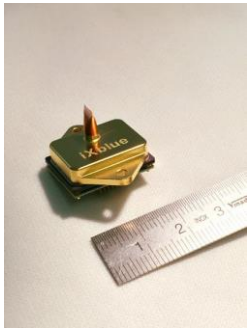
- **EURISA: H2020 project sponsored by the European Union with 4 partners**
  - ETH Zurich
  - Airbus Defence and Space
  - DLR Bremen
  - iXblue

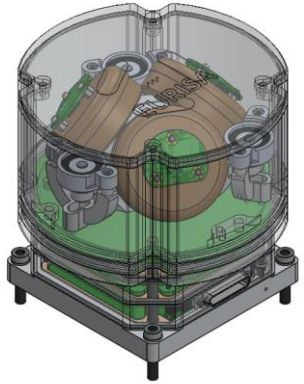
- **Based on Astrix NS with iXblue accelerometers**

- **On board IMU processing (lever arms, coning sculing,…) based on iXblue algorithm**



Astrix NS - an inertial measurement unit version





- **General features**
  - Compact : 110 x 110 x 120 mm
  - Low power : 12 W
  - Light : < 2 kg
  - RS422 communication and power supply 20V - 52 V
  - Based on space qualified COTS electronics to offer a competitive price while keeping high inertial performances and high reliability

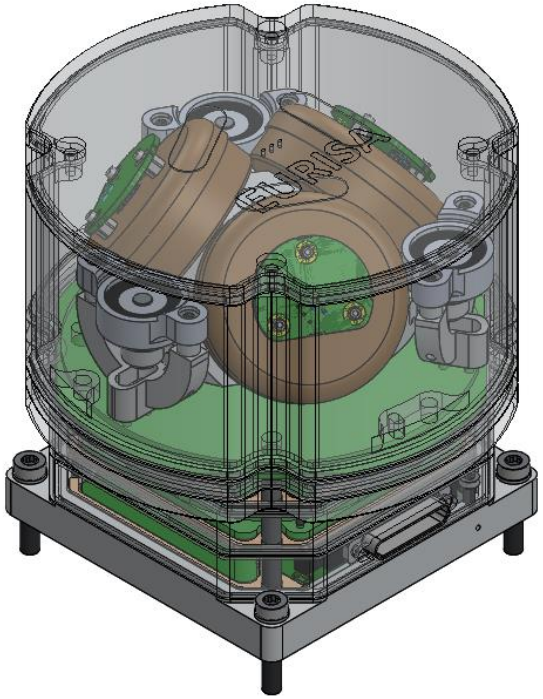
- **Main inertial performance gyroscope**
  - ARW : 0.005 °/√h
  - Bias stability 30 minutes : < 0.025°/h
  - Scale factor stability : < 300 ppm @3σ
  - Measurement range at full performance : +-30°/s

- **Main inertial performance accelerometer**
  - Long term bias stability EOL: 500µg
  - Bias stability 1 hour: 20µg
  - Scale factor stability : < 150 ppm @3σ
  - Measurement range at full performance : ±12g

Astrix NS - an inertial measurement unit version

- EM available in 2023 and fully tested by 2024 in the scope of the H2020 project

- FM available in 2025 following qualification (crucial qualification heritage from Astrix NS).




iXblue


exail

Questions ?

We would like to thank **Airbus** for our long-term collaboration
We would like to thank **CNES** for their technical and financial support