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NAVIGA: Multi Purpose European Space Navigation unit

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Contents:

- Introduction
- Development Challenges
- Unit Design and Performances
- Growth Capabilities
- Conclusions

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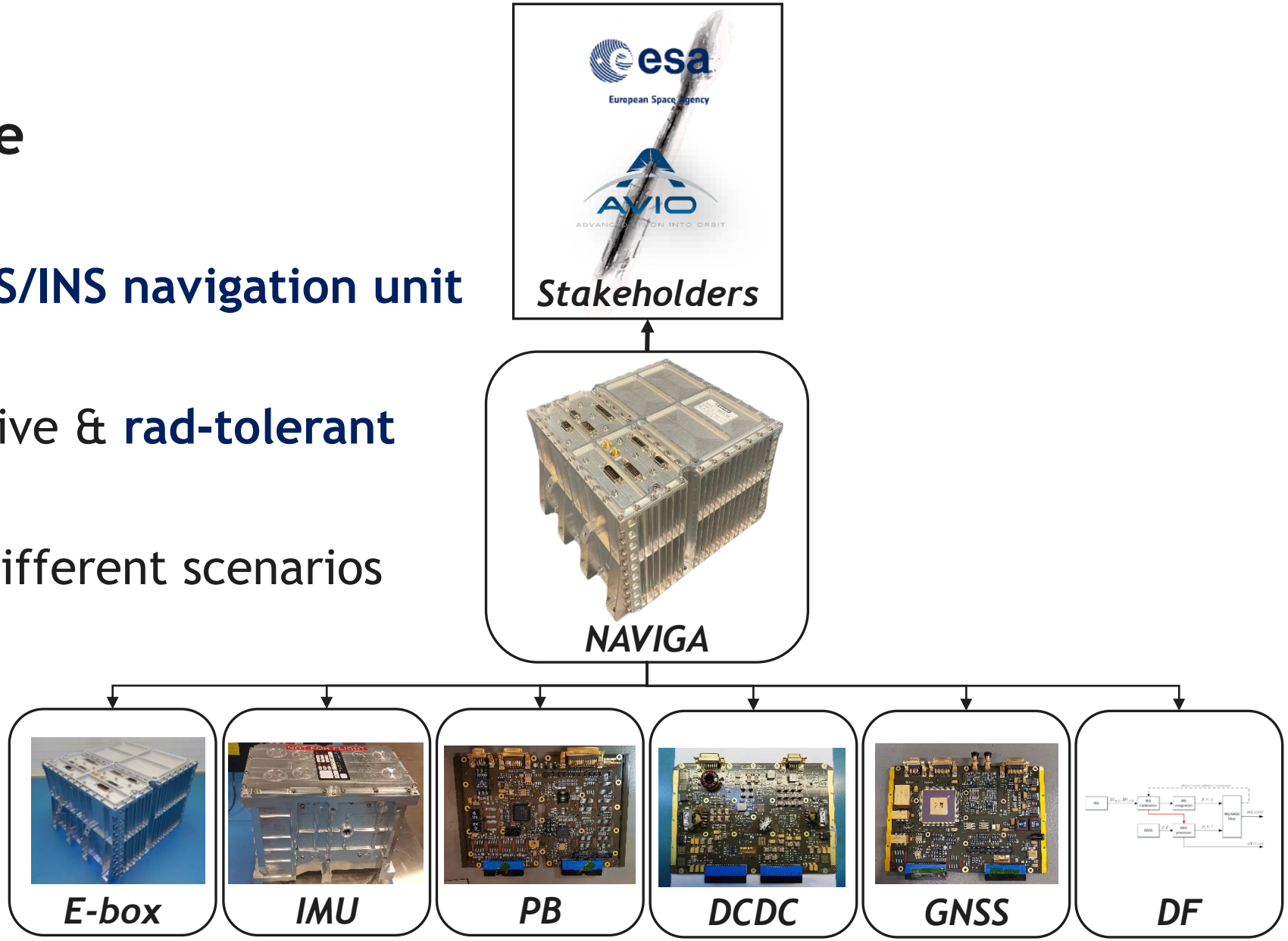
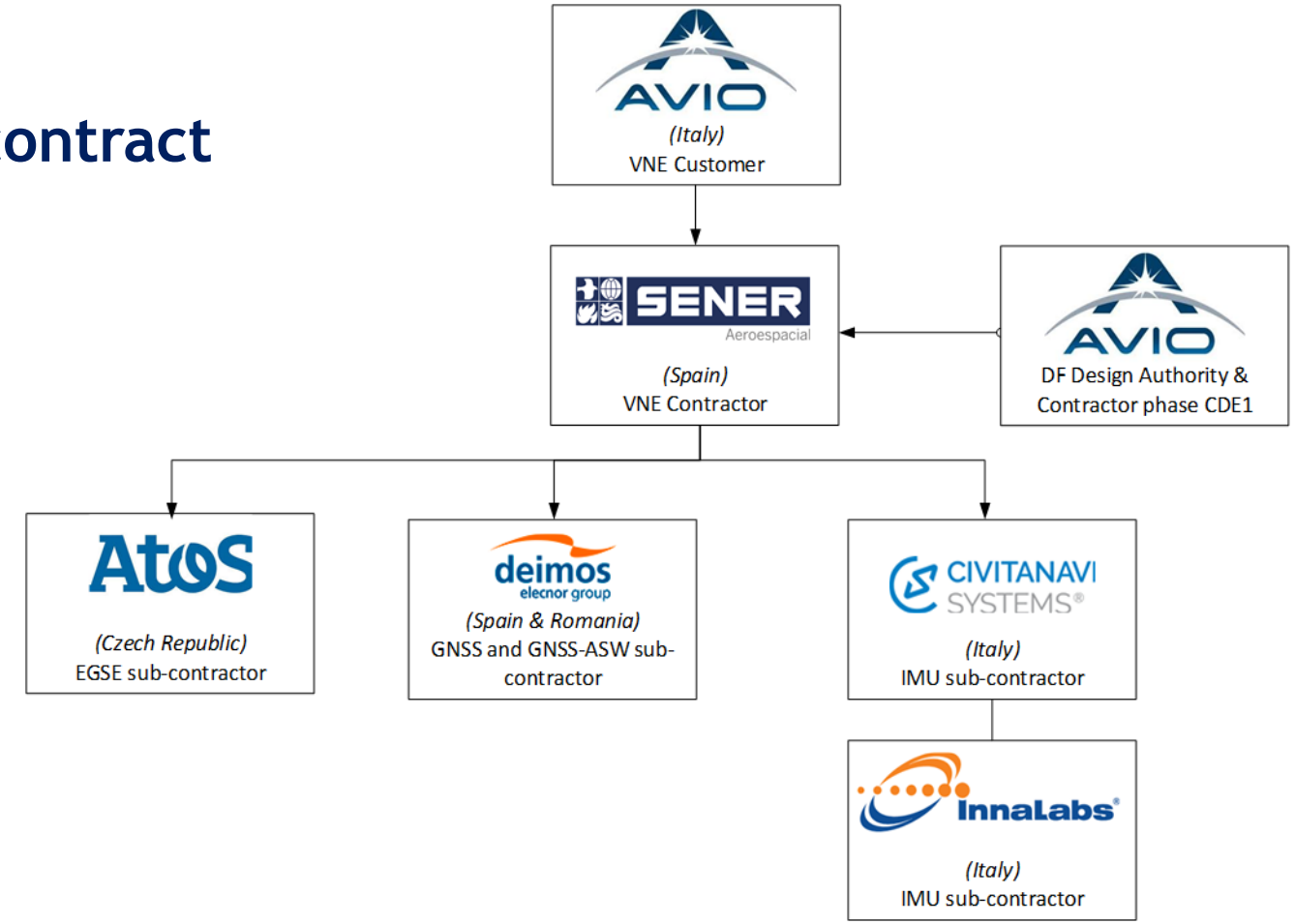
Introduction
NAVIGA at a glance

- **European hybrid GNSS/INS navigation unit**
- **Design to Cost**
- EEE policy → automotive & **rad-tolerant**
- SW cat. A/B
- **Modularity** → use in different scenarios



Introduction
Consortium

- Fully European – Under ESA contract
- SENER as Prime Contractor
- Mainly Spanish-Italian



Introduction
Context & goals

Opportunity: VECEP - VEga Consolidation and Evolution Preparation Programme

- *INS Obsolescence and high cost*

NAVIGA **wish list**:

- *Reduced cost*
- *European*
- *Performance*
- *Reliability*
- *Versatility*

Introduction
NAVIGA Use Cases

Launch – VEGA-C

Orbit – SR-AOM

Re-entry – SR-RM

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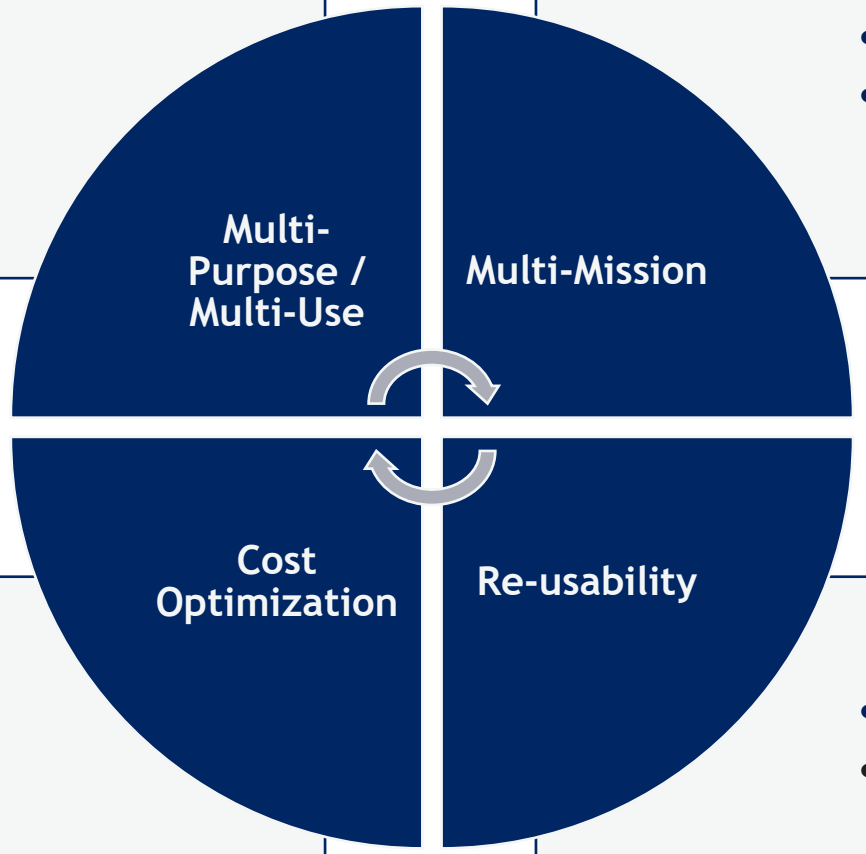
Development Challenges

Design drivers

- **Modular design** for versatility
- **Different outputs**
- Unit **configurability**
- **Growth capabilities**



- **Different use cases**
- **Ground initialization**
- **In-flight initialization**

- **Sensors hybridization**
- **Radiation tolerant and automative**
- **IPC standards**

- **Qualification**
- Inspection and health checks
- **Refurbishment** analysis

Development Challenges
NAVIGA development facilities

- **NAVIGA configurable models available**
- On-going VM and EM thermo-mechanical and functional campaign
- GSE, GNSS simulator and Rotation table available

Model	Main Purpose
Proto / HW pro-lab	VNE SW and FW development Sensor data post processing algorithms
VNE NUTEM Lab Model	VNE SW and FW development Final use: NUTEM / HIWL tests
VNE GNSS Lab Model	GNSS SW development
VNE DCDC Lab Model	IMU compatibility tests
VNE VM-1 **VNE VM-2**	MAIT Processes verification VNE Mechanical verification (partial)
VNE EM	VNE Functional verification
VNE EQM	Unit Qualification
VNE FM0	MAIDEN Flight

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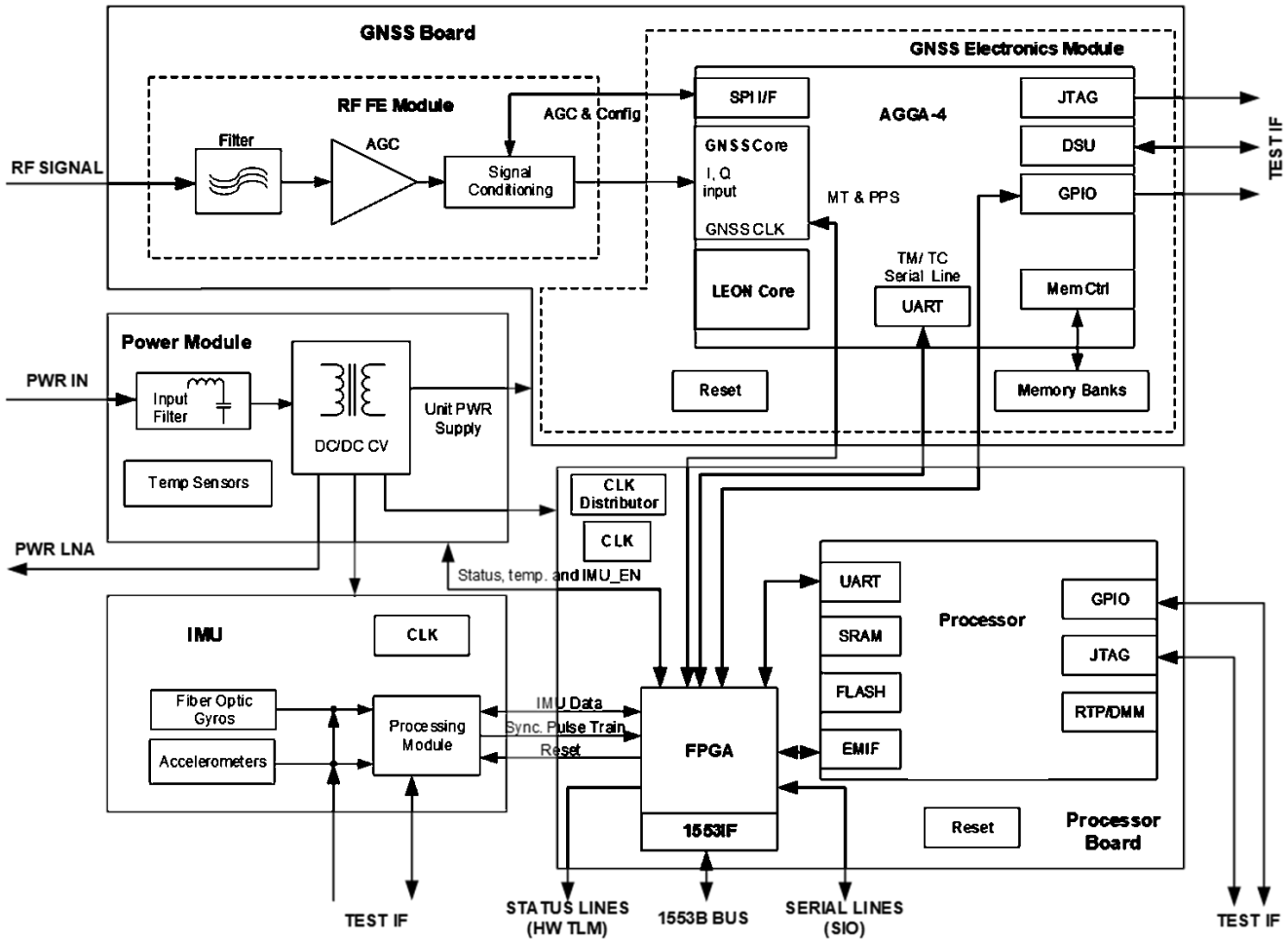
Unit Design and Performances

Functional Design



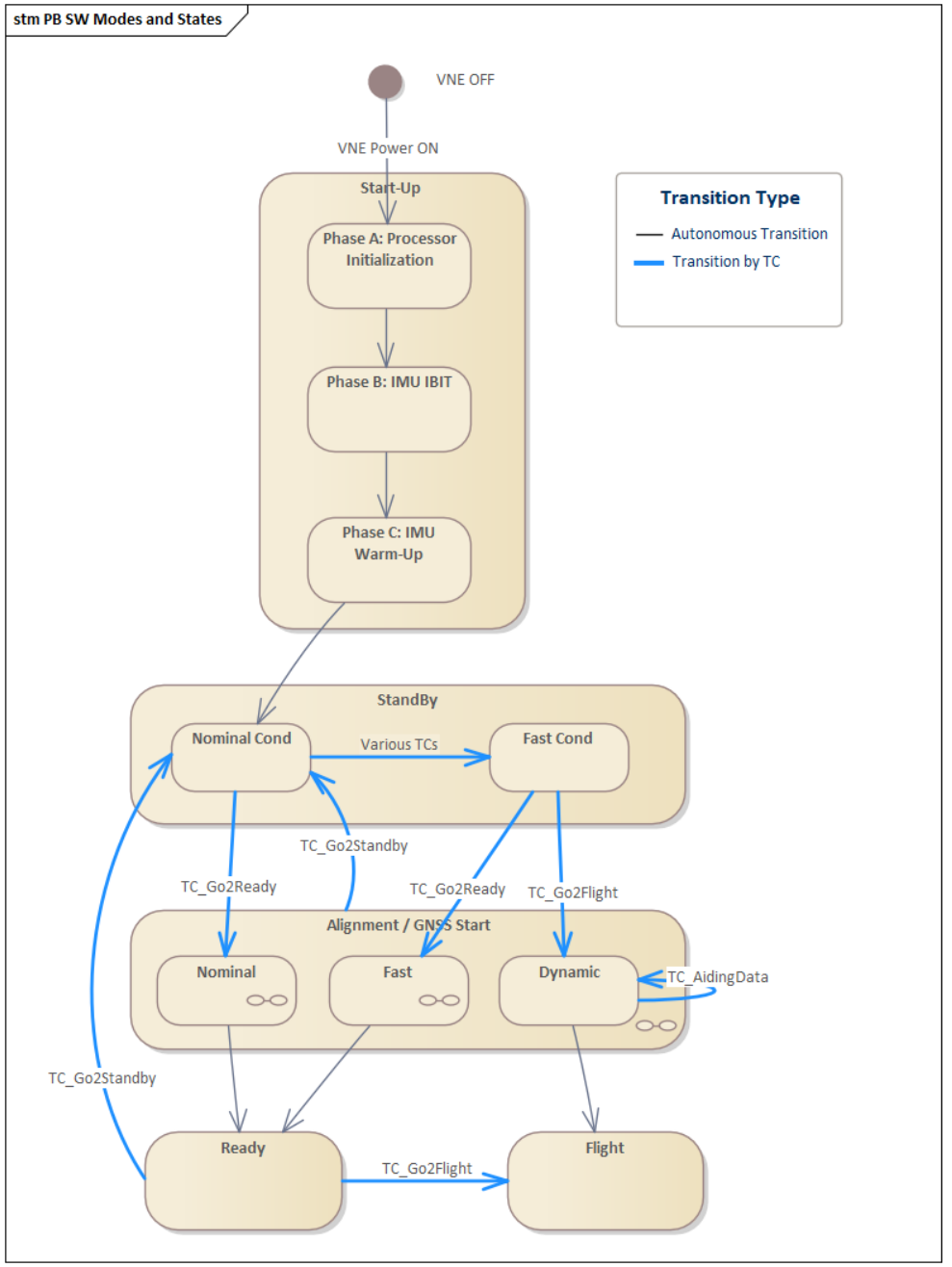
Mass	10 kg
Volume	5 l
Power Consumption	33 W
Data Aging	< 5ms
Output Frequency	10-200 Hz
Main Interfaces	MIL-BUS-1553 Power RF Serial Lines Debug & Test

Unit Design and Performances
Operation

- Standby **unit configuration**:
  - Custom output reference frame
  - Custom output frequency
  - Custom SW configuration (TMs, FDIR)
  - Extract the sensors raw data

- Three types of **initialization**

Alignment Type	Use Case	Time
Nominal Alignment	Launch Pad	<30 min
Fast Alignment	Launch Pad/Testing	<6 min
Dynamic Alignment	Flight	<15 min



Unit Design and Performances

Sensors Performances and DF Design

- **Hybridization of IMU/GNSS**,
- **Multiple rate** extended kalman filter with **36 states**
- Optimized to fulfil the **stringent data aging** requirement
- IMU at 2000 Hz
- GNSS runs at 1 Hz

Parameter	Units	Value
ARW	[°/√h] (RMS)	0.006
Gyro. Bias stability	[°/h] (RMS)	0.015
Gyro. Scale Factor	[ppm] (1σ)	≤ 80 ppm (BoL) ≤ 165 ppm (EoL)
VRW	[m/s/√h] (RMS)	0.01
Acc. Bias stability	[mg] (RMS)	0.01
Acc. Scale Factor	[ppm] (1σ)	≤ 100 ppm (BoL) ≤ 375 ppm (EoL)
IMU Misalignments	[mrad] (1σ)	0.2
GNSS Position	[m] (RMS)	5
GNSS Velocity	[m/s] (RMS)	0.07-0.2*

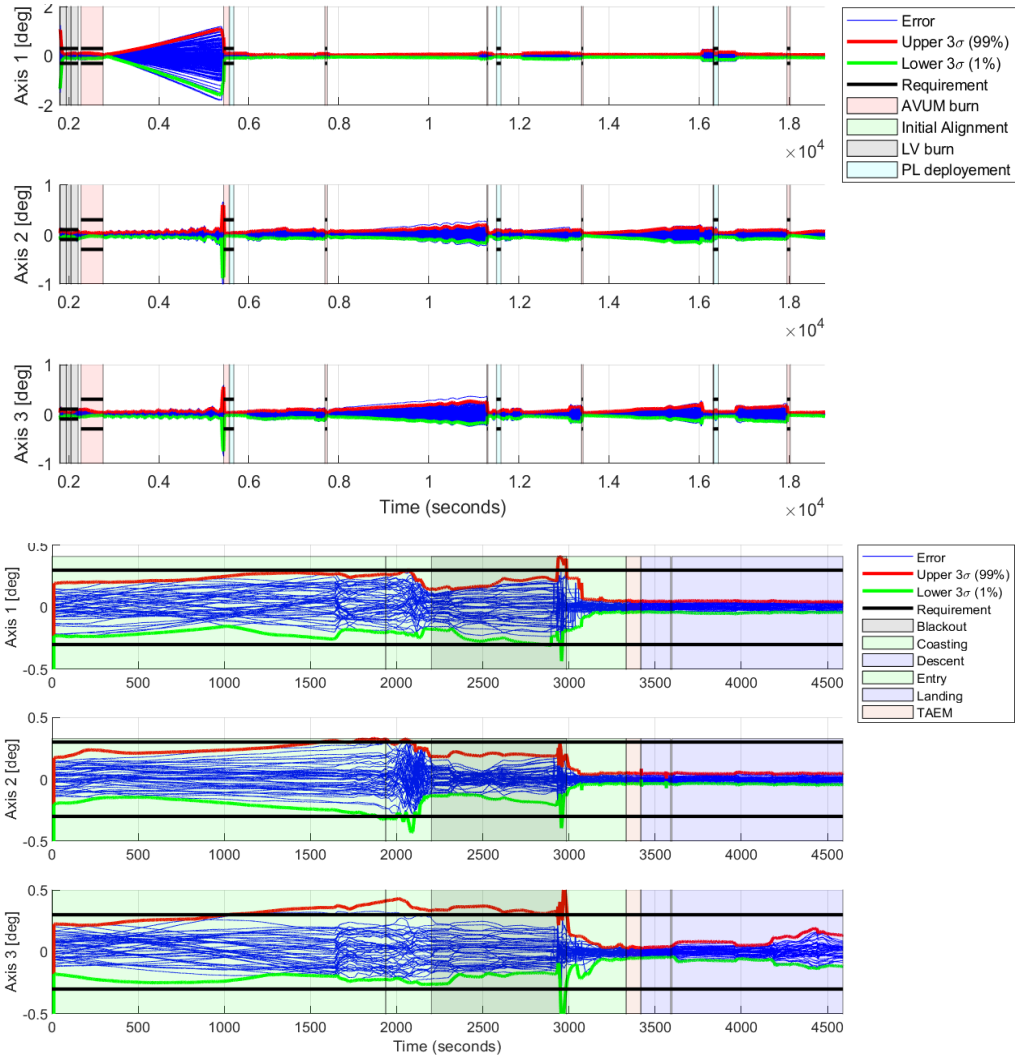
*Depending on launch phase

Unit Design and Performances

NAVIGA Hybrid Performances

Launch – VEGA-C

Re-entry – SR-RM

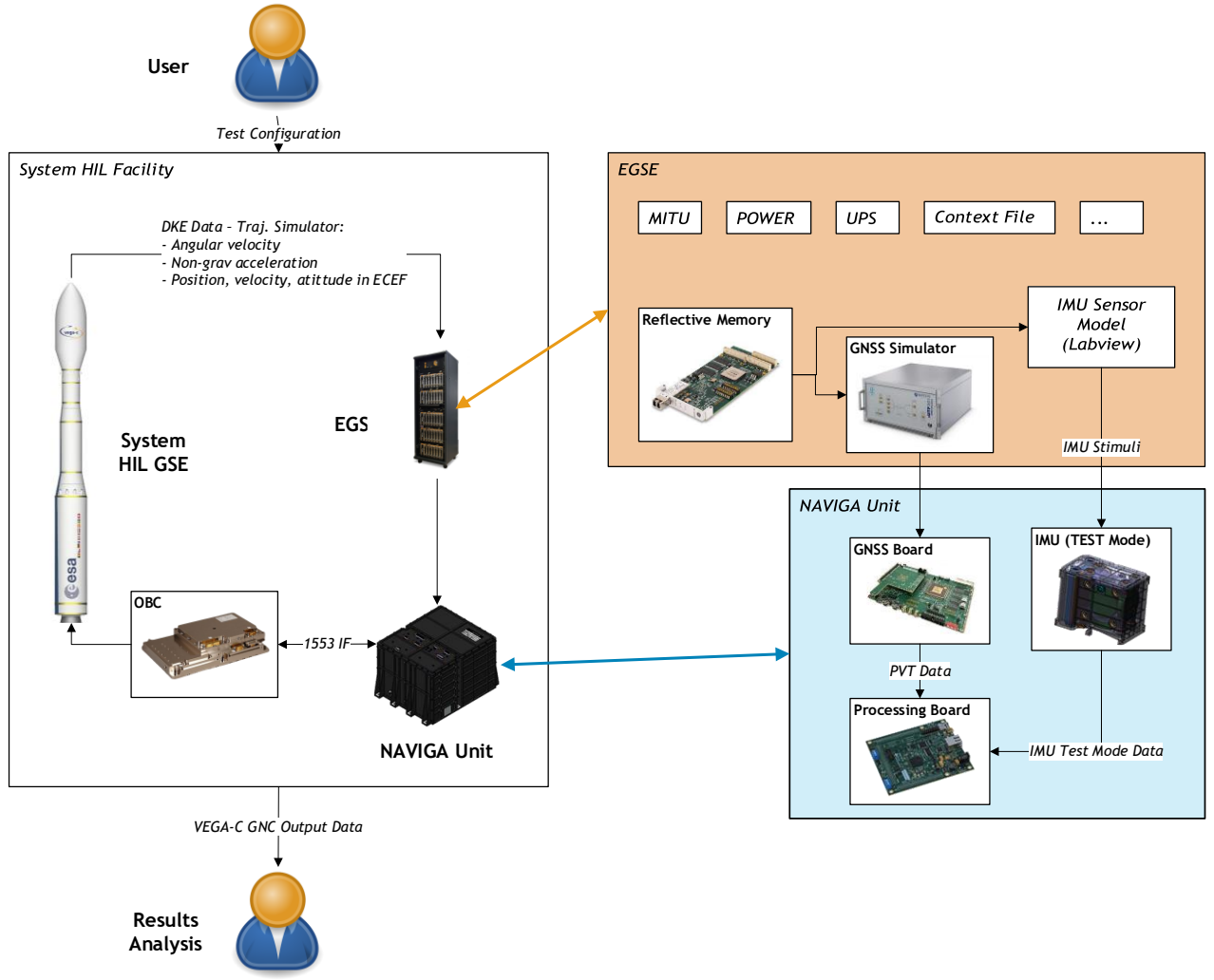


Unit Design and Performances
HWIL

- NAVIGA design integrates a **stimuli capability** for close-loop HWIL

- **IMU** -> the **stimuli data** is injected within the **internal integrating process**

- **GNSS** -> GNSS **RF simulator** (e.g. Skydel, Spirent)



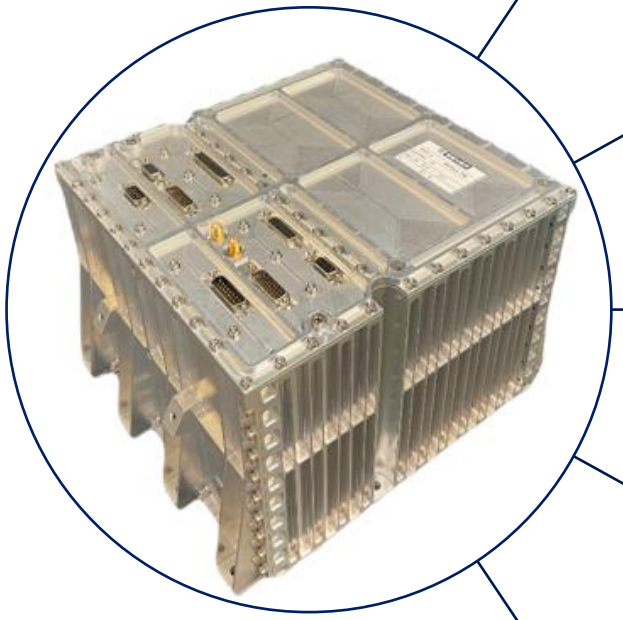
Contents:

Growth Capabilities

Possible Unit Improvements

- **Several improvements** already envisaged with the **same unit enclosure**

- NAVIGA provisions
  - External RS-422 (e.g. STR)
  - Additional RF chain
  - Double micro
  - FFF sensors
  - SW modularity



Spare GNSS RF Chain
- GNSS Dual Frequency
- GNSS Dual Channel

External Sensor RS422
- STR Hybridization
- Other sensors

Double Micro
- Custom User SW
- Reliability improvement

DF
- Tight Hybridization

IMU
- Higher performances FFF Sensors

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Conclusions

- **NAVIGA** is presented as a **multi-mission navigation unit for space transportation systems**
- Modularity facilitates modifications and increases versatility
- **Future NAVIGA evolution will focus in expanding its market**
- The **NAVIGA project heads** towards **the CDR and the qualification phase**
- **Exploitation** in VEGA-C and prepared for other missions by **2024**

NAVIGA (VNE) is a joint effort of many individuals and organisations during several years. We would like to thank to:

- All current and previous **NAVIGA team members at SENER, AVIO, ESA/ESRIN** (Frascati, Italy) and different **partners from industry**
- **All States and Delegations supporting the ESA VEGA development programme**, and in particular the Italian and **Spanish delegation**.

THANK YOU

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