SYDERAL SWISS

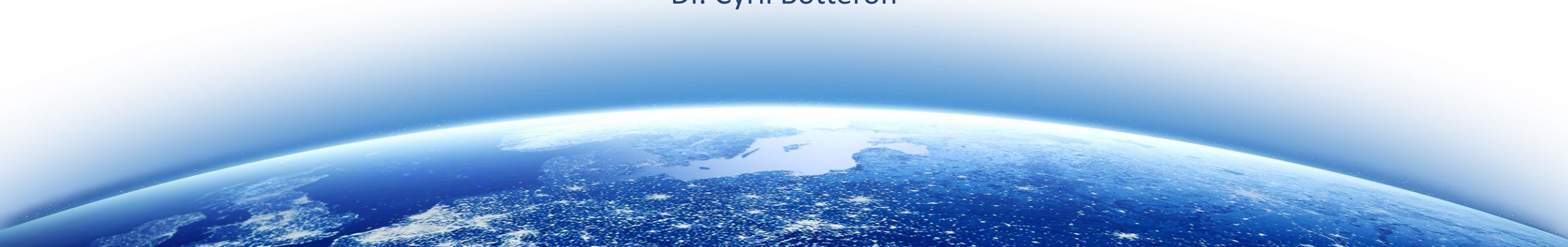
ELECTRONICS & SOFTWARE

NAVISP-El2-006 Development of a Spaceborne GNSS Receiver

NAVISP Industry Days

January 23, 2020

Dr. Cyril Botteron



Company overview

❑ Background

- National leader in hardware and software electronic solutions for satellites
- Design and production of flight electronics for more than 25 years, 50 missions with 100% success

❑ Full in-house production facility, ESA qualified

- 250 m2 clean room
- Automatic pick & place and manual assembly / test

❑ Syderal Swiss SA

- Date of creation : 1942 under the name of CIR
- Part of ALCATEL Space between 1998 & 2003
- SYDERAL SA since 2003 : Management owned, Swiss SME
- 70 employees in Neuchâtel, Switzerland

❑ Syderal Group

- Subsidiary in Poland: **SYDERAL POLSKA** → Space el.
- Subsidiary in Switzerland :
  - **KEYCOM** → Laundry/Building management system
- Total of ~90 employee

Company overview – Institutional market references

Data Handling

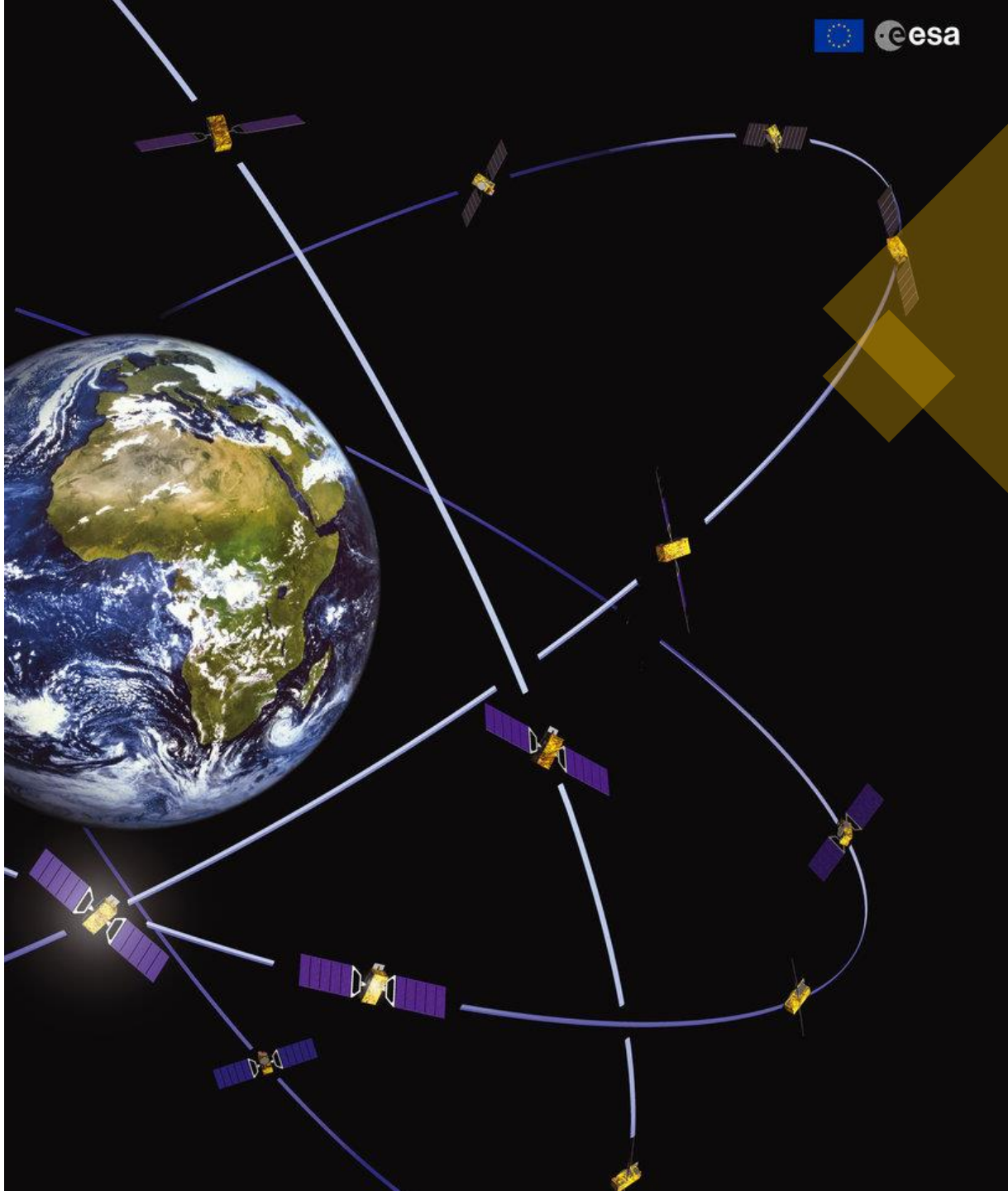
- **EARTH CARE / SVM** – Mass Memory and Formatting Unit
- **GAIA / SVM** – Payload Data Handling Unit
- **EXPERT** – Vehicle Memory Unit
- **SAR LUPE – DCSU** – Mass Memory board
- **KOMPSAT 2 – DCSU**- Mass Memory board
- **SOHO / VIRGO** – Data Acquisition System
- **XMM / RGS** – Data Acquisition System (incl. Formatting)

Instrument Controllers / Mechanism Drives

- **FLEX** - FLORIS Instrument Control Unit
- **INSIGHT** – Seismometer Electronics Box
- **SENTINEL 1 / SES** – Instrument Control Module
- **AEOLUS** – Aladin Control and Data Management Unit
- **GOCE** - Gradiometer complete electronics (3xFEEU, GAIEU & TCEU)
- **IASI Ng** – Mechanism Drive Electronics
- **MTG / IRS** – Interferometer Control Electronics
- **BEPI-COLOMBO / BELA** – Analogue Electronic Unit

NAVISP El2 006 “Space GNSS Receiver”

- **Goal:** development of a high performance, COTS based GNSS receiver targeting satellite constellations
  - To Bridge gap between low-end and high-end solutions
  - For single LEO spacecraft and large LEO constellations
  - Competitive price to performance ratio
  - Basis platform for future evolutions
- **Main project outcome:**
  - Engineering Model of NAVILEO receiver



NAVISP El2 006 “Space GNSS Receiver” - Characteristics

NAVILEO receiver

❑ Advantages

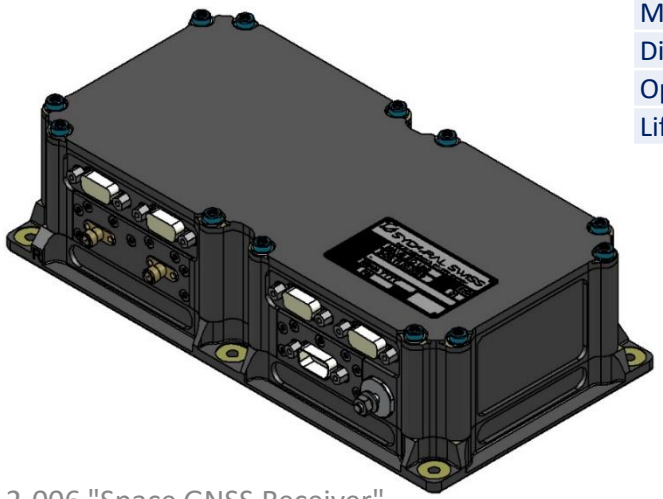
- Based on rad-tolerant architecture & COTS EEE components ⇔ low recurrent price, suitable for small/mini/micro sat & mega-constellations
- High sensitivity ⇔ supports both active & passive antennas
- Multi-constellation & multi-frequency ⇔ high PVT availability even in GEO, HEO,…; high accuracy (iono-free combination solution)
- Onboard orbital propagator ⇔ Improved PVT perfo., sensitivity and availability
- In-flight FW/SW upgradability ⇔ upgradable (new signals, constellations, …)
- Fugro Spacestar enabled ⇔ Real-time sub-dm (3D rms) POD on-demand

❑ Availability

- EM: Q2 2020
- FM Q4 2020

Performance characteristics	
Number of channels	48
Antenna inputs	1 (2 in option); supports both active and passive antenna(s)
Signals and frequ.	Galileo E1b and E5a GPS L1C/A and L5I/Q
Acquisition sensitivity (dBHz, for P_d=0.9)	28 (L1); 31 (E1b)
Tracking sensitivity (dBHz)	20 (L1, E5a); 22 (L5); 24 (E1B)
Warm / cold TTFF[1]	< 20 s / < 100 s
Typical pos. accuracy[1]	< 5 m (3D rms)
PPS signal (RS-422)	< 50 ns (rms)
TM/TC	UART, CAN in option (other interfaces possible). Fully compliant with PUS/CCSDS standard.
Update rate	1 - 10 Hz
Physical characteristics (TBC)	
Power / voltage	8 W typical at 5 VDC
Mass	1300 gr
Dimension	219.5 x 110.5 x 59 mm³
Operating temperature	-20°C - +50 °C
Lifetime	Min. 5 years in LEO

[1]Tested in a typical LEO orbit, all SVs at 44 dB-Hz

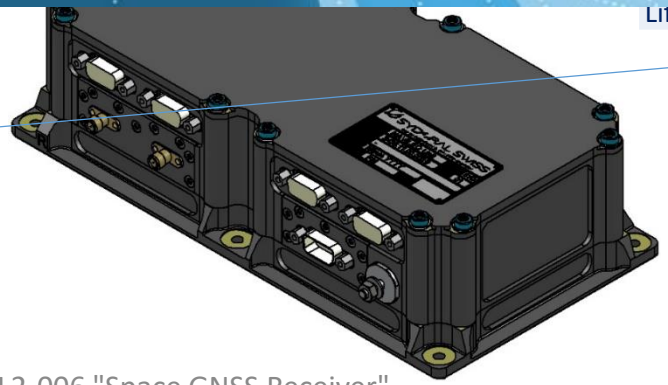


NAVISP El2 006 “Space GNSS Receiver” - Characteristics

- Proprietary global reference network supporting GPS, GLONASS, BEIDOU, & Galileo
- Orbit & Clock, Real time
- Position: <10 cm
- Velocity: < 5 mm/s
- Time: < 5 ns
- High availability & redundancy
- Track record & SLA’s

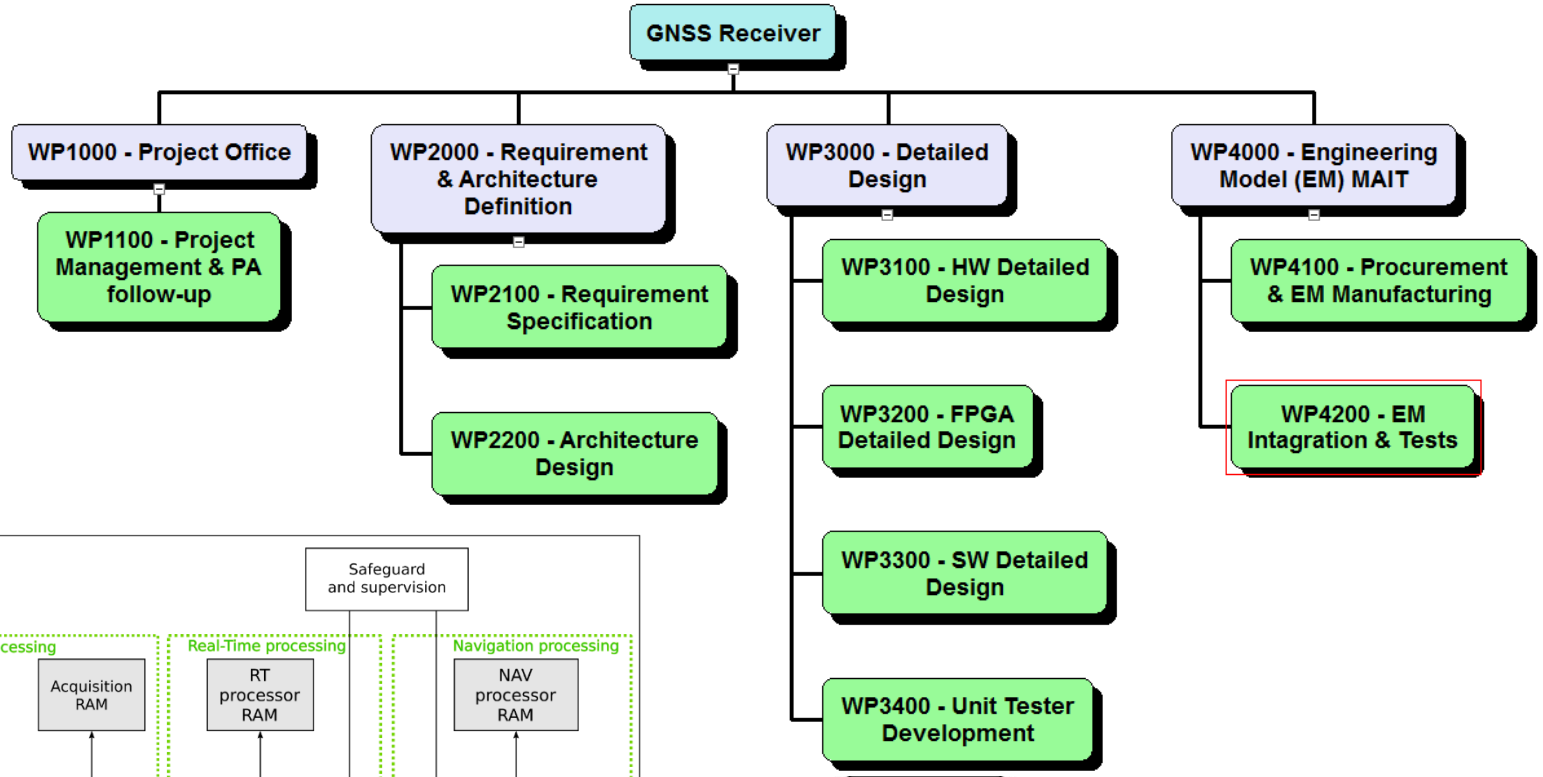
Lifetime	Min. 5 years in LEO

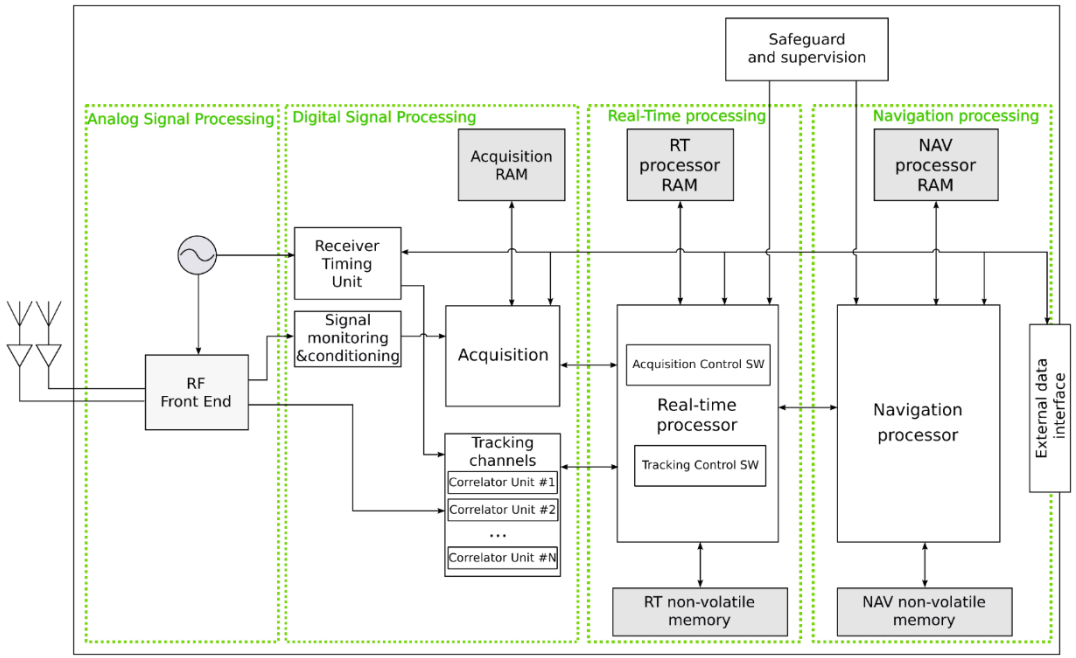
[1]Tested in a typical LEO orbit, all SVs at 44 dB-Hz

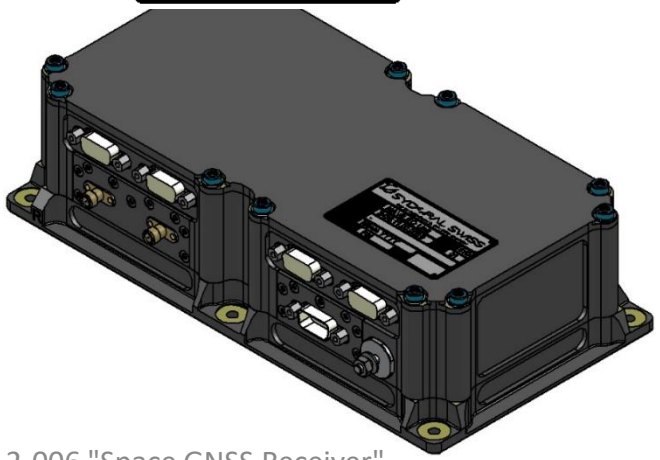


FUGRO SPACESTAR™
REAL TIME - ACCURATE POSITIONING
SYSTEM ENABLED

NAVISP El2 006 “Space GNSS Receiver” - Development







04, 2018 :
✓ **KOM**

07, 2018:
✓ **SRR&AR**

03, 2019:
✓ IDR

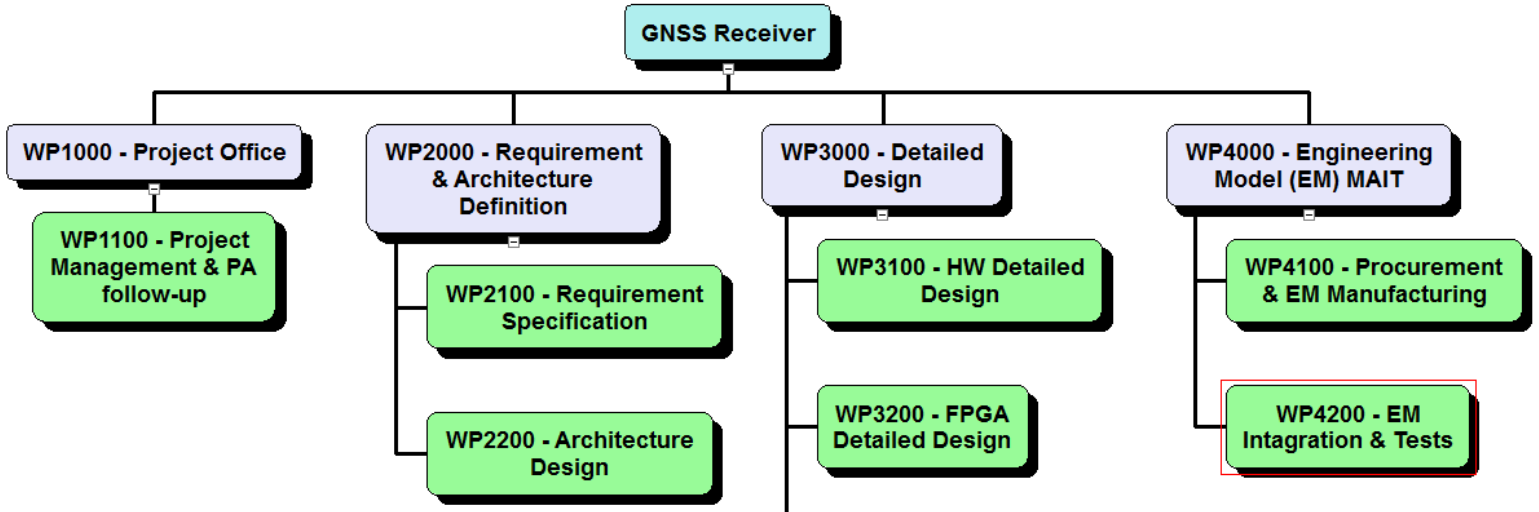
06, 2019:
✓ **PDR**

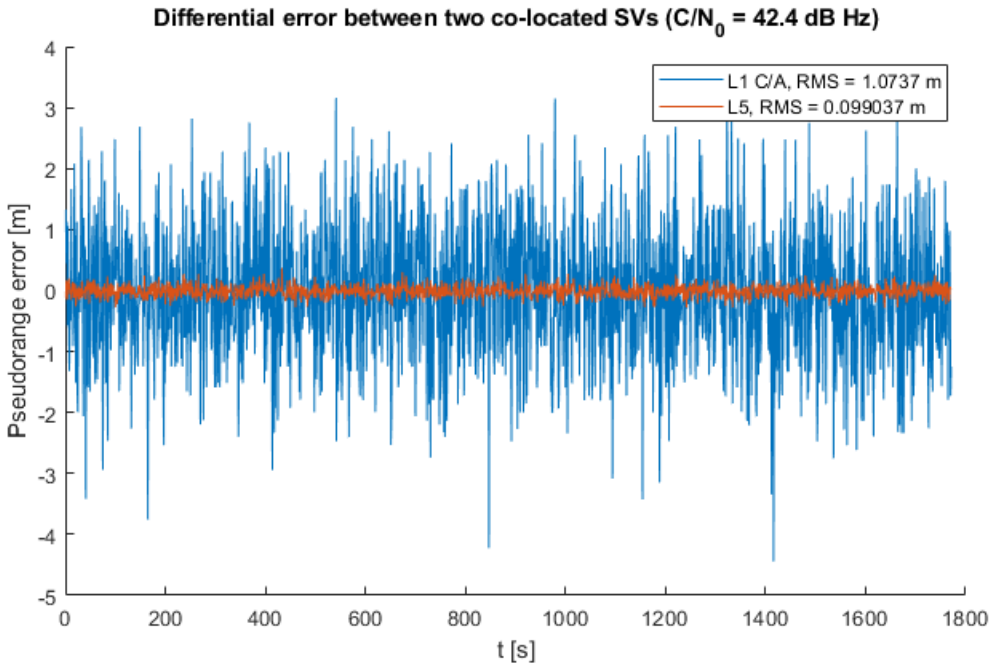
10, 2019:
✓ **CDR**

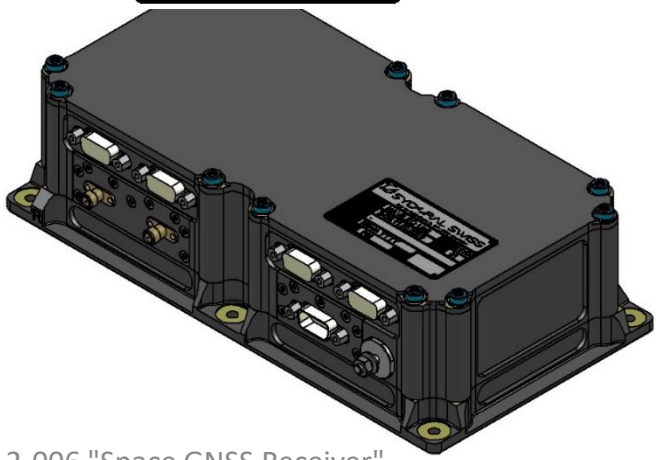
02, 2020:
❑ **TRR**

04, 2020:
❑ **FR**

NAVISP El2 006 “Space GNSS Receiver” - Development







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NAVILEO within the spaceborne receiver ecosystem

Price

Current solutions:
- High Reliability / High cost

Absolute nav GEO/HEO : 50-150 m
(STENTOR, SkyLAN, InteSat, GMP, SmallGEO, STE.QUEST)

Launchers GNS/GTO : 15 m
(ARIANE6, evols of ARIANEV and VEGA)

Absolute navigation (LEO) : 10m
(PLEIADES, DMC, Globalstar2Gm Proba-2, Demeter, EarthCare, COSMO-SKYMED)

Telecom (LEO/GEO) : 100ns
(GEO telecom, GLobalstar2G, O3B)

Relative navigation (LEO/GEO) : cms-1m
FF LEO cms / GEO 1m
(GRACE, PRISMA, Proba-3, MMS, TerraSAR-X/TD-X)
RV 1cm-10m
(ATV)

Scientific POD (LEO) : 0.01 m -2 m
(GOCE, SWARM, GMES sentines, CHAMP, GRACE, BIUOMASS, DEMETER, STE-QUEST)

Scientific GNSS-RO (LEO) : cms/0.1mm/s
(MetOp, CHAMP, MetOp2G, COSMIC, OCEANSAT-2, SAC-D, MEGHA-TROPIQUE)

Real-time POD (LEO) : 0.3 m -3 m
(SWARM, GMES sentinels, Topex-Poseidon)

Scientific GNSS-R (LEO) : m
UK-DMC, CYGNSS

Institutional market

NewSpace market

- Very low performance
- Lower Reliability / Lower cost

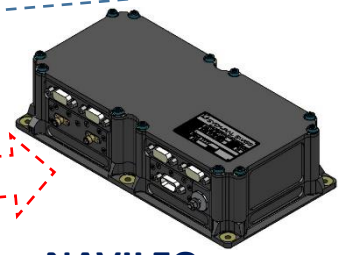
LEO OBC solutions
Newspace solutions
Cubesats

1 frequ. (w/OBC)

NAVILEO

Real-time POD

- High performance
- Lower Reliability / Lower cost



NAVILEO + Fugro SPACESTAR™

Perfo

Single-frequ L1
>15 m LEO

Single-frequ L1
6 m LEO
75m GEO

Multi-frequ.
1 m LEO
30 m GEO

Multi-frequ.
L1L2L5
POD on-GND

Multi-frequ.
POD in-flight

Future plans for the product

Step 1 : availability of NAVILEO's baseline version for Q2 2020 (EM) and Q3 2020 (PFM)		
NAVILEO GALE1/E5a+GPSL1/L5	NAVILEO	High-performance GAL. E1/E5a + GPS L1/L5 space GNSS receiver for LEO spacecrafts

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Step 2: in parallel, additional developments of NAVILEO to target additional applications / market segments		

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Step 2: in parallel, additional developments of NAVILEO to target additional applications / market segments		
Real-time on-board POD algorithms	+ Fugro Spacestar	For missions requiring < 10 cm 3D rms POD (real-time, absolute or relative)

Application benefits:

- ✓ Fully integrated within NAVILEO (no need for additional antenna)
- ✓ No need to download GNSS raw data and post-processing via ground infrastructure
- ✓ Allows for real-time on-board data processing
- ✓ Reduced product latency

POD Performance:

Position better than 10 cm 3D rms
Velocity better than 5 mm/s
Time better than 5 ns

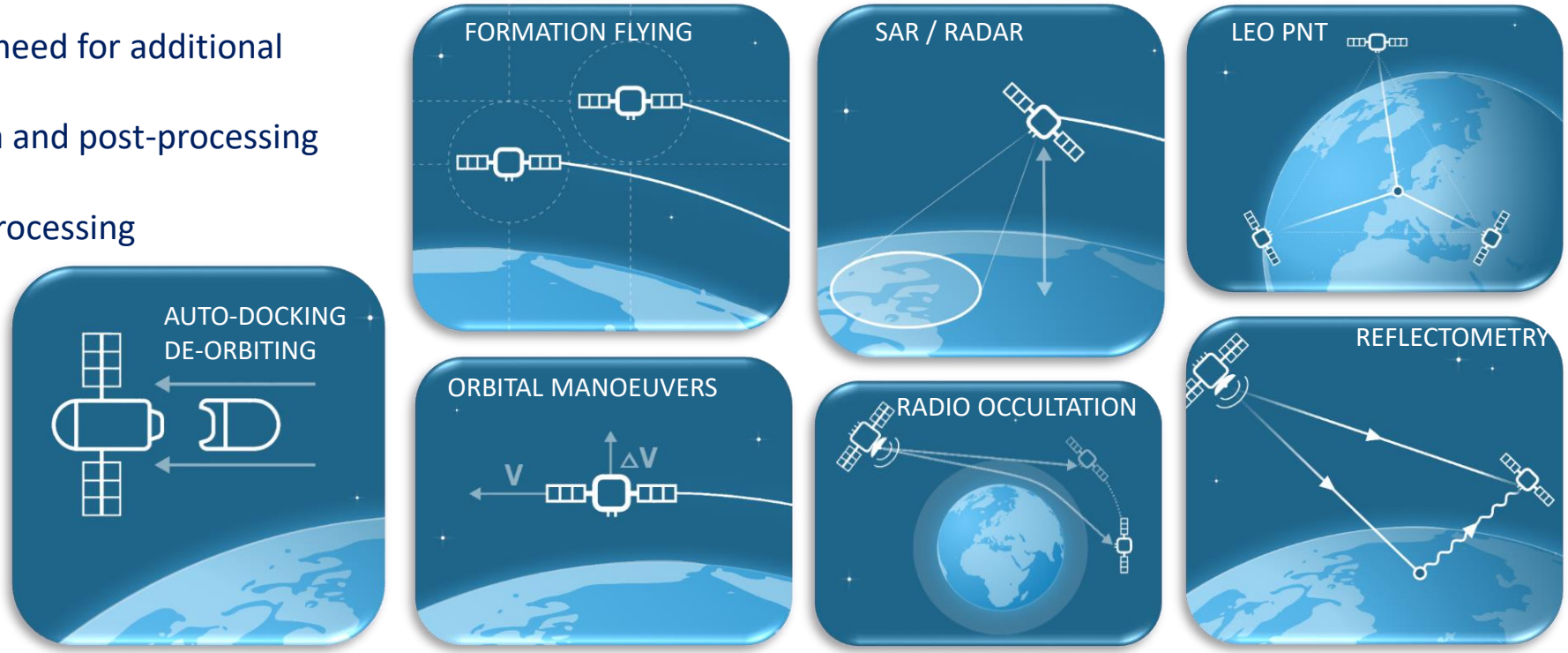

Image source: Fugro

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Implementation of very high sensitivity algorithms	NAVIMOON	For more demanding missions in GTO, GEO, HEO, MTO, and to the Moon!

NAVISP El1-023 : NAVIMOON project

- Goal: development of a Moon GNSS receiver prototype (EM)
- Applications
  - Autonomous navigation for Earth – Moon Transfer orbits
  - Autonomous navigation for cislunar orbits
  - More…
- Characteristics
  - Based on NAVILEO + higher sensitivity + tightly coupled navigation filter (GNSS+OF) + …
- Availability
  - EM: Q1 2021

Image source: https://www.esa.int/esearch?q=moon+village

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Implementation of very high sensitivity algorithms	NAVIMOON	For more demanding missions in GTO, GEO, HEO, MTO, and to the Moon!
Addition of GNSS signal re-generation capabilities	LEO-PNT	For leveraging LEO mega-constellations as alternate GNSS providing secured position, navigation and time, or synchronization of payload to GNSS time

LEO PNT demonstrator : NAVILEO receiver + POD SW + GALILEO-like signal re-generator and transmitter

❑ Applications

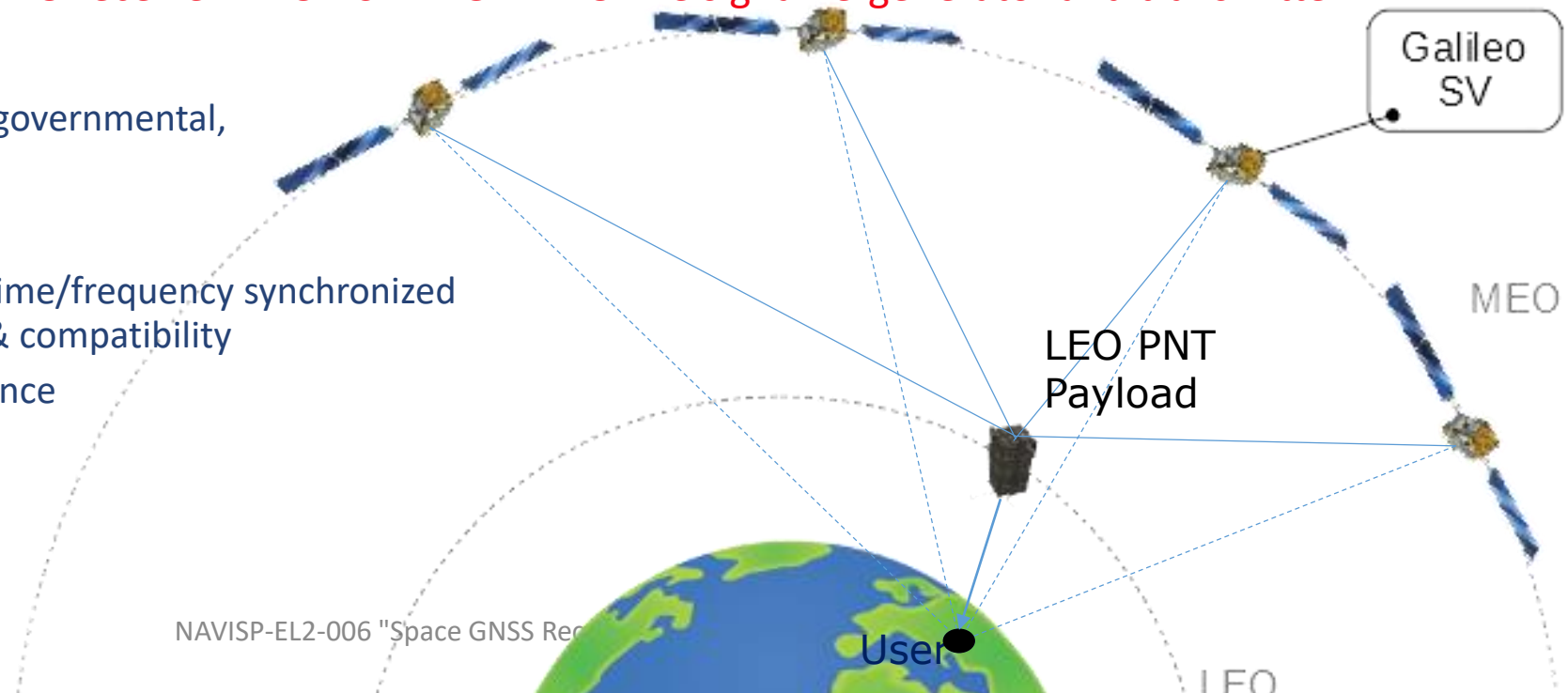
- Alternate LEO PNT constellation for governmental, IoT, road transportation users

❑ USP & Differentiators

- POD solution + signal regeneration time/frequency synchronized with GNSS time ⇔ interoperability & compatibility
- High dynamics ⇔ Fast PPP convergence
- Alternate PNT ⇔ more security
- Stronger signals ⇔ IoT

❑ Availability

- Demonstrator : Q2 2020



NAVISP-EL2-006 "Space GNSS Rec

Summary

❑NAVISP El. 2 benefits

- **Very flexible and effective programmatic Element 2 framework:**
  - ESA/SME co-funded scheme

  ➔Enables company to propose a project and define the product specifications, …

  ➔Ownership of developed IP remains to Industry

  ➔Fast submission & feedback process

- **Great ESA support:**

  ✓Project follow-up and constructive feedback/guidance through regular progress meetings & milestones

  ✓Access to some of ESA facilities / experts

  ✓Proposed a full evaluation of our final product (EM) at the end of the project

➔Enabled the creation of a new GNSS product line in Syderal!

from LEO → to LEO PNT → to MOON applications!

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- My colleagues in Syderal


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