Overview of Thales Alenia Space Italia
GNSS Products & Activities

7th Multi-GNSS Asia (MGA)
Industry Seminar

LIVIO MARRADI | Thales Alenia Space Italia
Thales operates as a single organisation, drawing on the talent and technologies of the entire Group to act as prime contractor, systems integrator, equipment supplier and value-added service provider on both civil and military programmes.
Thales plays a major role in space systems through two joint ventures with Finmeccanica: Thales Alenia Space and Telespazio serving satellite operators, space agencies and defence customers.

- Helping them to design, develop and deploy orbital infrastructure, systems, ground segments and services
- For telecommunications, Earth observation, navigation and scientific missions

### Telecommunications
Thales Alenia Space is prime contractor for all telecommunication satellite constellations, including Iridium Next, Globalstar, O3b

### Earth observation
Civil, military, dual-use
Meteosat 1st, 2nd & 3rd generations, Helios, CSO, Pleiades, Cosmo SkyMed, Sentinels

### Orbital infrastructure
Thales Alenia Space has supplied 50% of the pressurised volume of the International Space Station

### Science
Thales Alenia Space is prime contractor for ExoMars, Europe’s first mission to land on Mars

### Navigation
Space and Ground Segments
EGNOS, Galileo
Equipment & Infrastructures
Space and Ground GNSS Product Lines

**GNSS Ground Reference Receivers**
- EGNOS V2/V3 RIMS
- GALILEO GRCN IOV/FOC
- IONO MONITORING RECEIVERS

**GNSS Spaceborne Receivers**
- LAGRANGE-2G REAL-TIME NAVIGATION LEO/GEO/GTO
- GNSS RADIO OCCULTATION INSTRUMENT
- GNSS REFLECTOMETRY

**GNSS User Applications**
- TEST USER RECEIVER
- RAIL USER TERMINAL
- SW RADIO RECEIVER

**GALILEO NSGU Navigation P/L**
- NSGU IOV/FOC
- ENSGU / LNSGU new generation
Ground Reference Receiver Products

**EGNOS RIMS-B**

**Key features:**
- 16 channels GPS L1/L2
- 12 channels GLONASS L1
- 6 channels GEO L1
- All in view acquisition and tracking;
- Provides Raw Data, Navigation Message, Signal Quality and Signal Status Indicators, Health Status;
- Provides Timing Synchronisation (PPS);
- 19”, 3 PU (133 mm height) sub-rack plus antenna;
- Provides raw data to the EGNOS processing chain

**Domains for application:**
- Reference receiver for EGNOS SBAS Ground Segment

**Maturity on the market:**
- > 40 recurrent units operational on EGNOS sites worldwide

**GALILEO GRCN Rx for IOV/FOC**

**Key features:**
- Galileo receiver for OD&TS, IPF and PTF chains
- Processing of 16 GALILEO satellites L1, E5, E6 except PRS, 12 channels GPS L1/L2
- Raw measurements generation (code, carrier phase, C/No, Doppler, code-carrier coherency indicators) and validity flags from the E5a-b, E5 (AltBOC), E6 and L1 signals, for each Galileo satellite in view;
- Galileo PTF station receiver and automatic calibration mode
- Interference mitigation through pulse blanking
- Navigation Data Messages output
- PPS signal generation

**Domains for application:**
- Reference Rx for Galileo Ground Mission Segment

**Maturity on the market:**
- 40 GRCN Units delivered and operational
- 4 new generation GRCN-NG Rx delivered
- 4 PTF-C Calibrators
Ground Reference Receiver Products

RIMS-E/V3 New Generation Rx

Key features:
- RIMS New Generation Rx capable of providing raw data on the following signals:
  - Baseline provision
  - GPS L1C/A, L2P(Y), L2CM/L2CL, L5
  - GALILEO E1, E5a
  - GEO L1, L5
  - Expandability provision
  - GPS L1C
  - HEO L1, L5
  - GLONASS L1OC, L5OC
  - BeiDou B1C, B2a

- Antenna: interface to COTS geodetic reference antennas or dedicated Dual-Tracking Antenna (DTA) for increased performance in MP and Interference

Domains for application:
- Reference receiver for Ground Stations Infrastructure

Maturity on the market:
- Qualified unit Q2 2016

DUAL TRACKING ANTENNA Rx (DTA)

Key features:
- Based on TAS-I receiver platform
- The DTA concept is based on the tracking/acquisition of the GNSS satellites at any elevation angle dividing the field of view in two different sides (Low Elevation Antenna - LEA, High Elevation Antenna - HEA)
- Dedicated measurement chains and appropriate combination algorithms allow to mitigate the errors affecting the measurements for multipath and interferences and minimizing their impact

Domains for application:
- Reference receiver of ground reference stations
- Antenna/Receiver system for Airport GBAS Stations

Maturity on the market:
- Demo Proto available
- Qualified Unit Q2 2016
Multi-Constellation / Multi-Frequency Ground Receivers

COMMON PLATFORM SCALABLE ARCHITECTURE
- Designed for Ground Station Infrastructures & GNSS Networks
- Expandable to All-constellation / All-signals (GPS/GAL/GEO/GLO/BEI)
- State-of-Art Performance
- Robustness to environment for usage in harsh sites
  - Interference: NB, WB, Pulse, Extreme
  - Multipath: up to 6dB D/U
  - Scintillation: extension to Equatorial/Polar Regions
- 11+1 Multicorr/Channel for EWF function (local / central)
- Digital I/Q samples output for RF Env Monitoring (RFEM)
- Interface to COTS geodetic antenna or DTA technology
- Adaptable external data interface
- Security Features
- Qualified to DO-254/278 standards
- TAS-I commitment to continuous Rx technology evolution
GISMO
Ionospheric Monitoring Receiver

FLEXIBILITY & CONFIGURABILITY
- Dual Frequency, Dual Constellation Signal Tracking
  - GPS/GAL: L1CA, L2c, L5/E5a
  - Tracking Loops Configurability (DLL/PLL BW, code/phase discriminators)
- Expandability: Channels expandability by adding boards in the Rx

ROBUSTNESS
- Tracking Loops: PLL, FLL-aided-PLL, Kalman Filter PLL
- Bit grabbing capability: Storage capability and post-processing I/Q data

OBSERVABILITY
- Rate: Meas Rate configurable: 50, 20, 1 Hz (SNR and Carrier Phase)
- Clock: Ultra stable OCXO: spectral purity (phase noise) and short term (Allan deviation)
- Ionospheric Products: S4, Sigma-Phi, TEC, ΔTEC, Iono Flag
- Environmental Products: CCC Iono Free, Cycle Slip Flag, Interf. & MP Flags
- Data Output: Rinex, ISMR, Binary High Rate Files

EQUATORIAL REGIONS AFFECTED BY IONO

IONO MONITORING STATIONS FOR MODELING & FORECAST TO USERS

GISMO Reference Receiver

MISW, MONITOR, BELS Stations
Space-borne GNSS Receivers

**DUAL-FREQ GPS POD**
(LAGRANGE & LAGRANGE-2G)

- 12 GPS / GLO L1+L2 channels
- Precise Orbit Determination (POD by ground post processing)
- MIL-STD 1553B data I/F
- Mass 5 kg Power: 30 Watt
- Dimensions: 250 x 164 x 190 mm
- Navigation output states:
  - Position @ 1 Hz - Velocity @ 1 Hz
  - Time @ 1 Hz
  - Raw Data L1/L2 measurements @ 1Hz
- Maturity: 18 units produced for several missions

**NEW LAGRANGE-2G SDR:** ready Q3 2016
- SW Defined Radio based on FPGA
- In-Flight reconfiguration capability
- GPS L1/L2P(Y)/L2C, GAL E1

**GNSS RADIO OCCULTATION INSTRUMENT**
(ROSA)

- Spaceborne Instrument to sound the Atmosphere
- Real-time NAV and OBS measurements for meteorology and climatology science
- GNSS signals on L1 and L2
- MIL-STD-1553 communication interface
- Up to Two (velocity, anti-velocity) Radio Occultation Antenna with maximum gain at atmosphere layer from 0 to 100 km
- NAVIGATION MODE: real-time navigation
- OBSERVATION MODE: occultation measurements
  - 16 DFC Navigation Mode
  - 8 Navigation DFC + 8 DFC Observation
- OUTPUT:
  - Pseudorange, carrier phase, SNR @ 1-10-50 Hz (Closed Loop)
  - I/Q samples and Doppler Model @ 100 Hz (Open Loop)
  - 3 missions (ISRO / ASI / CONAE)
Combined Ground/Space Iono Monitoring

**GNSS-RO FROM SPACE A HIGH ACCURACY PROFILING TECHNIQUE**

- Long Term Stability
- All-weather operation, Global 3D coverage
- High Vertical Resolution

- Exploit “co-located ground/space” observations
- Relative strengths of different measurements
- Space RO provides good vertical resolution combined with ground based ionospheric tomography
- Physical modeling of neutral atmosphere using ground-based and radio-occultation space data
Earth Observation by GNSS Reflectometry

**EARTH OBSERVATION FROM SPACE FOR AGRICULTURE**

- Measure from satellite bio-geophysical quantities: soil moisture, soil roughness and plant water content
- GNSS Reflectometry based on interferometric measurement of the reflected signal vs. the direct signal
- Allow retrieval of arrival time delay and of properties of the reflecting surface
- GNSS-R implements a bistatic observation at L band
- Low cost, increasing number of GNSS transmitters, many specular points on earth (high coverage), L-band penetrates into vegetation and soil
MicroSatellite R&D for GNSS Remote Sensing

GNSS Remote Sensing Application (internal R&D):

- **GNSS RADIO OCCULTATION**: global meteorological predictions & space weather studies
- **GNSS REFLECTOMETRY**: land, vegetation and ocean studies

MICROSATELLITE BY ADDITIVE MANUFACTURING TECHNOLOGY (1.6m x 1m, 100Kg)
RAIL Safety-Critical GNSS User Terminal

- RAIL User Terminal based on GNSS Rx + IMU
  - Virtual Balise
  - Enhanced Odometry
  - Train Integrity (Train Head-Tail)

- Output Traveled Distance + Speed to Train On-Board Guidance System

- CENELEC Safety-Integrity-Level: SIL-2 (THR < 1e-7 / hr)

- Confidence level with TAS-I “Along-Track Protection Level” algorithm provides error over-bound

- The confidence level is the range around the provided distance (velocity) within which the true distance (velocity) lays with a probability of 5σ

FIELD TESTS ON HIGH-SPEED LINES IN SPAIN (MADRID-BARCELONA)
TAS-I GRAIL USER TERMINAL AND PEGASUS RECEIVER
Thales Alenia Space Research & Technology Activities

GNSS Receivers

<table>
<thead>
<tr>
<th>Needs</th>
<th>Technologies</th>
</tr>
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<tbody>
<tr>
<td><strong>Reference</strong></td>
<td>- Advanced Antennas (simple DBF)</td>
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<tr>
<td><strong>Safety Critical</strong></td>
<td>- RF Direct Sampling &amp; DDC</td>
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<tr>
<td><strong>Space</strong></td>
<td>- GNSS waveforms (SCA-like architectures)</td>
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<tr>
<td></td>
<td>- Algorithms for robust tracking, adaptive filtering, hybridization, confidence bounds</td>
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<td>- GNSS Remote Sensing techniques</td>
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1. Multi-constellation Multi-Frequency scalable architecture
2. Robustness to RF environments
3. Performance
4. Integrity & Continuity
Collaborations

• **TESTS IN NAVIS HUST CENTER (HANOI) IN THE FRAME OF BELS PROGRAM:**
  – TASI will install a GISMO Iono Receiver in Hanoi to perform measurements and analyse performance in presence of scintillation within this region

• **TAS-I READY TO COLLABORATE WITH SOUTH EAST ASIA INSTITUTIONS** in the fields of GNSS Equipment, Technologies and Applications related to:
  – GNSS Ground Infrastructures
  – Ionospheric Monitoring Networks
  – Remote Sensing by use of GNSS signals
  – Rail Safety-Critical Applications

• **TAS-I READY TO HOST RESEARCH STUDENTS FOR STAGE PERIODS IN ITALIAN SITES**
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