DOMAIN OBSERVATION AND NAVIGATION ITALY

Università di Roma La Sapienza, 21 Maggio 2019

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THALES GROUP

Collective intelligence for a safer world

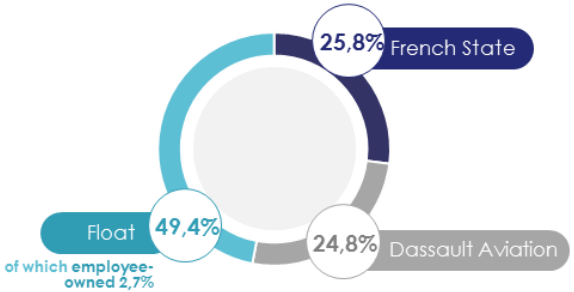
Whenever critical decisions need to be made, Thales has a role to play.
In all its markets (aerospace, space, ground transportation, defence and security) **Thales solutions help customers to make the right decisions at the right time and act accordingly.**

World-class technology, the combined expertise of **64,000 employees** and operations in **56 countries** have made **Thales a key player in keeping the public safe and secure,** guarding vital infrastructure and protecting the national security interests of countries around the globe.

A balanced revenue structure

Revenues in 2016
14.9 billion euros

Shareholders
(at 31 December 2016)



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THALES ALENIA SPACE OPEN

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a Thales / Leonardo company

THALES IN THE WORLD

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Immersive Space

Journey at Thales Alenia Space

A FEW NUMBERS

JOINT VENTURE

THALES (67%)
LEONARDO (33%)

A GLOBAL OFFER FROM EQUIPMENT TO END-TO-END SPACE SYSTEMS

SALES

2.6 BN€ IN 2017

EQUIPMENT PAYLOADS SATELLITES SERVICES SYSTEMS

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A FEW NUMBERS

MORE THAN
8,000 EMPLOYEES

17 SITES
WORLDWIDE

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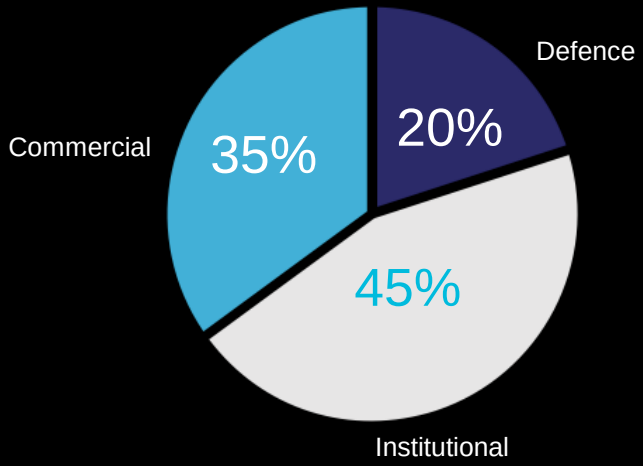
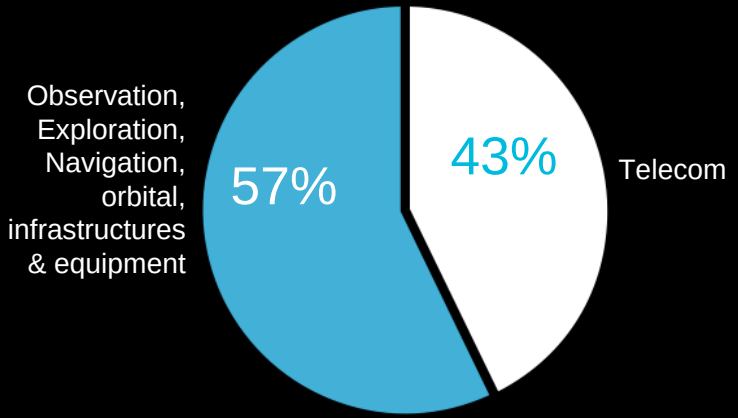
A FEW NUMBERS

BREAKDOWN PER MARKET*



BREAKDOWN PER ACTIVITIES*



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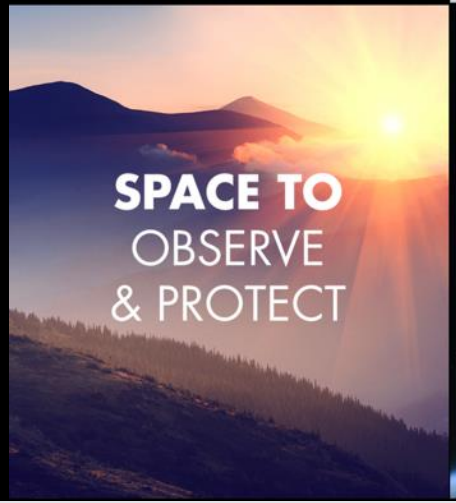
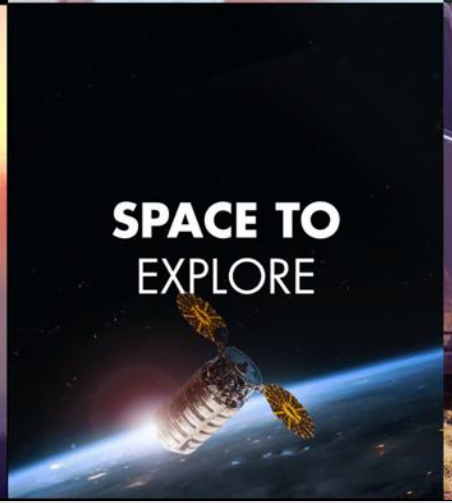
SPACE
FOR
LIFE ///





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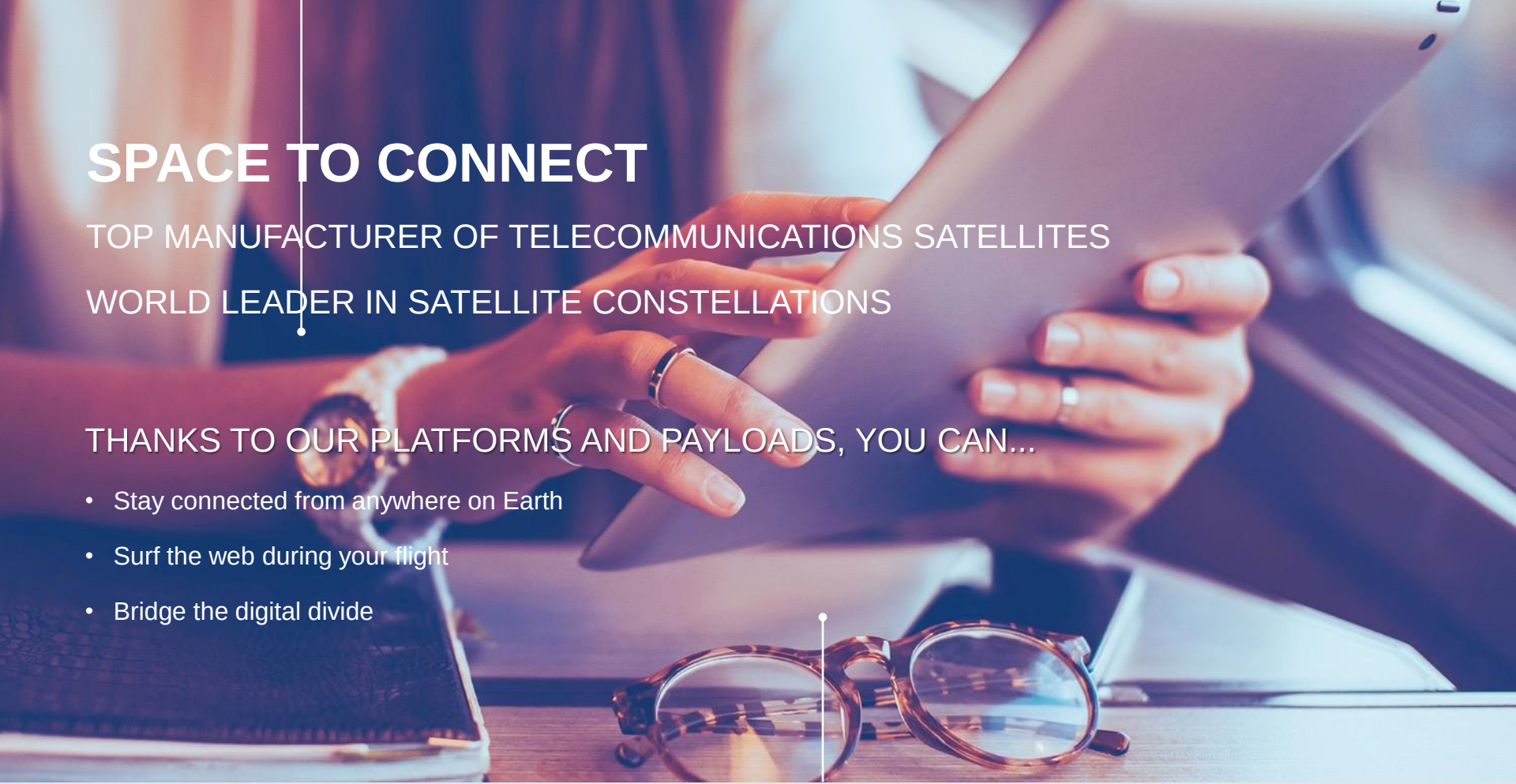

SPACE TO CONNECT

TOP MANUFACTURER OF TELECOMMUNICATIONS SATELLITES

WORLD LEADER IN SATELLITE CONSTELLATIONS

THANKS TO OUR PLATFORMS AND PAYLOADS, YOU CAN...

- Stay connected from anywhere on Earth
- Surf the web during your flight
- Bridge the digital divide

STAY CONNECTED FROM ANYWHERE ON EARTH

Zoom in on some success stories

Iridium® NEXT, the most sophisticated telecommunications system ever! >
We replaced the original Iridium constellation with a new one, satellite by satellite, without interrupting service for 1 million subscribers!

< The high performance O3b constellation
We built a total of 20 satellites for the O3b constellation, with which SES Networks supplies broadband services to its customers.

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STAY CONNECTED DURING YOUR FLIGHT

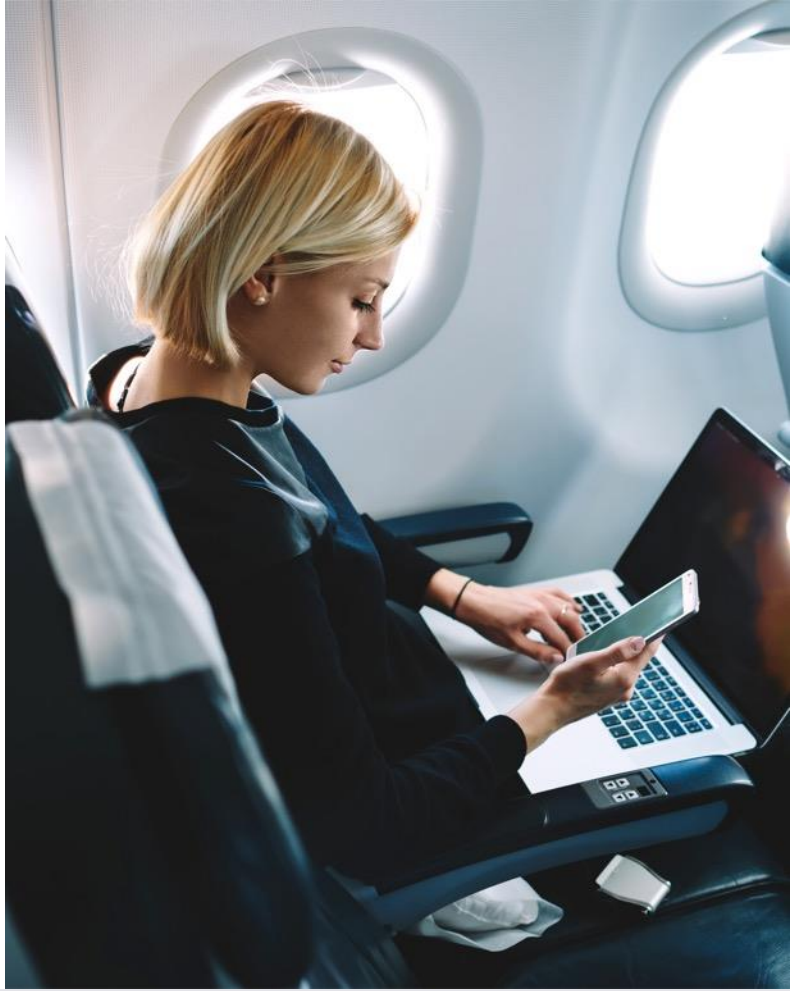
/// Satellites can let airlines offer in-flight voice calls and Wi-Fi to passengers

TODAY

Our Very High Throughput Satellite (VHTS) solutions offer capacity, digital agility, flexibility and competitiveness.

TOMORROW

We will build the Global Xpress (GX) satellite for Immarsat.



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SPACE TO SECURE AND DEFEND

DEFENSE TELECOMMUNICATIONS SATELLITES

VERY HIGH RESOLUTION OPTICAL OR RADAR INSTRUMENTS

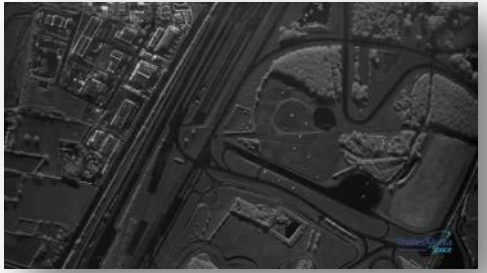
GROUND CONTROL SYSTEMS

TESTING & INTEGRATION CENTERS

SURVEILLANCE AND OBSERVATION FOR FIELD INTELLIGENCE

Zoom in on some success stories

COSMO-SkyMed: global standard in spaceborne radar tech >
By keeping watch day and night, no matter the weather conditions, COSMO-SkyMed helps Italy protect its citizens and ensure public safety.



< GÖKTÜRK-1 satellite: remarkable image quantity & quality
Turkey's Earth Observation satellite has a high-resolution optical sensor and an onboard digital imaging storage system, linked to an integration center in Ankara.

Pleiades, Helios & CSO: 30 years of keeping the watch
We are the exclusive supplier of all Very High Resolution optical instruments for these French intelligence satellites.

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SECURED COMMUNICATIONS FOR ARMED FORCES

Zoom in on some success stories

Supporting Syracuse with the French Ministry of Defense for more than 12 years >
French forces stationed in France or deployed overseas to HAVE access best-in-class military satellite telecommunications services.

Sicral 2 one example of a successfull French/Italian collaboration on space programs
< We also built Athena-Fidus, the French-Italian dual broadband satellite.

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SPACE TO OBSERVE & PROTECT

A COMPREHENSIVE LINE OF EARTH OBSERVATION SATELLITE SOLUTIONS, INCLUDING RADAR AND HIGH/VERY-HIGH RESOLUTION OPTICAL PAYLOADS

THIS ALLOWS EXPERTS TO...

- STUDY EARTH'S OCEANS & SURFACE WATER
- STUDY EARTH'S CONTINENTS & ISLANDS
- FORECAST THE WEATHER
- UNDERSTAND CLIMATE CHANGE

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EARTH'S OCEANS & SURFACE WATER

Zoom in on some success stories

SWOT, the oceanographic satellite from the French (CNES) and American (NASA) space agencies >

SWOT will collect detailed measurements on Earth's lakes, rivers, reservoirs and oceans, to improve ocean circulation models, enhance weather and climate predictions, and aid in freshwater management.

< Jason-2 and -3 and Sentinel-1 and -3

These satellites, all built by Thales Alenia Space, kept a friendly eye on the skippers of the 2016-2017 Vendée Globe.

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Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-005

EARTH'S CONTINENTS & ISLANDS

Zoom in on some success stories

We are developing the antenna feed array on the European Space Agency's Biomass spacecraft >
Its missions: quantify and generate maps of biomass in the world's forests and measure annual changes, in order to understand the role forests play in the carbon cycle.

< We are prime contractor for COSMO-SkyMed
This constellation is providing data that will enable experts to monitor deforestation in the Brazilian Amazon. Its radar sensors operate in all weather conditions, making it the ideal solution for the cloudy, rainy Amazon territory.

Date : 21/05/2019
Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-005

FORECASTING THE WEATHER

/// Will you need sun cream or an umbrella? We help provide the answer in Europe

TODAY

Thales Alenia Space has built all Meteosat European weather satellites since 1977. We are the world leader in geostationary meteorology.

TOMORROW

European meteorology is becoming more accurate: from 30 minutes between images in the 1980s to 15 minutes today, and in the near future, an image every 10 minutes with MTG.

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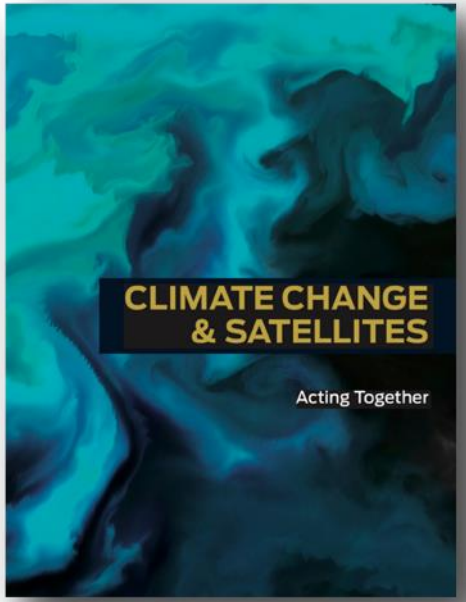
Ref Modele : 83230347-DOC-TAS-FR-005

UNDERSTANDING CLIMATE CHANGE

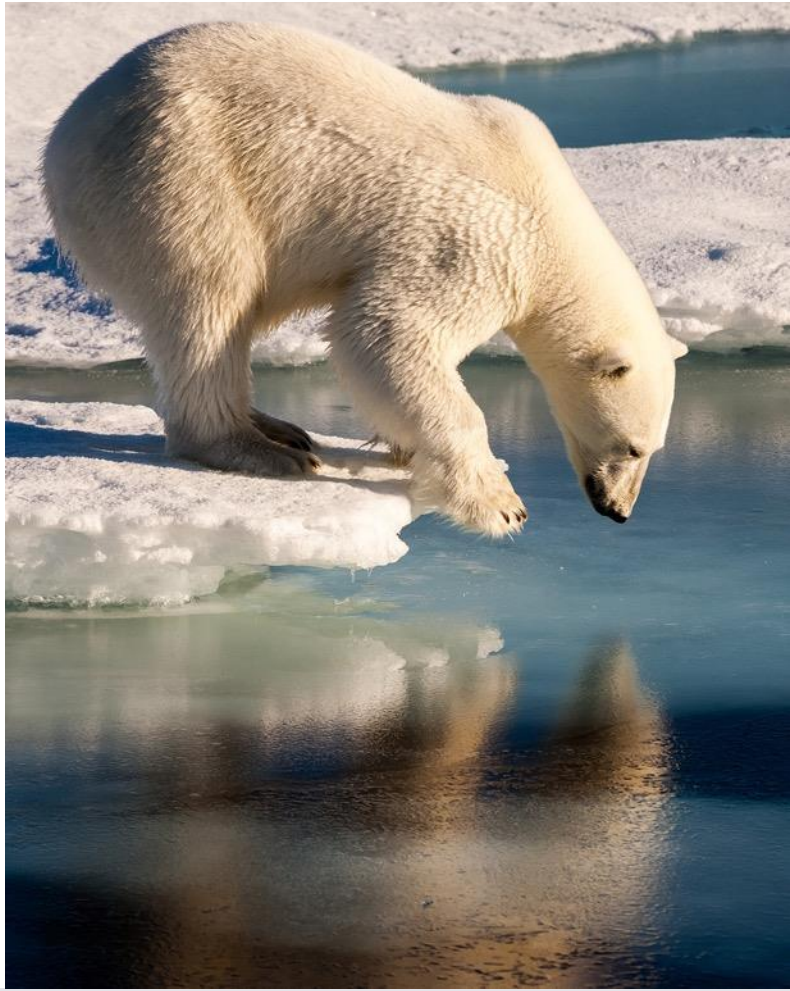
Zoom in on a success story



Satellites for a better understanding of Climate Change

Thales Alenia Space is prime contractor for the Sentinel-1 and -3 families (4 satellites each); in charge of the image ground segment for Sentinel-2; and constructor of the imaging spectrometer carried by Sentinel-5P as well as the Poseidon-4 radar altimeter for the Jason-CS/Sentinel-6 mission.

< Read Climate Change & Satellites: Acting Together a book published by Sud[s] Concepts for Thales Alenia Space



Date : 21/05/2019
Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-005

SPACE TO TRAVEL & NAVIGATE

A PIONEER IN EUROPEAN SATELLITE NAVIGATION, WE STILL LEAD THE WAY WITH OUR INNOVATIVE SOLUTIONS FOR RELIABLE LOCALIZATION AND ENHANCED SAFETY

IN EUROPE AND ASIA TODAY, WE ARE...

- Enabling location & map services
- Ensuring the safety of travelers
- Providing accuracy & reliability
- Enabling the Internet of Things

Date : 21/05/2019
Ref : xxxxx
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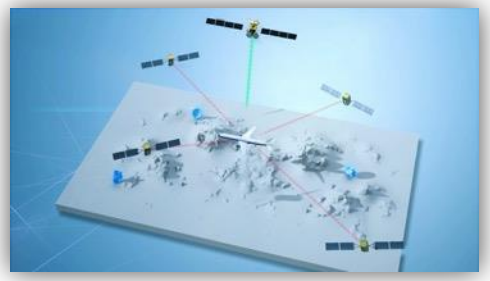
ENSURING THE SAFETY OF TRAVELERS

Zoom in on some success stories

EGNOS: helping manage the growth of global air traffic >
EGNOS Safety of Life services make aircraft landings safer and faster, helps improve the overall safety of air travel and contributes to reducing delays, diversions and flight cancellations



< COSPAS-SARSAT: search & rescue missions from space
We provided our breakthrough MEOLUT NEXT technology to this satellite-aided, intergovernmental search & rescue initiative.

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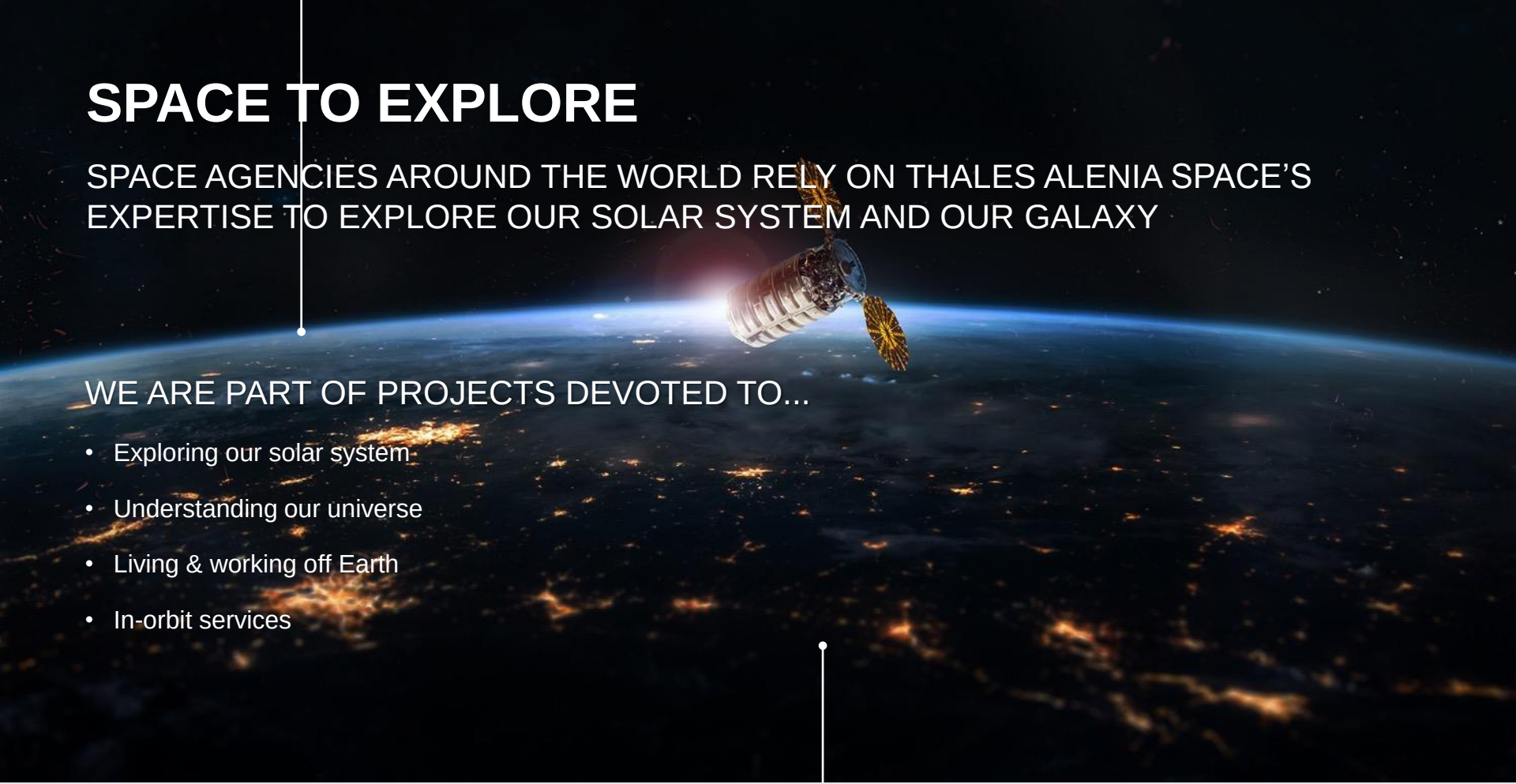
SPACE TO EXPLORE

SPACE AGENCIES AROUND THE WORLD RELY ON THALES ALENIA SPACE'S EXPERTISE TO EXPLORE OUR SOLAR SYSTEM AND OUR GALAXY



WE ARE PART OF PROJECTS DEVOTED TO...

- Exploring our solar system
- Understanding our universe
- Living & working off Earth
- In-orbit services

Date : 21/05/2019
Ref : xxxxx
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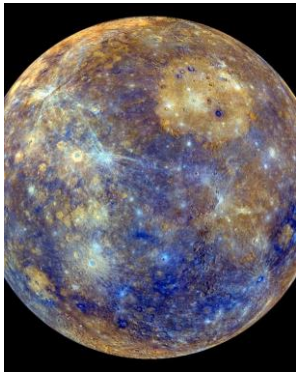
SOLAR SYSTEM EXPLORATION

/// After 20 years, the amazing adventure of Cassini-Huygens is now finished

CASSINI–HUYGENS WAS ONE OF THE MOST COMPLEX AND SUCCESSFUL MISSIONS IN THE HISTORY OF SPACE EXPLORATION. ITS MAIN ANTENNA, WHICH WE DESIGNED AND BUILT, TRANSMITTED DATA AND IMAGES UNTIL THE VERY END.

/// Launched in October 2018, BepiColombo is now on its seven-year journey to Mercury



BEPICOLOMBO IS EXPECTED TO PROVIDE SCIENTISTS WITH DATA AND OBSERVATIONS ABOUT IN ABOUT 2025, ADDING TO THE KNOWLEDGE WE HAVE FROM NASA'S MARINER 10 (1970S) AND MESSENGER (2010-2015) MISSIONS.

Date : 21/05/2019
Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-005

MARS

/// Is there life on Mars? This existential question about our neighbor may soon be answered

TASI CONTRIBUTION TO THE ANSWER HAS STARTED SINCE 90' WITH SOUNDER INSTRUMENTS (MARSIS AND SHARAD) DEPLOYED TO SEARCH FOR GROUND ICE OR WATER AND SUBSURFACE STRUCTURES. THE EXPLORATION OF MARS WILL CONTINUE WITH WITH EXOMARS 2020.

THE TRACE GAS ORBITER OF EXOMARS 2016 IS NOW "SNIFFING" THE MARTIAN ATMOSPHERE FOR EVIDENCE OF RECENT BIOLOGICAL ACTIVITY ON THE PLANET BELOW.

ExoMars 2020 will dig a record-breaking 2 meters below the surface of Mars and then analyze the soil samples in its own ultra-sophisticated mini-lab.

Date : 21/05/2019
Ref : xxxxx
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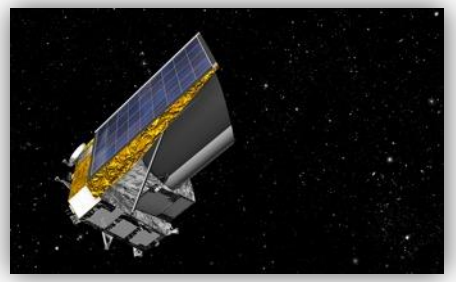
UNDERSTANDING OUR UNIVERSE

WHAT ARE THE ORIGINS OF OUR UNIVERSE?

We built 25 of the ALMA radio telescope's 64 huge parabolic antennas.



WHAT IS DARK MATTER?

We are prime contractor for Euclid's satellite, which will add to our understanding of dark matter & dark energy.

WHERE DO COMETS COME FROM?

We were a leading partner in Rosetta-Philae, the first mission to rendezvous with a comet.

HOW WAS OUR UNIVERSE FORMED?

We were prime contractor for both the Herschel and the Planck space observatories.

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Ref : xxxxx
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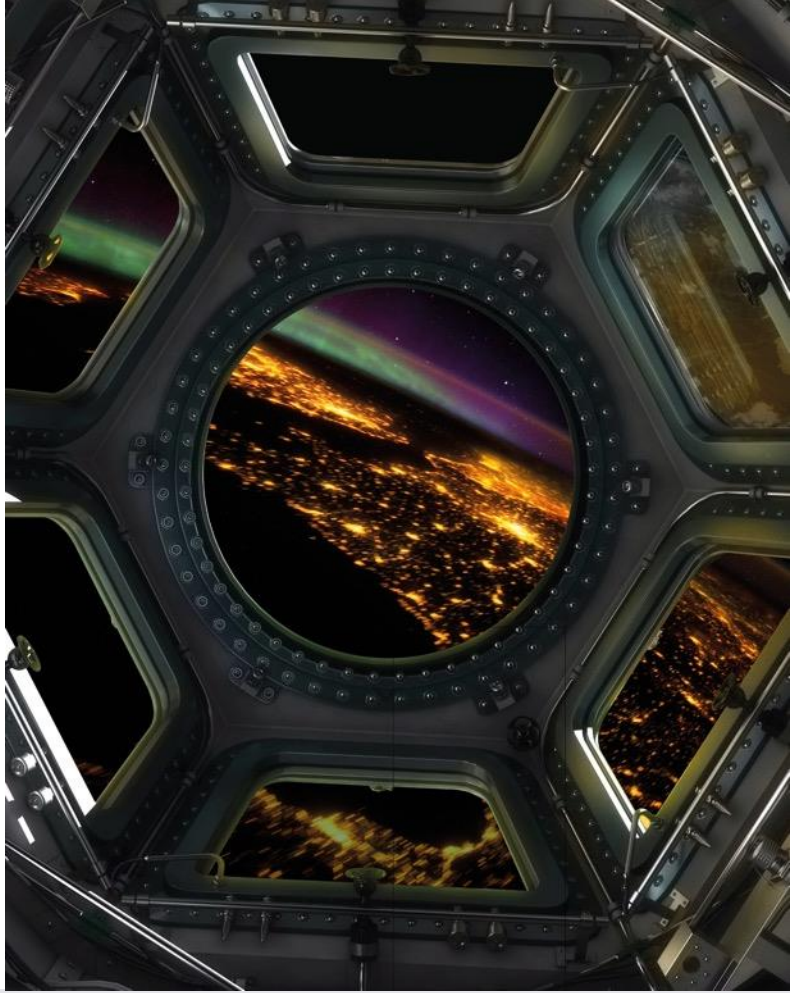
ZOOM IN ON A SUCCESS STORIES

Zoom in on some success stories

ALTEC >
The Thales Alenia Space/Italian Space Agency center of excellence, provides engineering and logistics services to the ISS!

< Rover Operations Control Center (ROCC)
A drilling test facility and a platform for simulating Martian gravity; ROCC will also receive and analyze data received from ExoMars via the ESA's Mission Operations Centre.



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A SPACE STATION IN LUNAR ORBIT

/// The Lunar Orbital Platform-Gateway will orbit the moon as a comms hub, science lab, short-stay habitat & equipment storage zone

TODAY

LOP-G will be a test-base for the environmental systems that will be needed to keep astronauts alive on long voyages to deep space.

TOMORROW

It could also be a launch point for future missions to the moon, to Mars or to rendezvous with asteroids.

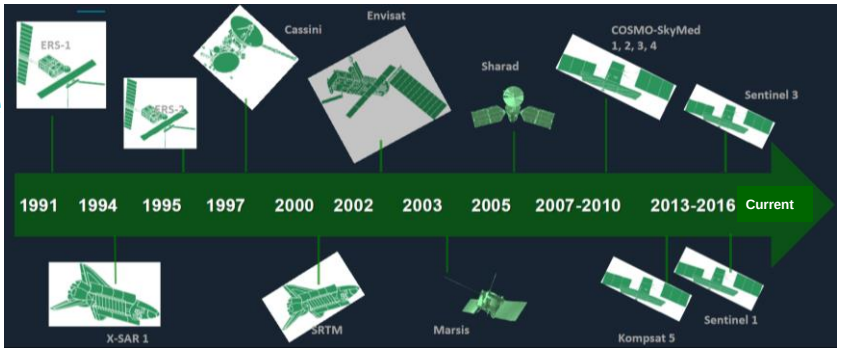
Date : 21/05/2019
Ref : xxxxx
Ref Modele : 83230347-DOC-TAS-FR-005

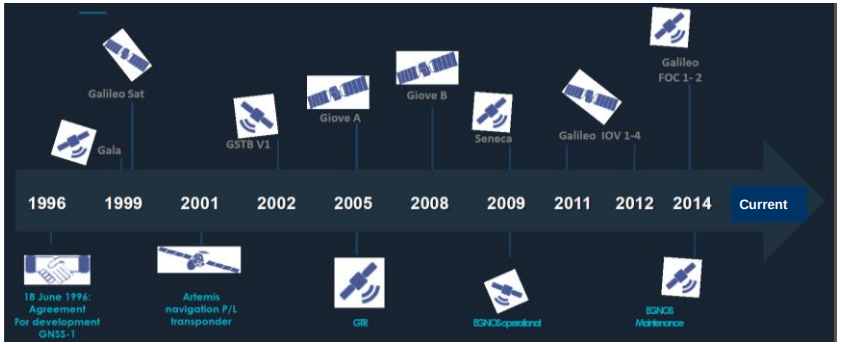
State of the art Labs

DONI HERITAGE

The Domain Observation and Navigation Italy (DONI) heritage cover more than 25 years of success.

This experience is the recognized passport for future products to satisfy the growing market needs.





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THALES ALENIA ITALIA SPACE ORGANIZATION

Date :
Ref :
Ref Modele : 83230347-DOC-TAS-FR-005

DONI ENGINEERING ORGANIZATION

OBSERVATION SYSTEM

NAVIGATION SYSTEM

INTEGRATED SYSTEM SOLUTION

OBSERVATION PAYLOAD

GNSS PAYLOAD

SPACE SEGMENT

CYBER SECURITY ENGINEERING

GROUND SEGMENT

INNOVATIVE SOLUTION, LABS & DIGITAL TRASFORMATION

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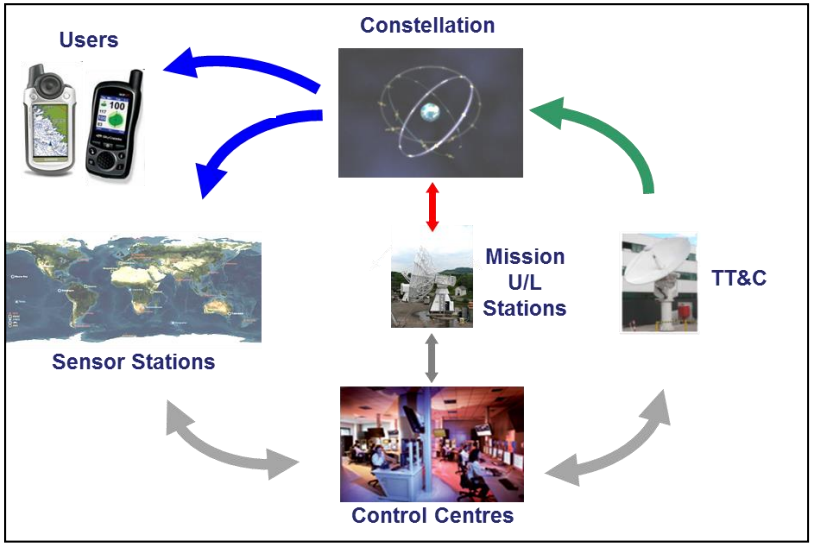
END TO END SYSTEM ACTIVITIES



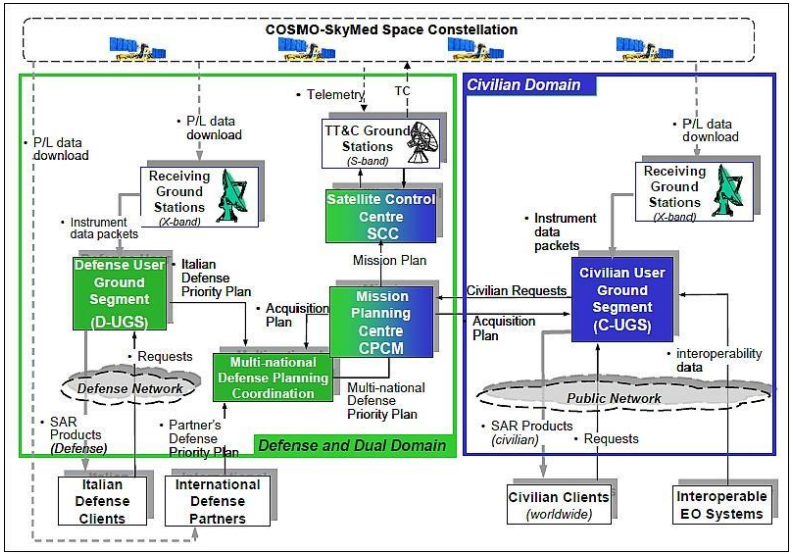


Image credit: ASI

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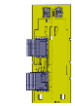
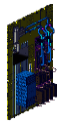
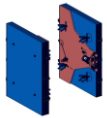
SATELLITE ACTIVITIES



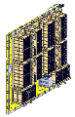
SAR panel



PDHT panel

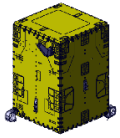


Solar panels



Battery panel

Assy

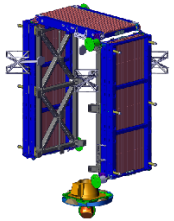


Payload Module

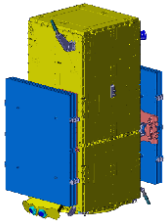
Propulsion module

Service Module

Platform modules



Payloads



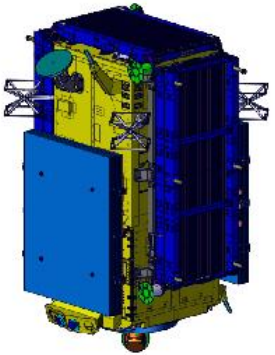
Platform

Elements

OBSERVATION SYSTEM | NAVIGATION SYSTEM | INTEGRATED SYSTEM SOLUTION

OBSERVATION PAYLOAD | GNSS PAYLOAD | SPACE SEGMENT

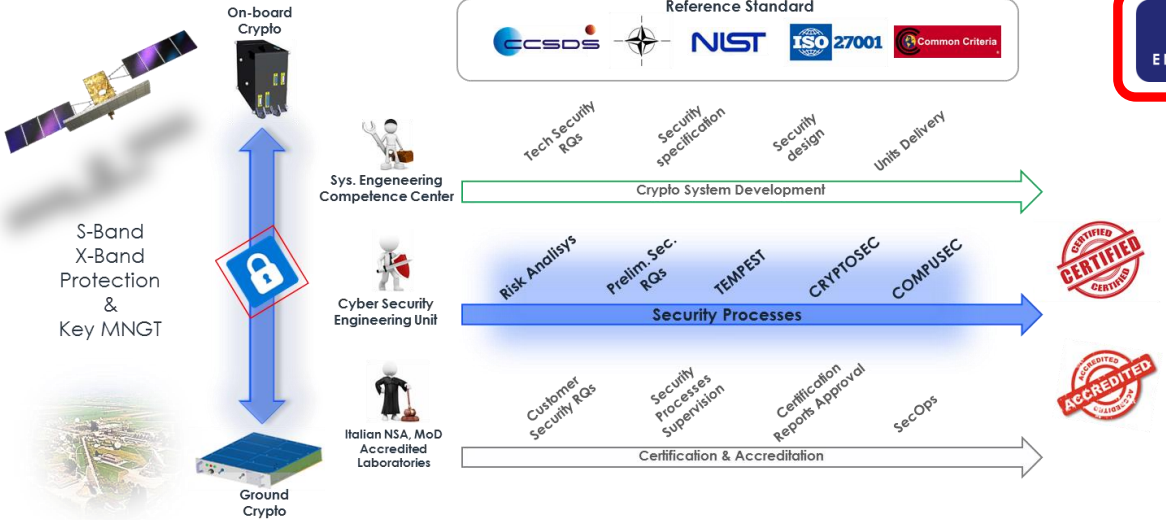
CYBER SECURITY ENGINEERING | GROUND SEGMENT | INNOVATIVE SOLUTION, LABS & DIGITAL TRASFORMATION

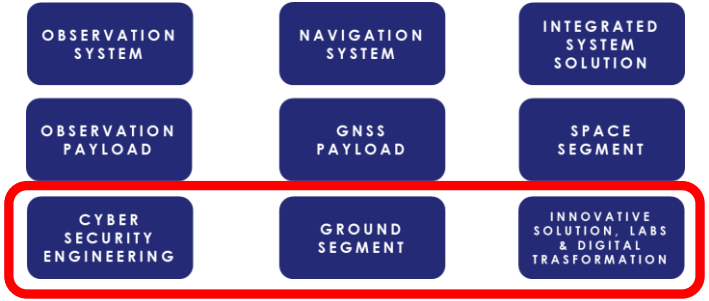


Satellite

Thales Alenia Space Integration Site Rome

TRASVERSAL ACTIVITIES





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Understanding Customer Need And System Requirement definition

Customer Need

System Requirement

Overall cycle of engineering activities at glance

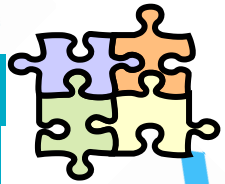
Customer Need

System Acceptance

System Requirement

System Qualification

System Design Verification Plan

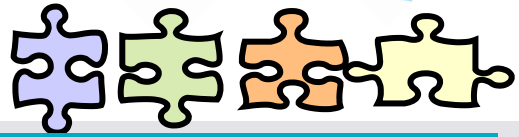


System Verification

Subsystem Procurement

Integration Plan

System Integration



Sub-System Qualified

HOW CAN WE GET IN TOUCH?

TAS actively participate to public events, such as Job search meeting or Sector Conferences

TAS has strong and dated collaborations with the best Universities

TAS promotes collaborations like

Thesis – Stages – PhDs

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SKILL

- Cyber Security, Artificial Intelligence, Neural Networks, Cloud, Big Data, Automation and Virtual Reality
- Signal theory and processing, electrical communication, probability and stochastic processes, remote sensing (radars, microwave payloads)
- Skill Digital design (VHDL, logical state machine), electronic equipment (RF units), antennas
- Orbital Design/Mission Analysis, SAR principles, Instrument calibration concepts, Concurrent Engineering concepts
- Navigation System, Signal Propagation, Digital Signal Processing

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Ref :
Ref Modele : 83230347-DOC-TAS-FR-005

DONI ENGINEERING POINT OF CONTACT

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Ground Segment	Mario Profili	Mario.profili@thalesaleniaspace.com	0641512306
Integrated solution	Roberto Winkler	Roberto.winkler@thalesaleniaspace.com	0641512557
Innovative solution, Digital trasformation and Laboratories	Quirino Morante	Quirino.morante@thalesaleniaspace.com	0641512439
Cyber Security Engineering	Daniele Frasca	Daniele.frasca@thalesaleniaspace.com	0641514438
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ANNEX

DETAILED ACTIVITIES PERFORMED AT DONI ENGINERING DEPARTMENT OF THALES ALENIA SPACE ITALIA

Observation System

Observation Payload

Navigation System

GNSS Payload

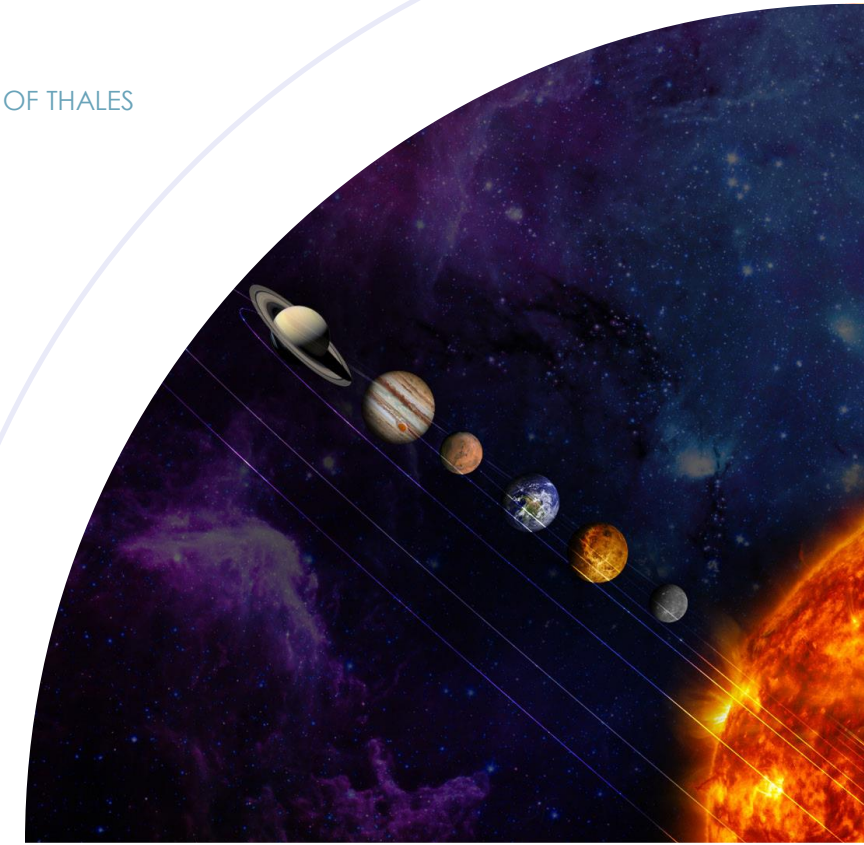
Space Segment

Ground Segment

Integrated solution

Innovative solution, Digital trasformation and LabS

Cyber Security Engineer



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OBSERVATION SYSTEMS 1/4

The mission

- Observation Systems is organized in two main units:
  - ✓ E2E System Design & Verification
  - ✓ Space Segment Operations
- The mission is:
  - ✓ Management of the whole Engineering Lifecycle from concept design and proposal to execution, including pre-launch, LEOP, commissioning , operative and disposal phases.
  - ✓ Technical interface with the Customer for Observation Program, Project technical management
  - ✓ Management and definition of Mission & System Requirement for Observation System
  - ✓ Apportionment of the System Requirements into Segments Requirements
  - ✓ System performance budget & Mission analysis
  - ✓ Definition of system V&V Plan (pre-launch, LEOP, Commissioning, Operative and disposal phase)
  - ✓ System and Space responsibility for the operative programs maintenance (including image quality, system performances, satellite telemetry analysis and trend both in nominal and in contingency conditions). "On-call" service to guarantee continuous satellites operation.
  - ✓ Operation Requirements Handbook and Flight Operations Procedure/Manual, definition and implementation of satellite database (TM/TC and SDB).
  - ✓ Mission Simulator, SAR programming tool, image quality processor, Kernel Prototype for mission planning, image processing and post-processing
  - ✓ Calibration and Validation facility (CAL/VAL) definition and development

OBSERVATION SYSTEMS 2/4

Main project/activities on-going

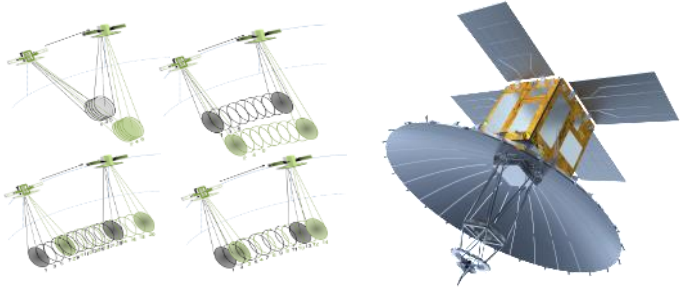
- COSMO-SkyMed First and Second Generation (ASI & MoD)
- Poland Defense Utilization Ground segment
- PLATINO (ASI)
- Sentinel-1 (ESA)
- Radarsat (CSA)
- ROSE-L (ESA)
- Sentinel-1 NG (ESA)

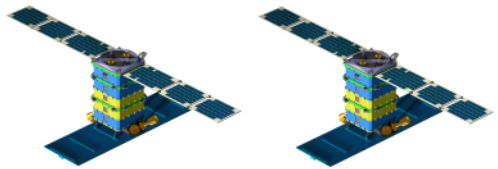
OBSERVATION SYSTEMS 3/4

Future projects/activities

- Design and development of:
  - ✓ New SAR acquisition Techniques
  - ✓ Models and tool for Constellation orbit optimization
  - ✓ Tools for system design and validation, dedicated to particular topics (e.g. maritime surveillance, infrastructure monitoring)
  - ✓ Advanced Processing concept (e.g. squinted, bi-statics)
  - ✓ E2E aspect relative to Geo-SAR, Distributed SAR Systems
  - ✓ Planning logics
  - ✓ Mathematical models for performances E2E prediction
  - ✓ Telemetries analysis for failure precursor detection

  …. and many others





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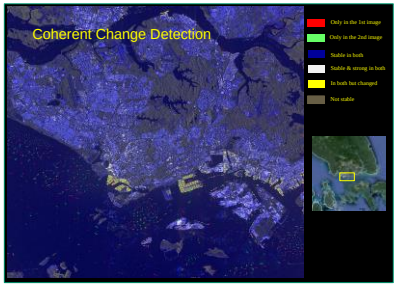
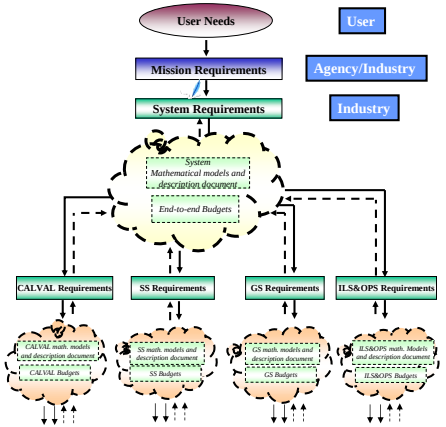
OBSERVATION SYSTEMS 4/4

Potential area of collaboration with University

- Main topics of collaboration with University include:
  - ✓Mathematical models
  - ✓Algo for telemetries analysis
  - ✓SAR and constellation Simulation
  - ✓Processing
  - ✓Post processing
  - ✓Calibration algorithms for new geometries





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OBSERVATION PAYLOAD1/4

The mission

- Observation P/L engineering activities and relevant projects technical direction:
  - ✓ Manage and Define Payloads Requirements for Observation Systems
  - ✓ Define Payload System Architectures
  - ✓ Define the apportionment of Payload System Requirements into Subsystems Requirements
  - ✓ Define and Maintain Observation Payload System Budgets and Performance
  - ✓ Define and Maintain Observation Payload System Verification & Validation Plans
  - ✓ Study new Observation Payload system concepts and techniques
- Observation P/L area includes :
  - ✓ Synthetic Aperture Radars (SAR), Doppler Radars, Sounders
  - ✓ Radiometers, AIS, and other microwave Sensors
  - ✓ P/L Data Handling and Transmission Systems (PDHT)
  - ✓ Satellite communication systems (TT&C)

OBSERVATION PAYLOAD 2/4

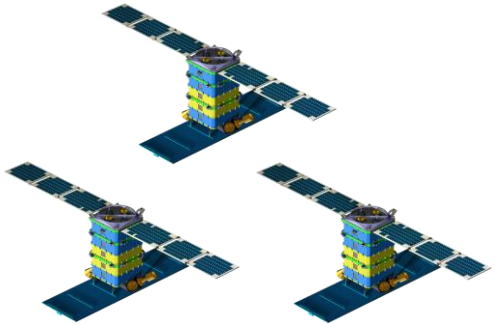
Main project/activities on-going

- COSMO-SkyMed Second Generation (ASI & MoD)
  - ✓ SAR, PDHT, TT&C
- PLATINO (ASI)
  - ✓ P/L Data Handling & Communication System
- PRISMA (ASI)
  - ✓ PDHT, TT&C
- Sentinel-1 (ESA)
  - ✓ SAR, PDHT, AIS, TT&C
- Sentinel-3 (ESA)
  - ✓ PDHT, TT&C
- Meteosat Third Generation (ESA)
  - ✓ Search & Rescue P/L
- Exomars (ESA)
  - ✓ Doppler Radar
- JUICE-RIME (ESA)
  - ✓ Sounder
- CIMR (ESA)
  - ✓ Radiometer
- ROSE-L (ESA)
  - ✓ SAR
- SARAh (German MoD)
  - ✓ SAR Electronics, P/L Data Handling Unit

OBSERVATION PAYLOAD 3/4

Future projects/activities

- Design and development of:
  - ✓ Ultra-high Resolution SAR Systems
  - ✓ High Resolution Wide Swath SAR Systems
  - ✓ High Rate Data Handling Down-link Systems
  - ✓ SAR and Microwave Observation Payloads for Mini and Micro-Satellites
  - ✓ Distributed SAR Systems
  - ✓ Distributed Passive Microwave Observation Systems
  - ✓ Geo-SAR Systems
  - ✓ Photonic Based Radars
  - …. and many others



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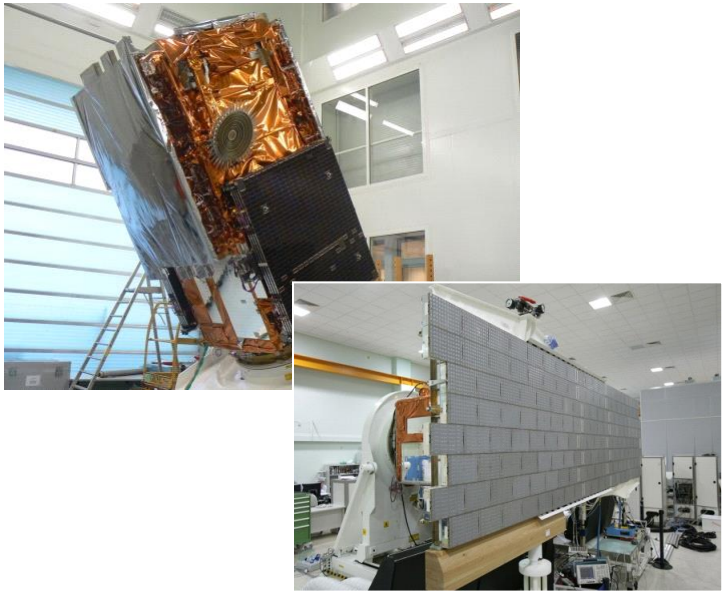
OBSERVATION PAYLOAD 4/4

Potential area of collaboration with University

- Main topics of collaboration with University include:
  - ✓ Radar techniques & technologies
  - ✓ Microwave technologies for observation
  - ✓ Digital communications
  - ✓ Models, analysis and simulation
  - ✓ Radar signal processing
  - ✓ Communication signal processing
  - ✓ Antennae and micro-wave devices design
  - ✓ RF and digital system design
  - ✓ Photonics system design



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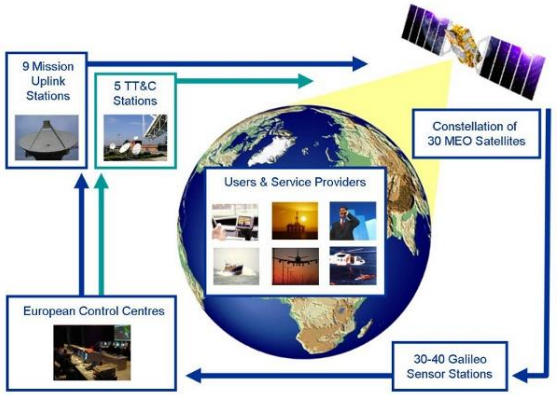
NAVIGATION SYSTEM 1/4

The mission

- Navigation System engineering activities and relevant projects technical direction:
  - ✓ System and Service Requirement engineering and Validation:
    - ✓ Define Mission & System Requirement for Navigation System
    - ✓ Apportionment of the System Requirements into Subsystems Requiremen
    - ✓ Define the System Requirements verification matrices
  - ✓ Define the Navigation System Architecture and the Subsystem breakdown
  - ✓ Define the Navigation System budget
  - ✓ Define the Integration, Verification & Validation Plan
  - ✓ Execute the System Integration and Verification Test Campaign (Test Procedures, test execution and reporting)
  - ✓ Technical coordination of Navigation System evolution toward Space and Ground Engineering activities



https://ec.europa.eu/growth/sectors/space/galileo/history_en

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NAVIGATION SYSTEM 2/4

Main project/activities on-going

- Galileo WO1 (ESA):
  - ✓ Definition of the Galileo FOC2 System Technical Requirement Baseline (capabilities operation from 2020 onwards)
  - ✓ Definition of corresponding system architecture upgrades and architecture evolution
  - ✓ Definition of corresponding Integration, Verification & Validation Plan
  - ✓ Acceptance of Segments and corresponding integration into System (Verification at Interface level)
  - ✓ System Functional test (including System Compatibility Test Campaigns (SCTC)) and corresponding qualification of the Galileo FOC2 configuration
  - ✓ Support to In orbit test campaign (IOT) for navigation P/L check after launch
- Galileo WO2 (GSA)
  - ✓ Definition of the Galileo Service Requirements
  - ✓ Definition and execution of the service validation campaign
- Galileo 2nd Generation (ESA)
  - ✓ Definition of the evolution of the Galileo System in terms of System Technical Requirement evolution and corresponding architecture of 2nd generation System

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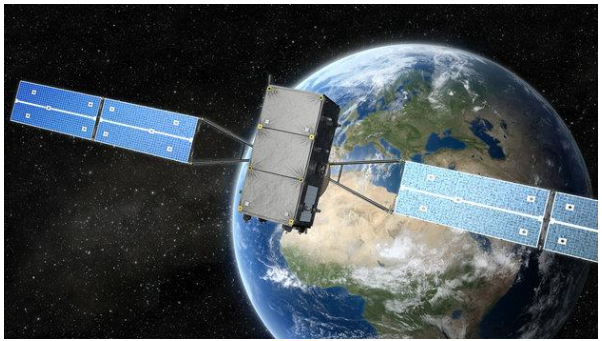
Ref :
Ref Modele : 83230347-DOC-TAS-FR-005

NAVIGATION SYSTEM 3/4

Future projects/activities

- Follow up of:
  - ✓ System Engineering Support to Galileo First Generation Systems
  - ✓ System Engineering Support to Galileo Second Generation Systems
  - ✓ Service Enginereing Support to Galileo Service Provision
  - …. and many others



https://www.esa.int/Our_Activities/Navigation/Galileo/Next_steps

NAVIGATION SYSTEM 4/4

Potential area of collaboration with University

- Main topics of collaboration with University include:
  - ✓ High Accuracy Service Demonstrator
  - ✓ PPP algorithm definition
  - ✓ New Integrity Concept Definition
  - ✓ New strategy of dissemination for navigation messages
  - ✓ Definition and implementation of a System simulator in support of the engineering activities for Galileo Evolution

GNSS PAYLOADS 1/4

The mission

- **GNSS P/L's engineering activities:**
  - **Full system engineering flow**
    - Definition of Payloads Requirements, Architecture, Payload Budget, Payload System performance
    - Definition and maintenance of Navigation Payload System Verification & Validation Plans (including Test Bed design and development)
  - **Innovation**:
    - Study new Navigation Payload system concepts
    - Propose to customers innovative Navigation Payloads designs including the technical state-of-the-art (Software Defined Payloads, Digital Payloads)
- **Reference User Receiver and Space Services engineering activities:**
  - **Definition of Galileo TUR architecture, requirements and performances. Definition of test bed architecture**
  - **Study of GALILEO 2nd Generation signal and navigation message definition (in support to ESA)**
  - **Definition of GALILEO 2nd Generation Space Services requirements and performances**
  - **Support to spaceborn receivers architecture, requirements and performances**
  - **GALILEO 2nd Generation GNSS-based Orbit Determination performances and analysis**
  - **GNSS TUR area includes :**
    - Advanced GNSS signal processing and PVT techniques
    - HW/SW receiver breadboarding
    - Receiver testing campaigns
    - Space Service performances simulation
- **E2E Technical solution for the generation of Timing Reference systems (ground and space solutions)**

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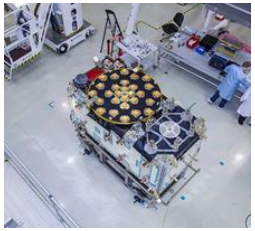
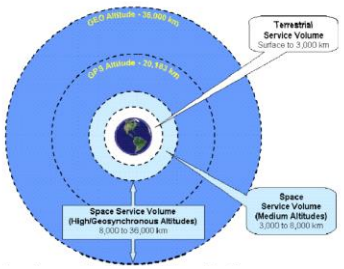
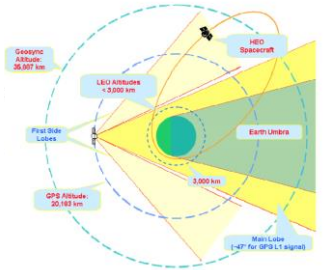
GNSS PAYLOAD 2/4

Main project/activities on-going



- **GNSS payload:**
  - Galileo System design and system verification;
  - Galileo Second Generation Space Segment Study and ISL pre-development
  - Main ESA support to Galileo FOC Payload IOT
  - Galileo Evolution main predevelopment Studies:
    - L-NSGU - Direct L band Navigation Signal Generation Unit
    - Antenna High EIRP
    - NAVANT - Multifunctional Navigation and SAR antenna
- **Reference User Receiver and Space Services engineering activities**
  - GALILEO 2nd Generation (ESA)
    - Open Service Bread-Board Emulating Platforms
    - TUR study, System studies and Space Segment studies
  - GENESIS (EC)
    - Space Services definition at mission level



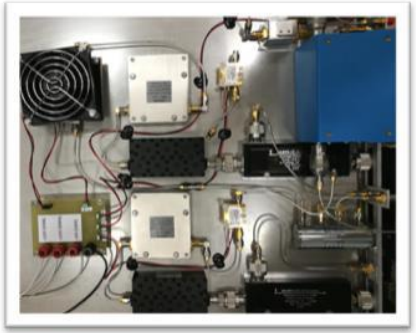


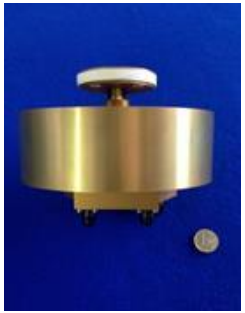
- **Timing:**
  - Galileo PTF (Precise Timing Facility)
  - Galileo CMCU (Clock Monitoring and Control Unit)
  - Galileo 2nd generation Timing Concept

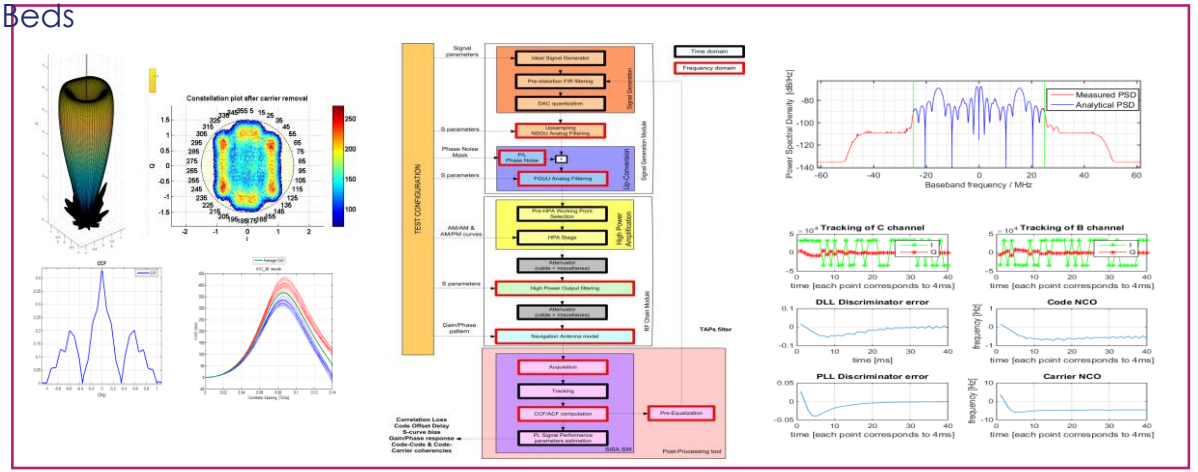
GNSS PAYLOADS 3/4

Future projects/activities

- Several Internal funded R&D projects devoted to:
  - ✓ Evolution of NSGU (LNSGU) and related test bed
  - ✓ SISA SW and GNSS PL SW simulator
  - ✓ Payload Self compensation
  - ✓ NavAnt 2G study
  - ✓ Navigation Payload Test Beds
  - ✓ CMCU evolution
  - ✓ etc







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GNSS PAYLOAD 4/4

Potential areas of collaboration with University

- Main topics of collaboration with University include:
  - ✓ Design and definition Signal, Timing and User positioning algos
  - ✓ E2E Signal, Timing and user positioning algos modelling, analysis, simulation and verification
  - ✓ Enabling Technologies (FPGA, DSP, multi core DSP, fully digital etc))
  - ✓ PLs design (signal generation, UP/Down Converter, RF Power, RF filters, antenna)
  - ✓ Timing facilities
  - ✓ Digital Signal Processing
  - ✓ E2E Test Bed, emulators, Lab and R&D activities
  - ✓ Software Defined Radio Payloads/Equipment

SPACE SEGMENT 1/3

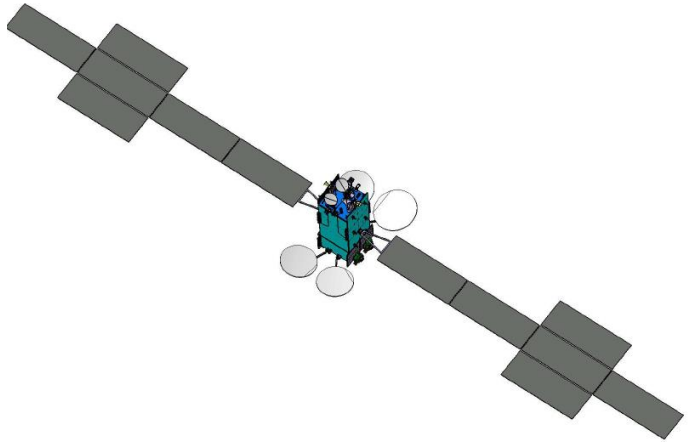
The mission

- Satellite & Integration Validation and Verification engineering activities and relevant projects technical direction:
  - ✓ Definition of Space Segment Architecture for LEO, MEO, GEO and HEO Mission (Satellite, Launch and SC Mission) for all of the Project phases: from Mission Analysis (phase 0) to Disposal (phase F)
  - ✓ Satellite System Engineering and IVVQ contribute and support the Satellites Products in the whole Engineering Lifecycle from proposal to design, execution, validation and qualification phase to ensure they are delivered in time, compliant with the requirements and in line with Domain Business Plan.
  - ✓ To lead satellite projects execution in support to program management, with the contribution of the engineering units within the Domain (i.e. System Engineering, Satellite System Engineering and Payload Engineering) and the Competence Centers
  - ✓ Definition/Apportionment of the Space Segment Requirements into Launch, Satellite, Platform and Payload Requirement
  - ✓ Responsible for all the Satellite performance budgets, analysis and trade-off

SPACE SEGMENT 2/3

The mission

- Space Segment engineering activities and relevant projects technical direction:
  - ✓ Definition and Responsibility of Space Segment IVVQ Plan and Satellite Verification Test Requirements
  - ✓ Spacecraft Electrical EMC/ESD/RFC
  - ✓ Mechanical & Thermal Design Requirements
  - ✓ ICD/IRDs requirements
  - ✓ Command & Control Specification
  - ✓ Finite Element Model Requirements for Structural Analysis
  - ✓ Thermal Model Requirements
  - ✓ System FDIR Requirements Specification
  - ✓ S/C to GSE interface Specification



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SPACE SEGMENT 3/4

Main project/activities on-going

- COSMO-SkyMed Second Generation (ASI & MoD)
- PLATINO (ASI)
- PRISMA (ASI)
- Sentinel-1 (ESA)
- Sentinel-3 (ESA)
- IGSC-Ital GovSatCom
- CIMR (ESA)
- ROSE-L (ESA)
- K425 (KOREA)
- SICRAL 3

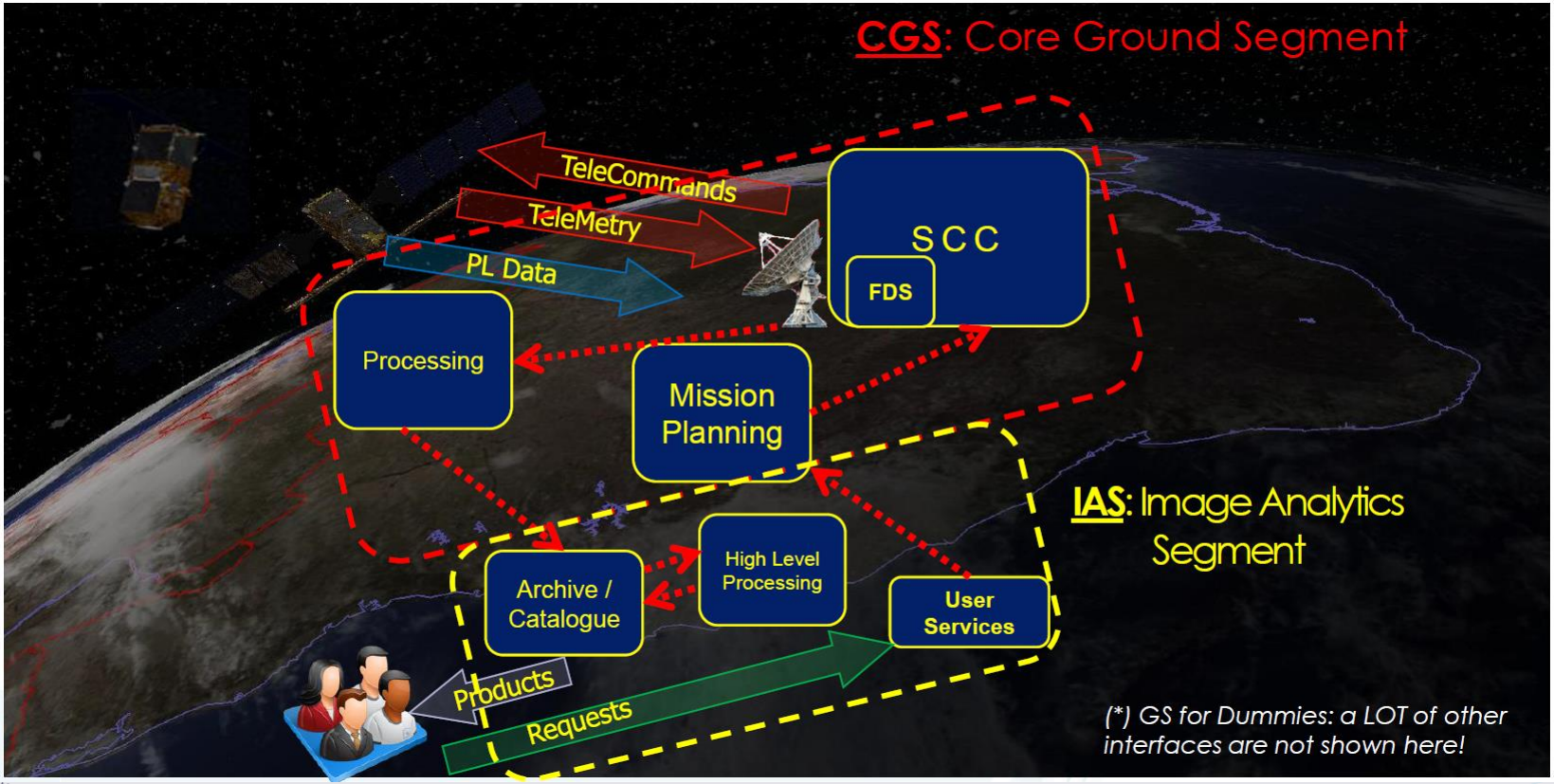
GROUND SEGMENT 1/5

The Mission

- Ground Segment area includes:
  - ✓ Core Ground Segment for Radar systems: Mission-specific ground segment core, fully satellite dependent
  - ✓ Image Analytics Segment: multi-mission core functions, that can be communalized among different systems
  - ✓ Marketplace, Data Analytics, Added-value Applications
  - ✓ Operation environment and Logistic Support Environment
- Ground Segment engineering activities and relevant projects technical direction:
  - ✓ Manage and Define Ground Segment Requirements for Observation Systems
  - ✓ Define Ground Segment Architectures
  - ✓ Define the apportionment of Ground Segment Requirements into Subsystems Requirements
  - ✓ Define and Maintain Observation Ground Segment Budgets
  - ✓ Define and Maintain Observation Ground Segment Performances
  - ✓ Define and Maintain Observation Ground Segment Verification & Validation Plans
  - ✓ Study new Observation Payload system concepts and techniques

GROUND SEGMENT 2/5

HOW AN OBSERVATION GROUND SEGMENT WORKS



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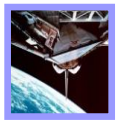
GROUND SEGMENT 3/5

Main Projects History

1990 1997 2002 2006 2011 2012 2013 2014 2015 2016



X-SAR: DTS Planning System – SRTM Processing

HELIOS 1A & 1B: Prime for Italian Segment

CASSINI: Processing

MARSIS: Payload Oper. GS

SHARAD: Payload Oper. GS

PROC: Planetary Radar Oper. Centre

KOMPSAT-5: SARP SAR Data Processing Station

COSMO-SkyMed: Ground Segment Prime - Phase C/D/E1

COSMO Second Generation: Ground Segment Prime

SFM : Military Image Exploitation System

COSMO Second Generation P-DUGS: Ground Segment Prime

GROUND SEGMENT 4/5

Future trends and activities

Design and development of:

- ✓ Ground Segment as a Service
- ✓ Value-Oriented Ground Segments
- ✓ Heterogeneous Data Integration Systems

…. and many others

TRENDS ON EARTH OBSERVATION VALUE CHAIN DISPLACEMENT

Images are going to be a commodity in the near future

A vertical integration is occurring among the players of the value chain

Analytics demand is growing at a fast pace

- *"Customers do not want to acquire raw images anymore. It will soon become a free data to download."* **Global Insights**
- *"Demand is currently growing for SAR data. Sooner, analytics demand will grow exponentially. The demand will not depend on the technology used."* **Iceye**
- *"US Gov. is actively working on a way to automatize feature extraction i.e. internalize first level of data analytics."* **NGA**
- *"For institutional applications, especially military ones, the highest value lies in the feature extracting. Currently, analyst are doing it without automated tools."* **French military**
- *"Over the last years, Planet has established numerous partnerships with analytics companies. We plan to launch full set of analytics by the end of 2018."* **Planet**
- *"Right now, image providing is growing as industry standards are here. But the industry will look for analytics in the future, around 2019-2020."* **Astrodigital**
- *"There is a consolidation toward niche markets by big players. The prices are higher so it worth it. It allows them to understand truly the end-user needs."* **Descartes Labs**

GROUND SEGMENT 5/5

Potential area of collaboration with University

Artificial Intelligence, Neural Networks Image Analytics

Mission Planning based on AI, automatic Image analysis and Feature Extraction using Digital Factory MVPs, to process the large data volume and immediately adapt the mission

Automation

Reduce staffing as the System performs many tasks autonomously: reduced Operational costs.
Collect free data, resubmit failed requests, Operator should not work on more than **30% satellite load!**

Cloud, Big Data, Telemetry Analytics

Exploit recent technos to manage large data volumes and new paradigms, i.e. PaaS *(*)*, and applying predictive satellite maintenance

Social Networks, Bulletins

Increase System Efficiency by gathering information and adapting the Mission planning automatically

Cyber Security

Leverage on Thales brand to ensure maximum (or adequate…) protection against Cyber threats

Virtual Reality, User Experience, Advanced Interfaces

Improve attractiveness and User eXperience with new technos: WOW factor and efficiency

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Ref Modele : 83230347-DOC-TAS-FR-005

INTEGRATED SYSTEMS SOLUTIONS 1/4

The mission

- Integrated Systems Solutions engineering activities :
  - ✓ Management of Integrated Systems Solutions, covering all Phases and TRLs
  - ✓ Identification, technical definition and competitive technical positioning of Integrated Systems Solutions
  - ✓ Technical Management of User, Mission and System Requirements, including verification and validation
  - ✓ Definition and trade-off / selection of Integrated System Architecture(s), as for Functional and Physical breakdown
  - ✓ Definition and management of the Integrated System technical and performance budgets
  - ✓ Apportionment of Integrated Systems Solutions Requirements into User, Ground and Space Segments Requirements
  - ✓ Define, Perform and Maintain Integrated Systems Solution Verification & Validation Plans
  - ✓ Management of technical roadmaps, including study and feasibility of new concepts and techniques
- Integrated Systems Solutions engineering include:
  - ✓ System and Payload Engineering for space based "Safety" communications (aircraft, ships, trains)
  - ✓ Integrated Terrestrial and Satellite Communication System for critical applications
  - ✓ System of Systems Engineering for multi-sensors and cyber-secured architectures
  - ✓ Etc.

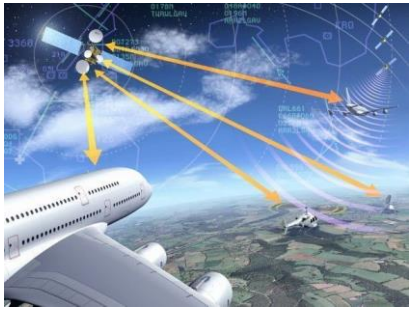
INTEGRATED SYSTEMS SOLUTIONS 2/4

Main project/activities on-going

- Iris (ESA) - Satellite System for Air Traffic Control
  - ✓System design and dimensioning, GEO and HEO Payload design
- SESAR (EC) - Communication System for Air Traffic Control
  - System specification
- Sat4Rail (ESA) - Integrated System for Rail Traffic Control
  - ✓System design and feasibility
- EGNOS and RIMS (ESA, EC)
- CIMR (ESA)
  - ✓LEO Radiometer System specification
- Foldout (EC)
  - ✓System of System design and verification test campaign

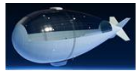
INTEGRATED SYSTEMS SOLUTIONS 3/4

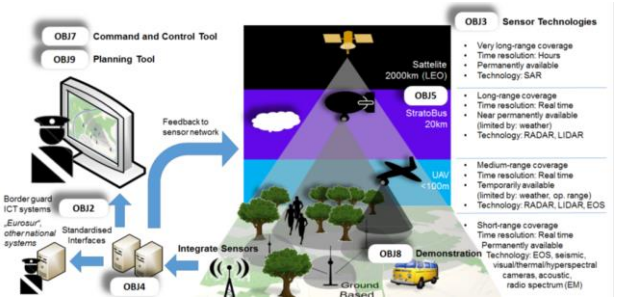
Future projects/activities



- Specification, Design and Development of:
  - ✓ VDES System and Payload for Maritime Safety communications
  - ✓ Agent based Routing and Link selection for Safe Multi-Radio Communications
  - ✓ Command and Control radio for drones ‘beyond line of sight’
  - ✓ System and Payload for Space based Interference Detection and Reporting
  - ✓ On-orbit Detection, Observation and Classification of space debris

  …. and many others





Date :
Ref :
Ref Modele : 83230347-DOC-TAS-FR-005

INTEGRATED SYSTEMS SOLUTIONS 4/4

Potential area of collaboration with University

- Main topics of collaboration with University include:
  - ✓ Architectures and protocols of Integrated satellite and terrestrial systems: Simulation, Emulation and Design
  - ✓ Satellite Communication Systems: Specification, Design and Verification
  - ✓ Digital communications
  - ✓ Channel access and Radio Resource Management: methods and performance evaluations
  - ✓ Cognitive Radios and Woftware Defined Networks
  - ✓ Models, analysis and simulation
  - ✓ Concepts of Operations and Use Cases of integrated systems

INNOVATIVE SOLUTIONS, LABS AND DIGITAL TRANSFORMATION 1/4

The mission

- ✓ To technically manage research studies and new initiatives fostering the development and usage of innovative solutions and technologies
- ✓ To identify requirements for the development of Innovative Solutions and Technologies to foster the evolution of the DONI products in line with Roadmaps.
- ✓ Design and develop new and innovative technical solution and prototype them
- ✓ To coordinate, manage and harmonize R&D and CAPEX activities and budget (internal and co-funded)
- ✓ To guarantee for DONI engineering the link with Universities, Research Centers and Smart Companies (to select the best in class)
- ✓ To support improvement and transformation projects, tools and methodologies (e.g.: AB initiatives)
- ✓ To act as DONI digital transformation reference for all the projects and related activities
- ✓ To manage DONI Labs (incl FabLab, when applicable) coordinating the relevant activities execution, infrastructure evolution and maintenance
- ✓ To act as metrological focal point for timing reference

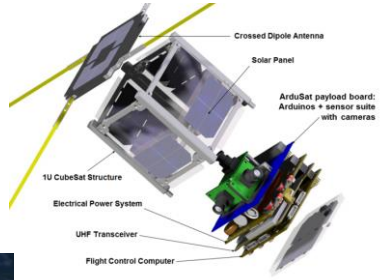
INNOVATIVE SOLUTIONS, LABS AND DIGITAL TRANSFORMATION 2/4

Main project/activities on-going

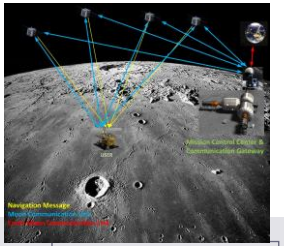
- Formation Fight system for cluster of satellites
  - Development of a proof of concept based on CubeSat
- Usage of AI and Machine Learning in support to predictive maintenance
- Optical and Photonic based satellite system
- Additive Manufacturing to reduce the weight and size of satellites
- Usage of Commercial Electronics in Space
- Lunar infrastructures (nav + obs)
- Local Navigation System based on IoT technologies
- Development of Virtual/Augmented reality tool applied to the whole Satellite lifecycle
  - First version already in TAS FabLab Rome

INNOVATIVE SOLUTIONS, LABS AND DIGITAL TRANSFORMATION 3/4

Future projects/activities



- ✓ Big Data and Machine learning:
  - ✓ Telemetries and Logs analysis for predictive maintenance
  - ✓ Image analysis for objects classification
  - ✓ Nav data usage for weather forecast
  - ✓ On Board processing
- ✓ Formation Flight:
  - ✓ First in orbit demonstartor
- ✓ Optical and Photonic
  - ✓ Testbed realization



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INNOVATIVE SOLUTIONS, LABS AND DIGITAL TRANSFORMATION 4/4

Potential area of collaboration with University

- Main topics of collaboration with University include:
  - ✓ Formation Flight algos
    - ✓ Including on board control systems
  - ✓ Optical/Photonics
  - ✓ Big Data: Algos for Data Analisys
  - ✓ Artificial intelligence and Machine learning
  - ✓ Timing and metrology
  - ✓ Additive manufacturing for Space

CYBER SECURITY ENGINEERING DPT 1/3

Main Features

- ✓ **Security Engineering activities** :
  - ✓ Security Risk Analysis with proprietary Model and tools on Satellite System
  - ✓ Security Requirements , Design and Architectures Definition
  - ✓ Security Engineering Management in the frame of Projects and Programs
- ✓ **Ciphering Systems and Algorithms design and validation**
  - ✓ Ciphering System Space Ground design
  - ✓ Key Management design
  - ✓ Algorithm design
  - ✓ Crypto analysis and Random simulation with customize tools
  - ✓ CRYPTOSEC evaluation
  - ✓ COMMON CRITERIA Evaluation

Date :
Ref :
Ref Modele : 83230347-DOC-TAS-FR-005

CYBER SECURITY ENGINEERING TASI 2/3

/// TAS-I has performed the definition, manufacturing, integration, validation, certification and testing of Satellites (and Ground) Crypto units for the protection of:

- **TC/TM DATA UP/DOWN LINK (~0.01 MBPS)**
- **END-USER DATA DOWN LINK (~280 MBPS)**

/// Specifically, TAS-I has produced crypto units for the following Telecommunication and Earth-Observation Satellite Systems:

- **SICRAL 1 (2001)**
- **COSMO SKYMED - 4 SATELLITES CONSTELLATION (2007/2010)**
- **SICRAL 1B (2009)**
- **SICRAL 2 (2014)**
- **COSMO SECOND GENERATION - 2 SATELLITE –PROGRAM ON GOING**

All mentioned satellite systems (and related crypto units) are operative.

COMMON CRITERIA CERTIFIED EAL4+

/// The production of Crypto units has always been performed within TAS-I certified infrastructures (e.g. clean rooms)

/// At the time being, production of crypto units for Cosmo Seconda Generazione Satellites constellation is ongoing.

COLLABORATION'S TOPICS 3/3

- ALGORITHMS STUDY
- RANDOM SIMULATIONS TOOLS
- NEW SPACE CYBER PRODUCTS
- TASI ADVANCED RISK ANALYSIS TOOLS INTEGRATION

Consultative Committee
CCSDS
for Space Data Systems

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THANK YOU
FOR YOUR ATTENTION