ARAMIS – CubeSat ISL Project

28^{th} APRIL 2021

Ing. Giovanni Nicolai - Italspazio

13th IAA Symposium on Small Satellite for Earth Observation – 27-29 April 2021

ARAMIS – ADVANCED RADIO ACCESS FOR MILITARY SOLUTIONS

The Aramis Feasibility R&D Contract has been awarded to Italspazio (Leader of a SME Grouping constituted by SBS and SIA) by Ministry of Italian Defence Teledife Department.

The ARAMIS project aims to develop and verify advanced technologies which, once validated, allow the creation of a satellite constellation based on CubeSats and Inter-Satellite Link (ISL) communication between CubeSats and between a CubeSat and the GEO satellite Athena-Fidus.

ITALSPAZIO BRIEF NOTES

Italspazio has been operating for over 30 years in the field of **satellite technologies** and is active all around the world providing project support and development in the SatCom, Earth Observation, VSAT, Space and Teleport.

[Satellite telecommunications and communications | Italspazio]()

Italspazio:
p.vita@italspazio.com

Italspazio
Build. Connect. Innovate.

Index:

INTRODUCTION

The Project regards a feasibility study for a CubeSat constellation performing ISL.

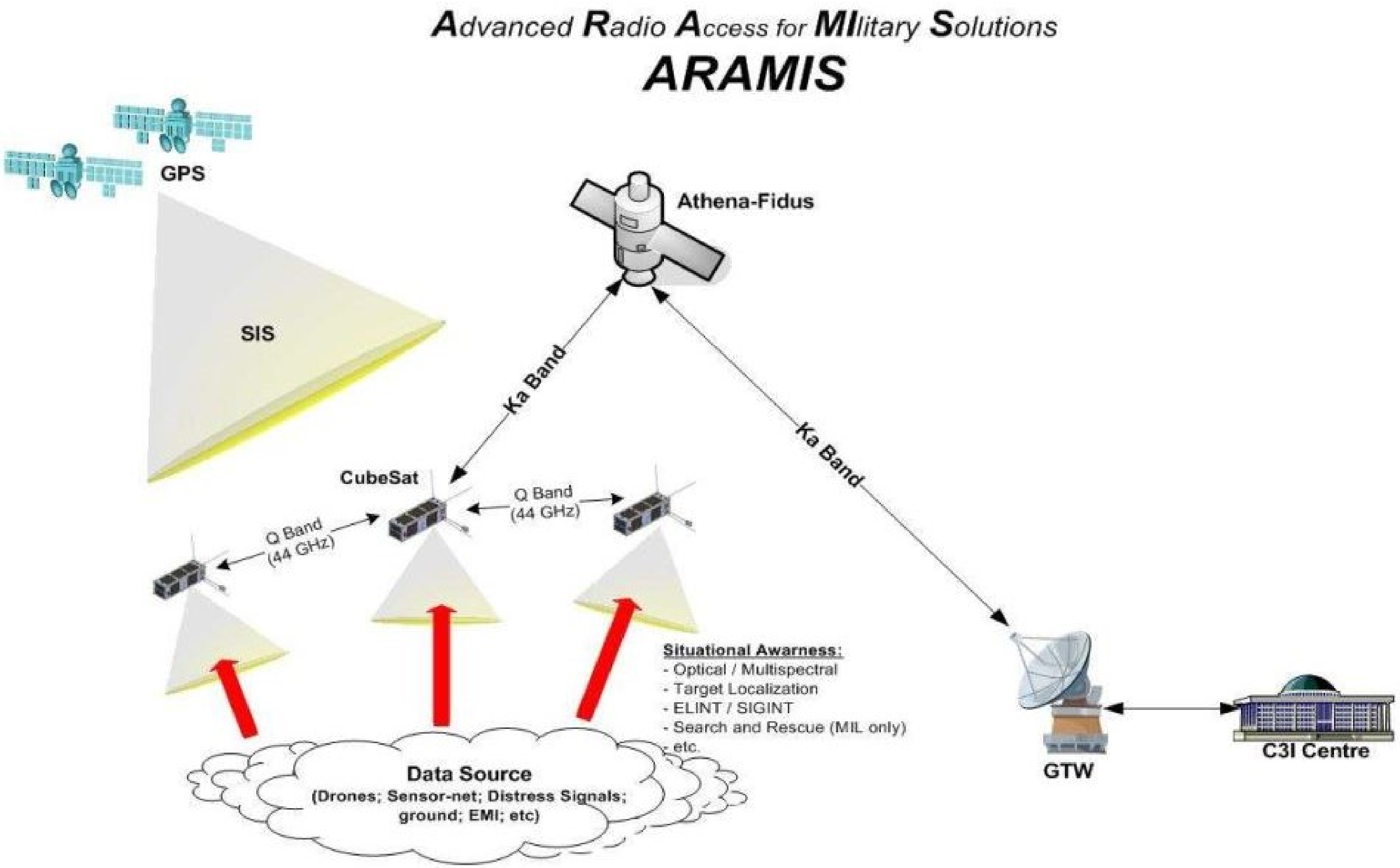
Depending on the final application, the CubeSats range from 6U to 9 U (1U=10x10x10 cm^3).

The ISL operates in two bands:

- Q band at 42 GHz, for transmission between the CubeSats;
- Ka band (31 GHz Tx and 21 GHz Rx), when a CubeSat, depending on the visibility, is connected to the GEO satellite Athena Fidus.

The system can offer IoT or Elint services with Sun Synchronous, Polar or Inclined Orbits at an altitude of 510-530 Km.

ARAMIS – NETWORK ARCHITECTURE

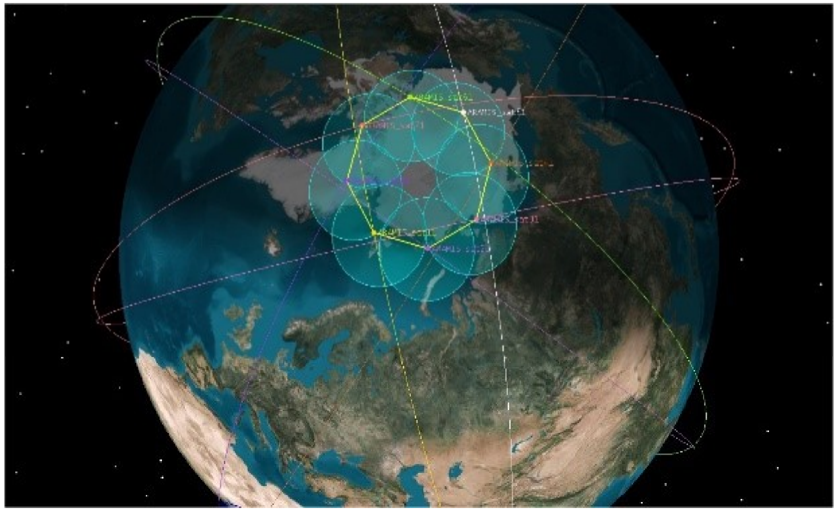


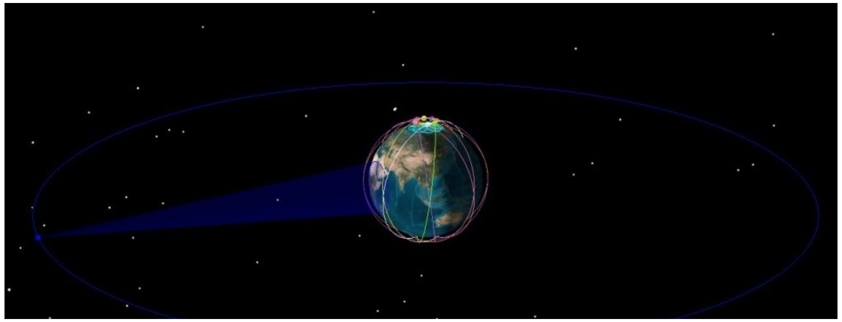
GENERAL DESCRIPTION

The advanced ISL systems developed for the ARAMIS project can be useful part of several type of missions. After a tradeoff two types of missions have been selected:

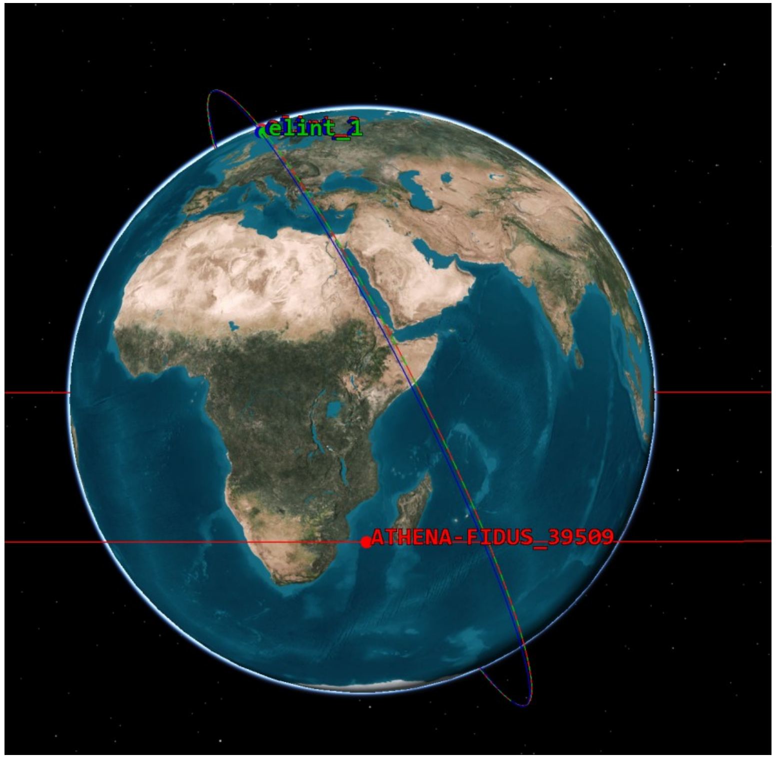
- a data relay constellation of CubeSats for collecting data from IoT/IoBT devices released over battlefield or an area of particular interest;
- a constellation made of triplets of CubeSats to collect ELINT signals from low frequency radio sources (radars). ARAMIS ISL systems can relay data about positions of these sources in short time to the ground segment.

IoT Applications with Cubesats in Polar Orbits





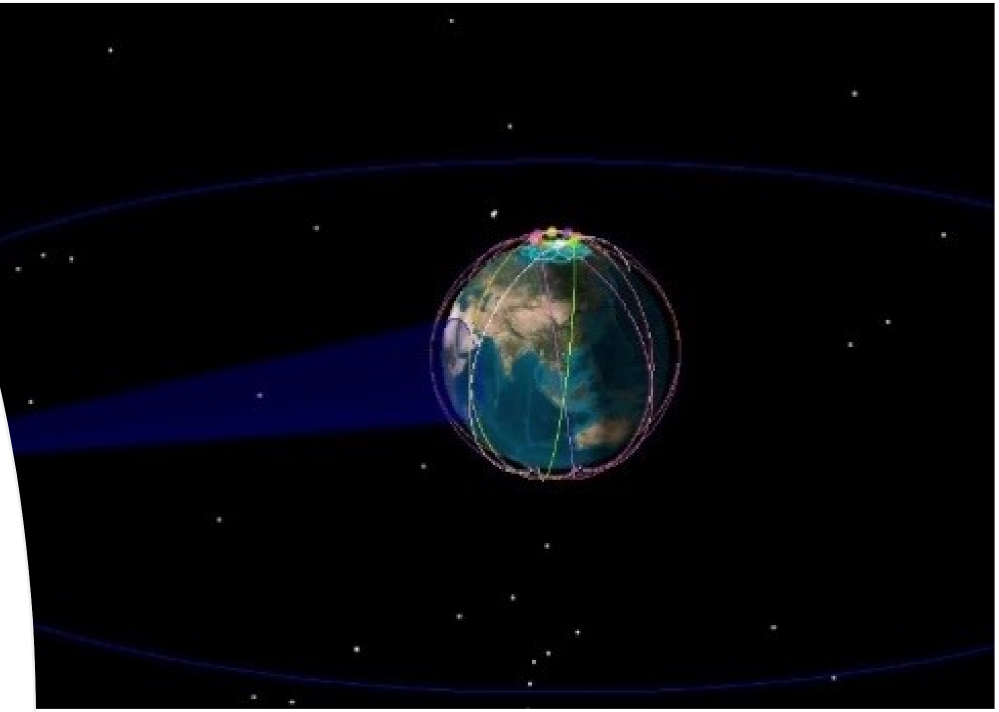
ELINT Applications with Cubesat Triplets in SSO or Polar Orbits

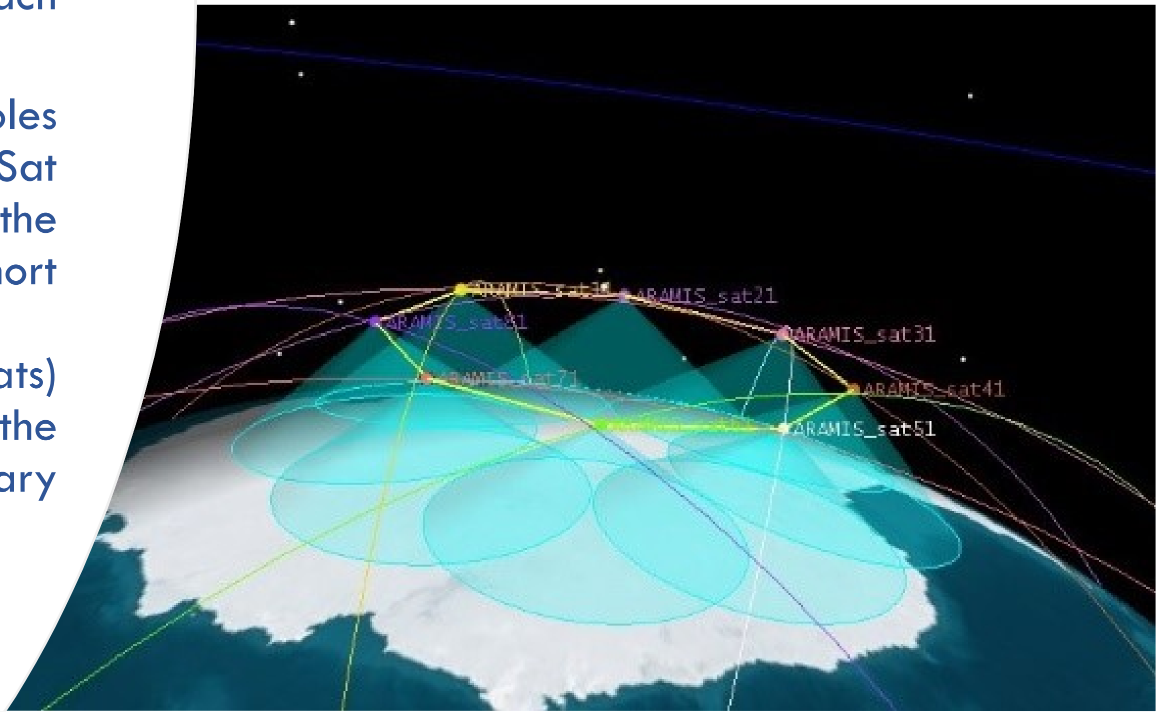


ARAMIS – MISSION ANALYSIS

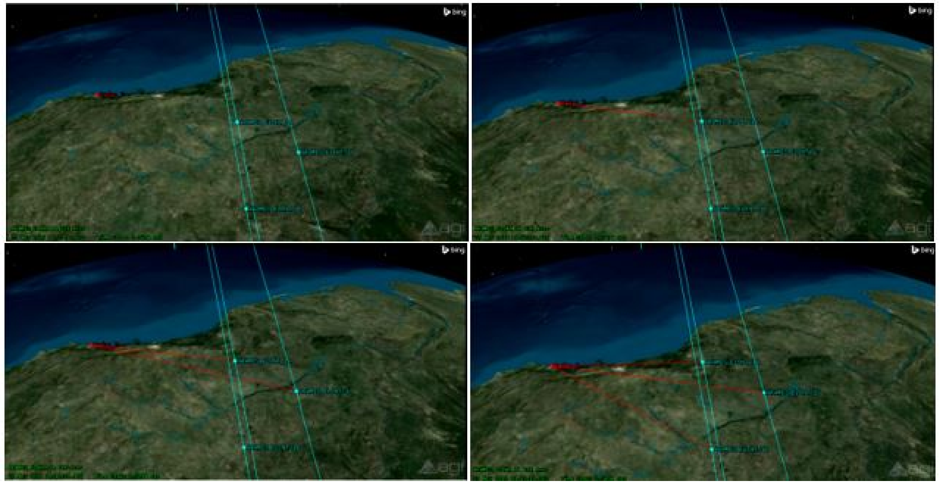
To satisfy the common requirement of global coverage for ELINT and IoT/IoBT mission Polar Orbits Mission has been selected. The common mission philosophy includes the following aspects:

- Collect data from IoT/IoBT sensors or signals and positions of low frequency radars and store them in the internal memory of each CubeSat;
- Exchange data near the Earth poles via Q-band ISL from each CubeSat (or each triplet of CubeSats) to the others in different orbits and short distance;
- The CubeSat (or triplet of CubeSats) in the best position send data to the Data Relay Satellite in Geostationary Orbit via Ka-band hi-speed link.





ARAMIS – MISSION ANALYSIS



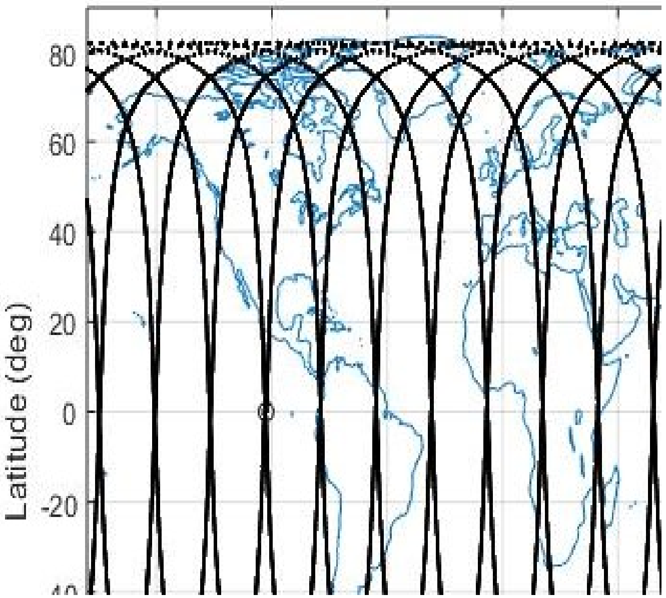
ELINT mission data collect philosophy to achieve maximum precision in location of radar signals

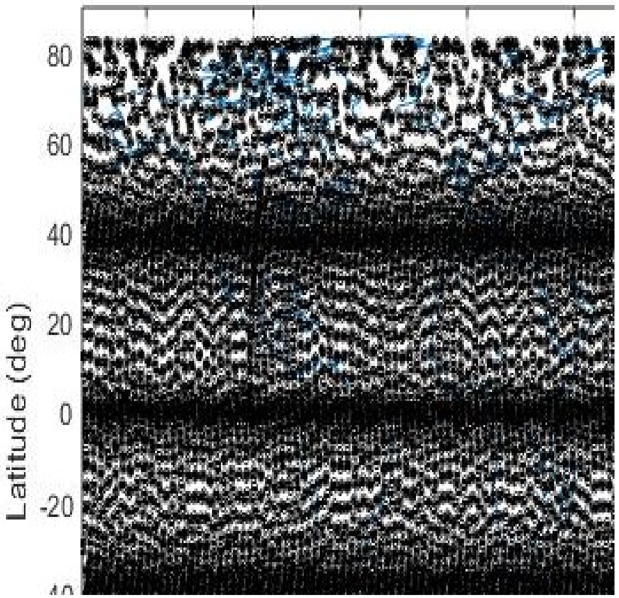
- The IOV/IOD mission for IoT/IoBT configuration is a reduced constellation, composed of two or three satellites, whose purpose is to validate LEO-LEO ISL and LEO-GEO Link;
- The IOV/IOD mission for ELINT configuration includes a single triplet of satellites, aimed at validating LEO-GEO Link and LEO-LEO ISL from each satellite of the triplet;
- The GEO satellite (acting as Data Relay Satellite) could be initially the governamental Italian satellite Athena Fidus and in future the new planned Ital GovSatCom satellite;
- Q-Band ISL synchronization between each micro-satellite part of the triplet allow better classification and scanning mode optimization of the ELINT Targets (radar signals);
- The ELINT algorithms to identify the targets make use of TDOA/FDOA techniques in order to achieve maximum precision location and accurate classification of radar signals;

IOV/IOD: In Orbit Validation/In Orbit Demonstration
IoT/IoBT: Internet of Things/Internet of Battle Things
ISL: Inter Satellite Link
TDOA/FDOA: Time Difference of Arrival/Frequency Difference of Arrival

ARAMIS – ELINT Mission Analysis

Every triplet has an approximate altitude of 510-530 Km with Polar Orbits at 82° of inclination. These Orbits allow global coverage of this system with a revisit time of 7 days for a single satellite triplet.



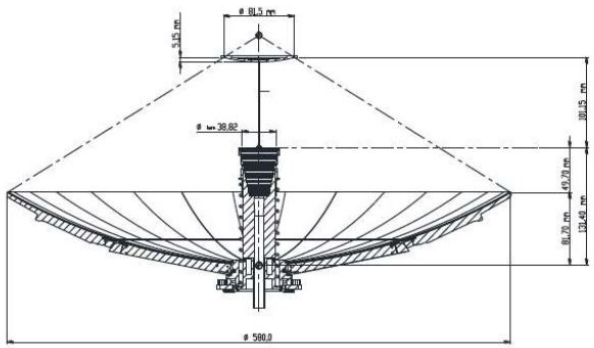


ARAMIS – MAIN DEVELOPMENTS

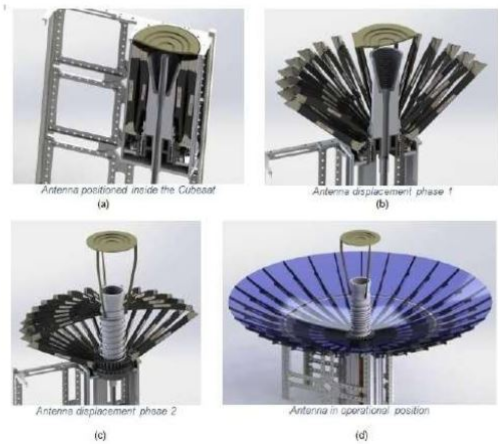
Deployable Ka Band Antenna

The reflector antenna is optimized for the Ka frequency in the Rx bands: 20.7 - 21.2 GHz and Tx: 30.7 - 31 GHz.
Among the possible solutions antenna configurations, a Cassegrain type was chosen to meet deployment constraints.

Antenna Optic



Antenna Deployment Phases

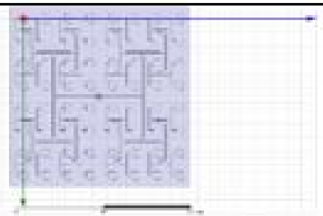
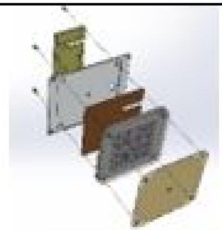


Italspazio
Build. Connect. Innovate.

ARAMIS – MAIN DEVELOPMENTS

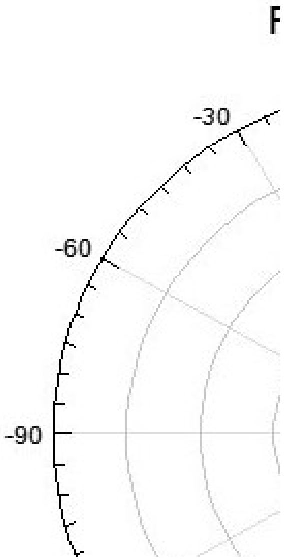
PATCH ARRAY Q BAND ANTENNA

- The layout has been designed taking into account :
  - System specifications;
  - The need to obtain a circular polarization;
  - The need to have impedance adaptation in correspondence with the power supply.
- The total size of the antenna is 4.56 x 4.56 x 0.00254 cm (Width x Depth x Height).

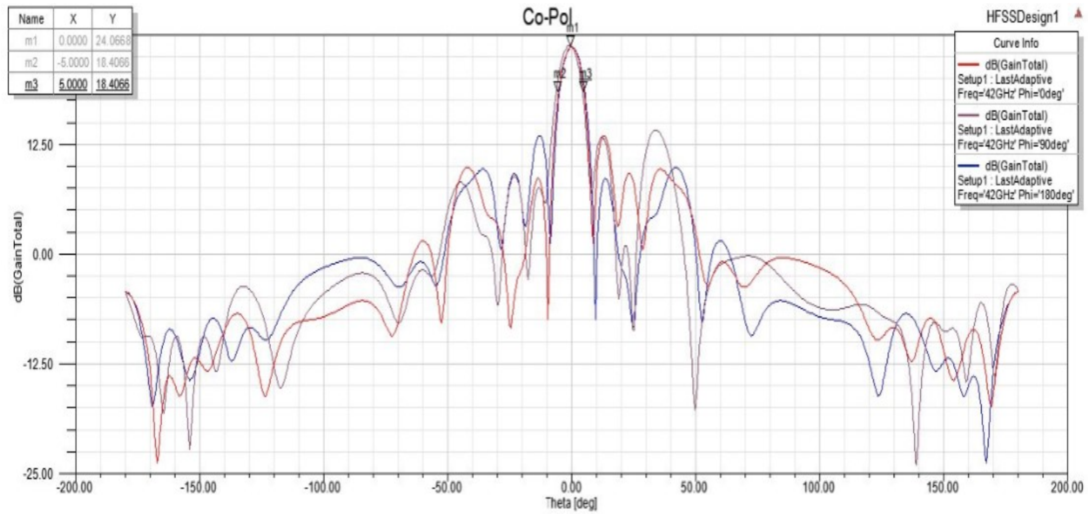
		
Radiation Element Layout	Board Layout	Board Mechanical Support

ARAMIS – MAIN DEVELOPMENTS

PATCH ARRAY Q BAND ANTENNA



RADIATION PATTERN

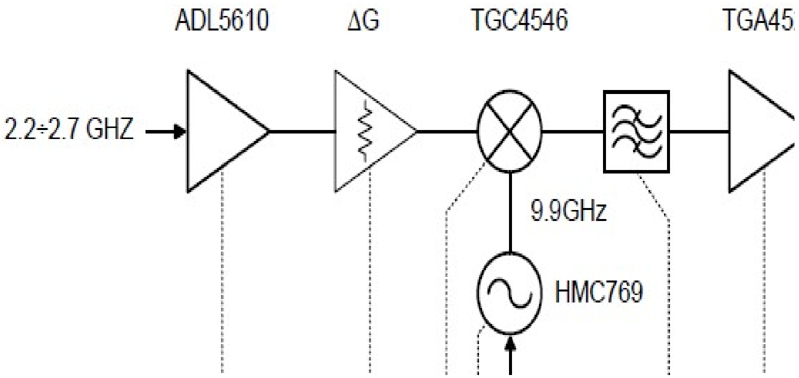


GAIN

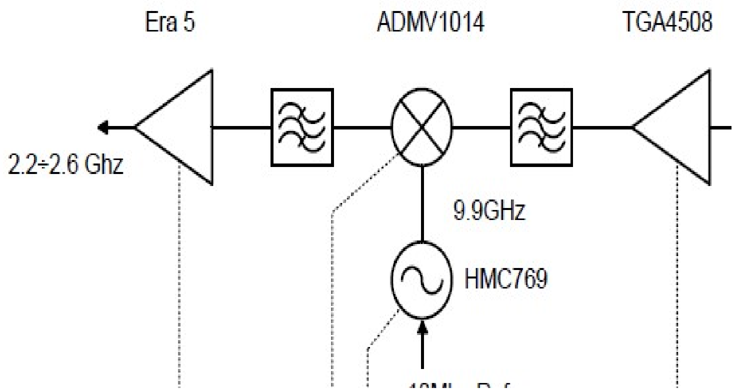
ARAMIS – MAIN DEVELOPMENTS

Q BAND INTER SATELLITE LINK (ISL) TRANSPONDER

SSPA & UP CONVERTER LAYOUT FOR THE TX CHAIN



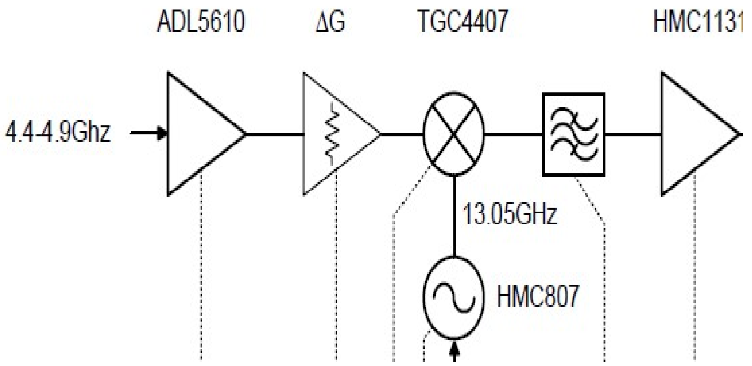
LNA & DOWN CONVERTER LAYOUT FOR THE RX CHAIN



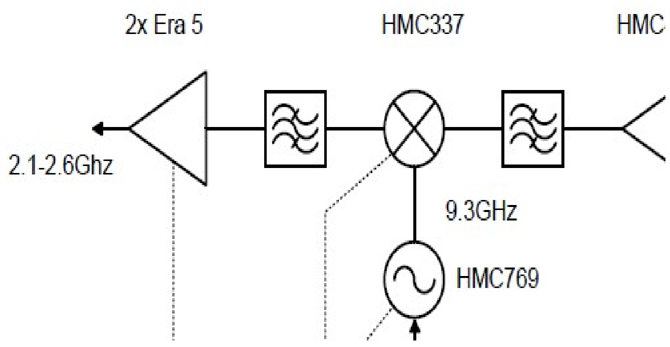
ARAMIS – MAIN DEVELOPMENTS

KA BAND AF COMMUNICATION TRANSPONDER

SSPA & UP CONVERTER LAYOUT FOR THE TX CHAIN



LNA & DOWN CONVERTER LAYOUT FOR THE RX CHAIN



ARAMIS – MAIN DEVELOPMENTS

SDR MODEM

- The Modem will be realized in SDR-FPGA technology and making use of Open-Source libraries in particular for the algorithms of recovery of frequency, phase and symbol synchronism;
- The VHDL language will be used for the FPGA development phase of the functionality of the Modem;
- The choice of the FPGA HW will be made between the available COTS products;
- The OBP processor will be selected from the available COTS products.
- Below a list of COTS technologies potentially usable in the implementation of Modem:
  - LMS6002D - Multi-band Multi-standard Transceiver (Limemicrosystem)
  - AD9361 - RF Agile Transceiver (Analog Device)
  - CMX-7164 -Multi-mode Wireless Data Modem IC (CML Microcircuits)
  - SX-3000 Ultra-Wideband SDR Modem SoC (SatixFy)

ARAMIS – IoT MAIN DEVELOPMENTS

IoT APPLICATION PAYLOAD

- The ARAMIS IoT payload will be based on a very flexible SDR design such to cope with many of the current standards operating in the UHF bandwidth (400-3000 MHz).
- A UHF deployable antenna with 6 dBi gain will gather the ground data.
- The SDR receiver based on COTS and FPGA can be programmed to operate even for other applications if requested.
- The gathered data are stored in the cubesat mass memory to be sent via the ISL's to the ground station after formatting and encryption.

ARAMIS – ELINT MAIN DEVELOPMENTS

ELINT APPLICATION PAYLOAD

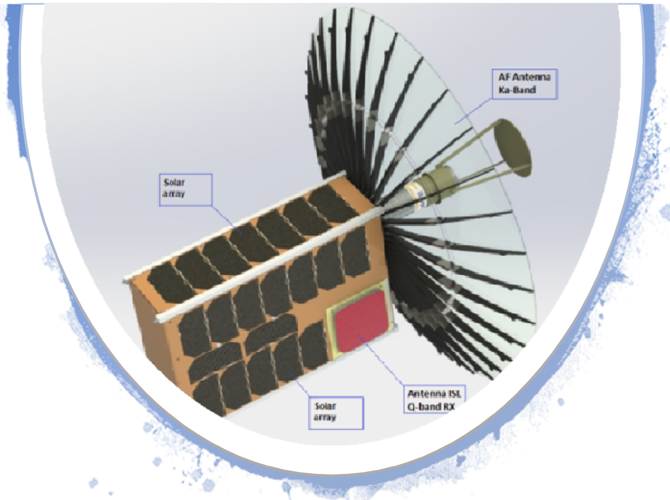
- The ELINT application payload operates by a TDOA/FDOA approach based on a formation of three satellites each embarking a wide BW signal acquisition payload;
- The payload includes two wide BW deployable antennas followed by innovative receiver chains. The data are then transmitted to ground via GEO ISL when inside the Athena Fidus coverage;
- The formation configuration sees two satellites on the same orbit plan and a third flying around. Relative positions are computed by processing powerful EGNSS receivers' observables;
- The data processing and on ground source location and analysis is done on ground in the processing center.

Italspazio

ARAMIS – CUBSAT LAYOUT

IoT MISSION

- In case of an IoT mission, it is possible to integrate the Aramis CubeSat Satellite into a 6U units, respecting the volume, mass and power requirements;
- All the main functions will be assumed by OBC (On Board Computer) and by the Electrical Power Subsystem (EPS);
- Satellite balance and flight dynamics will be very important, especially in case of incorporating an orbital control system.



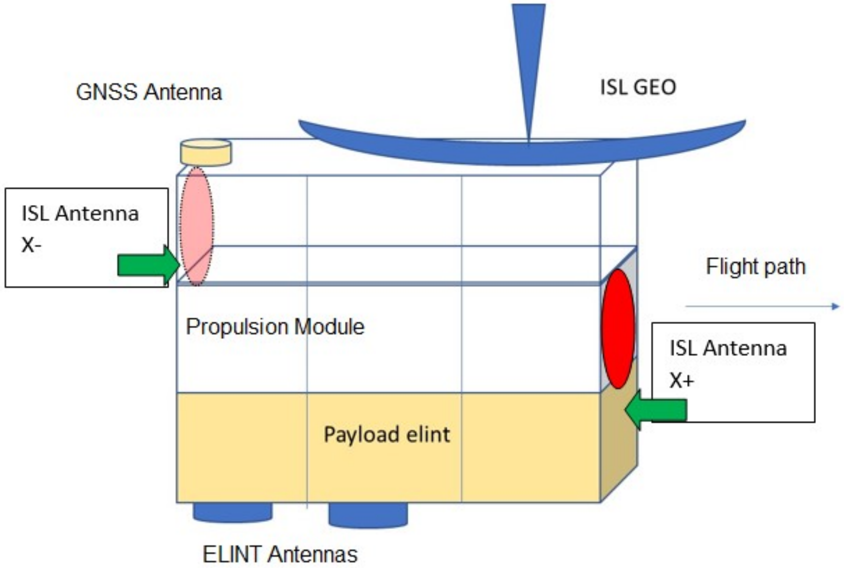
Italspazio

Build. Connect. Innovate.

ARAMIS – CUBESAT LAYOUT

ELINT MISSION

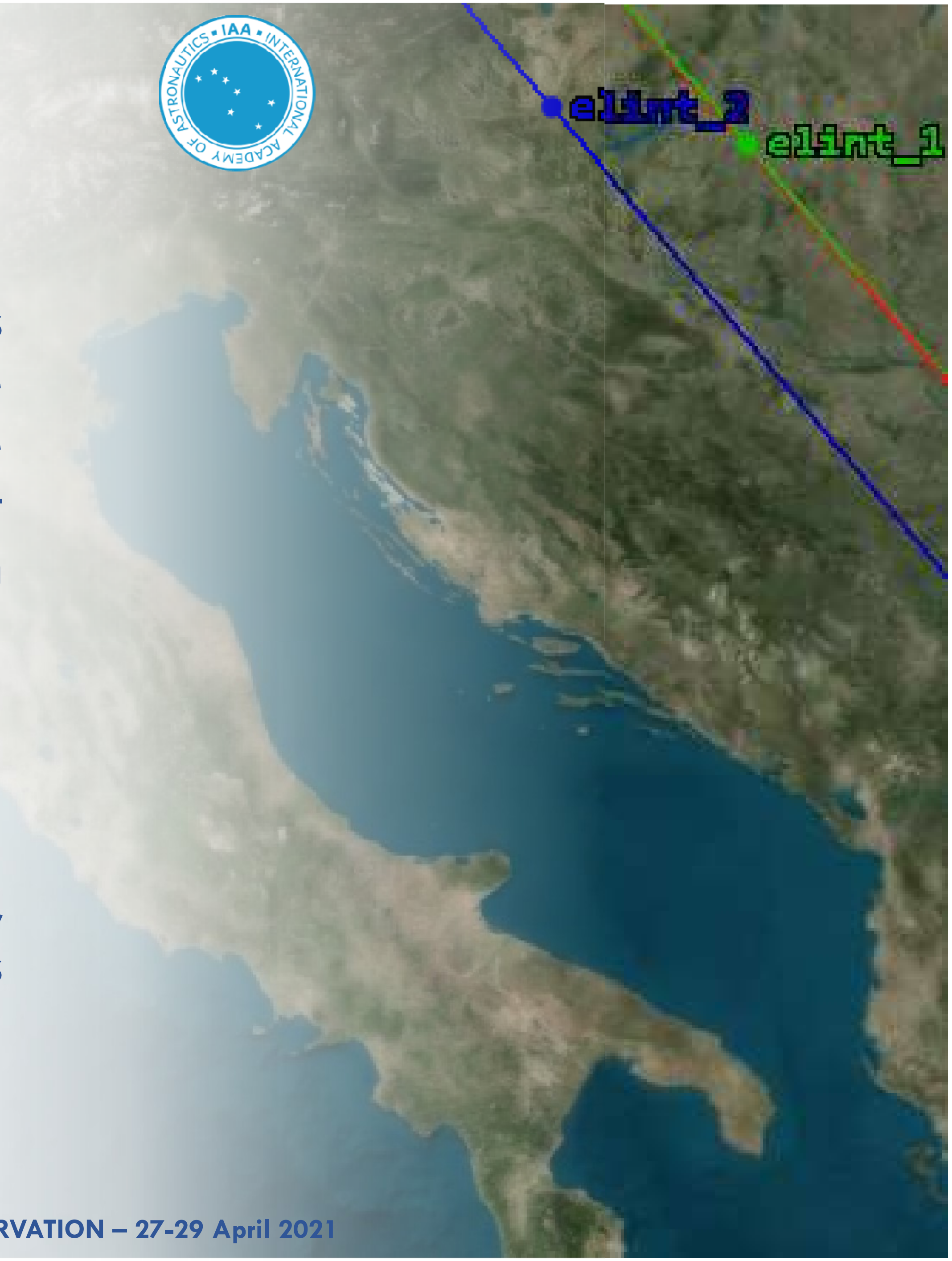
- The typical CubSat Layout for the ELINT Mission should include at least 9 U but considerations on the allocation of the ADCS, Radio Frequency, Base Band and Modulation equipment and the thrusters needed for the attitude control from TT&C could lead to a solution with 12 U.
- Italspazio recently received a contract from the Ministry of Defense Teledife to continue Phase 2 of the Aramis project for the construction of a prototype for ELINT applications.



ARAMIS – CONCLUSIONS

- Italspazio, and his team, has developed an innovative application based on the use of CubeSats, state-of-the-art devices and technologies with IoT/ELINT payloads.

- The solution is characterized by good performance and great operational flexibility, also being able to use links between satellites.



Next
ARAMIS – CubeSat
in the Space

13th IAA SYMPOSIUM ON SMALL SATELLITE FOR EARTH OBSERVATION – 27-29 April 2021

CV Ing. GIOVANNI NICOLAI. nicgio65@gmail.com

Degree in Electronic Telecommunications Engineering at the University of Rome "La Sapienza" in 1979. 40 years of experience, of which 21 spent in Finmeccanica-Leonardo companies (Telespazio, Marconi, Italcable, Alenia Spazio, MAC, Elsacom). Consultant on behalf of Italcable for the MOPTT and Sauditel in Saudi Arabia 1987-1989 for the long distance satellite network. Project Manager / Program Manager of the Ground Segment of Italsat and Sicral from 1989 to 1997 in Alenia Spazio and MAC. Technical Director for Fixed Services via satellite in Elsacom from 1997 to 2003. CEO of Start-up (Aersat and Esset) from 2003 to 2007 and CTO of S2E for the construction of the Armasat Network in the years 2007-2010. He participated for ITS in phase B of a space program for the KACST Saudi Arabia research center (payload manager) from 2011 to 2012. Elital consultant from 2012 to 2016. European Community expert for the evaluation of Compet 2 and Compet 3 calls in the 2016 and 2017. Author of international articles in technical journals Intelsat, Eutelsat, Italcable, Alenia Spazio and ESA and author of publications for the annual “Ka Conference”. Since 2017 he is President of the Aerospace Commission of the Rome Association of Engineers and Consultant for italian aerospace sme companies (Italspazio, Elital, Innovery, etc).