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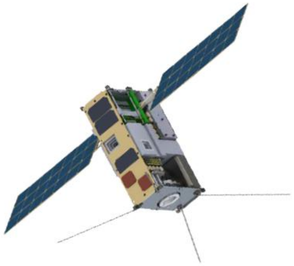
SAFEGUARDING HUMANKIND'S HERITAGE, THE GREAT CHALLENGE FOR ENGINEERS
The World Federation of Engineering Organizations

NEW TECHNOLOGIES AND SERVICE PROSPECTS FOR THE SPACE



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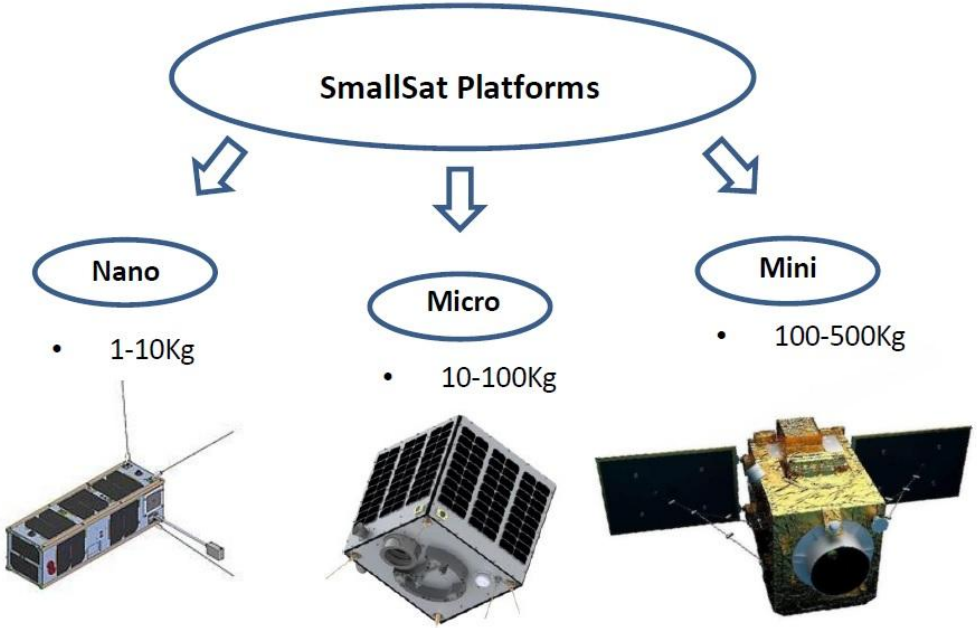
INTRODUCTION

Progress in technology has pushed the space community to focus on miniaturization of conventional satellites. Now the small satellite term does not just mean the educational satellite but extends to business for a large number of industries and large service companies. The miniaturization of satellites has opened new business opportunities for Telecommunications and Earth observation services.

The amount of data captured by these small satellites is large and growing. Existing data aggregation satellite systems (like Copernicus) will directly benefit from increased data from small satellite transmission capacity. This will have an impact on the amount of data available for some *humankind safeguarding applications such as control of migratory flows of refugees and asylum seekers, control of natural disaster, control of agricultural resources and pollution.*

SMALL SATELLITES

Small satellites are located on Low Earth Orbits (LEO) between 400 km and 800 km above the Earth's surface and have a visibility time from the receiving earth station in the order of 8 to 15 minutes. In this short period, all information gathered along a full orbit must be discharged to the receiving ground station. The characterization of these small satellites is shown in the figure below.



FREQUENCY BANDS FOR SMALLSAT

The most commonly used frequencies for data transmission from small satellite (nano,micro and mini) are the following:

- C band (5-6 GHz) for data trasmission to ground facilities;
- X band (7-8 GHz) for data trasmission to ground facilities;
- S band (2 GHz) for telemetry and remote control.

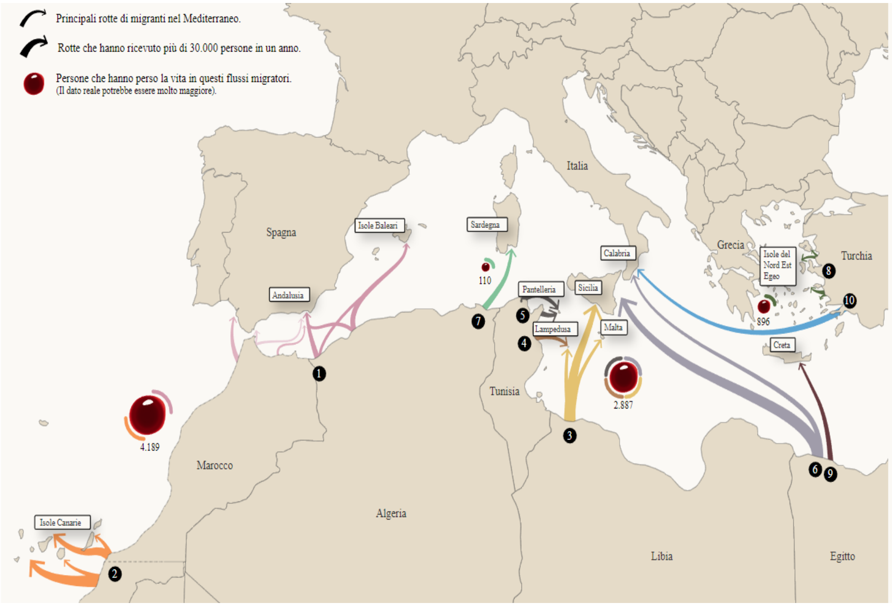
In order to increase the bandwidth capability, frequency bands less crowded (like the Ka band at 26 GHz) will be implemented on board of these smallsat for Earth Observation (EO) applications.

Ka band at 26 GHz provides bandwidth 4 times greater than X bandwidth. The *Final Report of the 2016-11-18_LEO26SG Expert Group* says: "The 26 GHz frequency is a viable option for ground-based communications from low orbital space vehicles (LEOs)”.

SMALLSAT MAIN APPLICATIONS

Crucial applications for this kind of small satellites could be:

- Control of migratory flows of refugees in the Mediterranean Sea;
- Control of Natural Disasters in Italy;
- Monitoring of Agricultural Resources and Pollution.



Migratory Flows in Mediterraneum Sea

BIT TRASMISSION RATE AND TECHNOLOGIES

The maximum bit rate reached up to-date by these nano and micro-satellite missions is about 100 Mbps. So there is a great deal of COTS (commercial off the shelf) technology to increase the transmission capacity of up to 500-1.000 Mbps on board these small satellites by:

- Standardization of Nano satellites;
- Frequency bands less crowded such as the Ka (26 GHz) band;
- Communication Technologies like Software Defined Radio (SDR);
- Photonic technologies for signal processing and optical signal transmission systems;
- High-definition sensors/cameras for data acquisition.

An important aspect of this technological revolution is the integration of these small satellites with the 5G terrestrial mobile network to provide services such as:

- Dissemination of Data to End Users;
- Android Applications for Data Dissemination.

Standardization of Nano Satellites

The Nano satellites today can do almost anything that a conventional satellite does, and even at a fraction of the convention satellite cost. And, though no one contests that small satellites can not replace larger conventional satellites, both governmental and start-up organizations are trying to play a role with these new opportunities.

Only in 2016 about 300 satellites were launched, weighing between 1 and 50 kg.

The realization and success of commercial-based satellites is the first indication of the need for a change of technology. Various private initiatives in the United States have led to the standardization of CubeSat satellites falling within the Nano Satellite typology.

Cubesat Standards

Cubesat Advantages and Disavantages

Cubesat standardization has produced two great advantages:

- First of all **the existence of a large community of operators** working on the same platform and addressing similar problems by providing solutions that are widely shared over the Web;
- Secondly this standardization has produced **automatisms in the integration into the launchers**. There are several launchers (Vega, PSLV, Dniepr) that accept Cubesat even a few months before the launch if they are released by the standard system (the PPOD).

Disadvantages are mainly related to:

- Cubesat Reduced Lifetime (about 2 years);
- Electrical powers that can be made available (small satellites = little surface for solar panels).

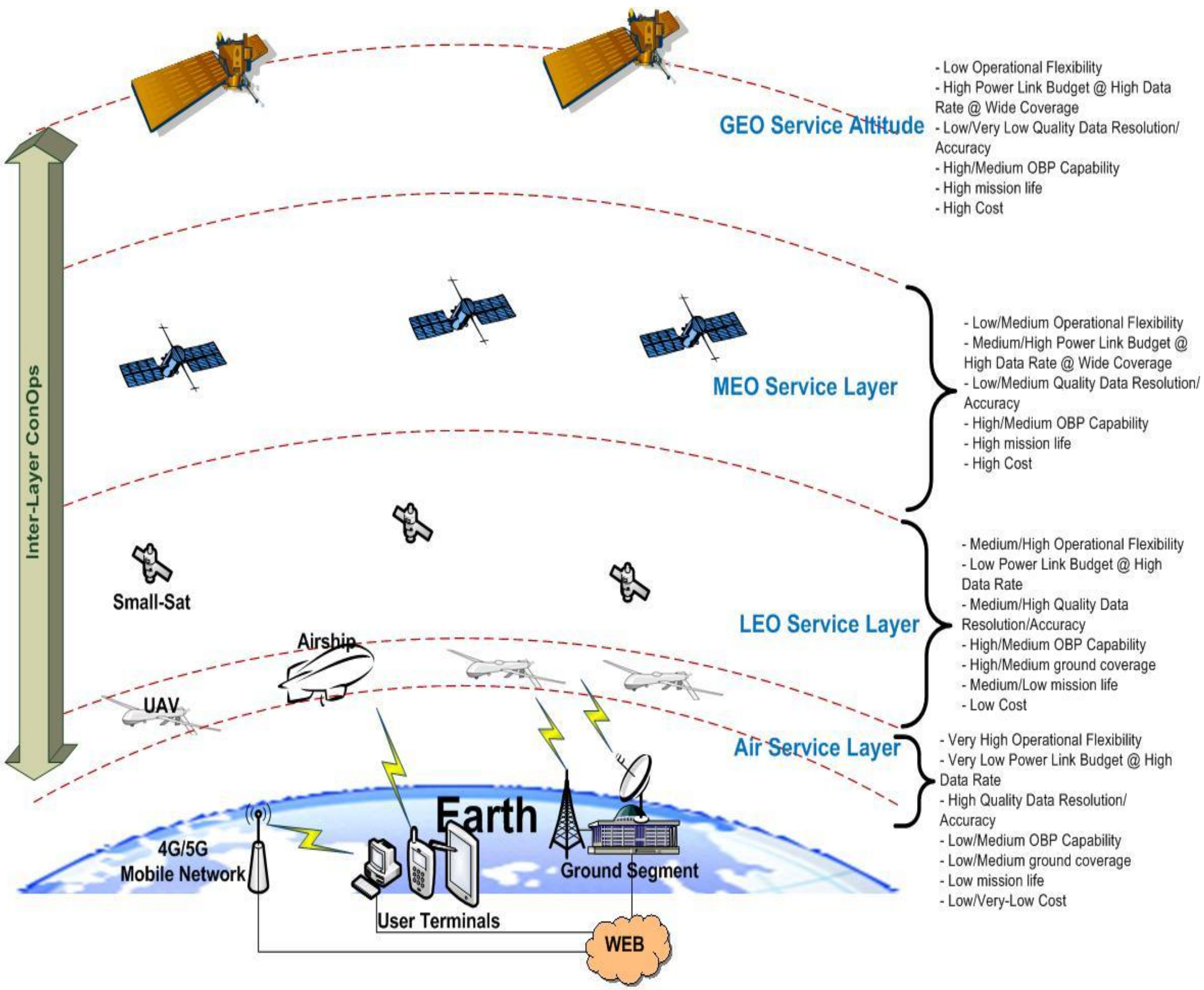
NEW TECHNOLOGY TRENDS FOR SMALLSAT

What is required for future satellite technology is therefore:

- **Greater integration with land systems**, adopting compatible standards allowing cheaper equipment and flexible bidding by operators;
- **System Efficiency Increase**, in order to reduce the cost per bits with limited power satellites adopting advanced technologies like DVB-S2 and DVB-S2X;
- **Development of SDR Modem** utilizing programmable FPGA (Field Programmable Gate Array) signal processor;
- **On-board processing**, more flexible and with a large number of interconnect bundles;
- **Scalable satellite systems smaller and more powerful** in order to avoid high costs.

Such satellites can be interconnected in orbit via inter satellite links (ISL), as well as they grow in number and flexible reconfiguration demand is required.

FUTURE SCENARIOS FOR SATELLITE SERVICES

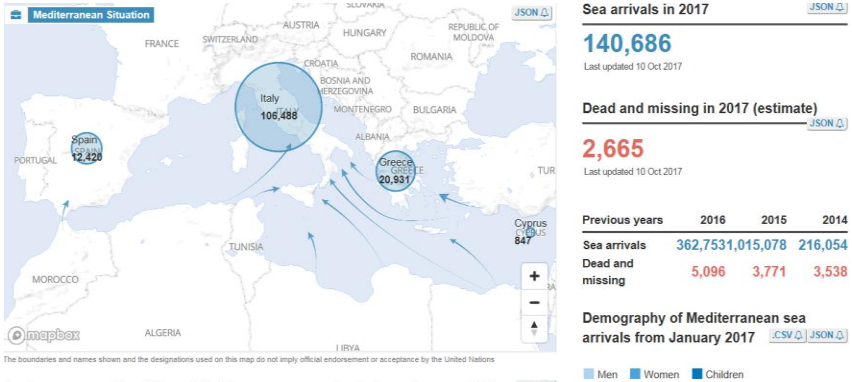


SERVICE PROSPECTS FOR SMALLSAT 1/2

Small Satellites in Low Earth Orbit (LEO) are often deployed in a constellation because the coverage area of a single satellite is relatively small. To maintain a continuous coverage of a particular area of the globe, several satellites are needed to be deployed in LEO orbit. Therefore the main application areas for smallsat constellations are related to:

- ***Search And Rescue (SAR) operations*** - The term SAR refers to a set of rescue operations conducted by trained personnel in conjunction with the use of specific naval, aerial or land-based facilities for the safeguarding of human life;

Dashboard with daily tracking
(slide of October 10, 2017)

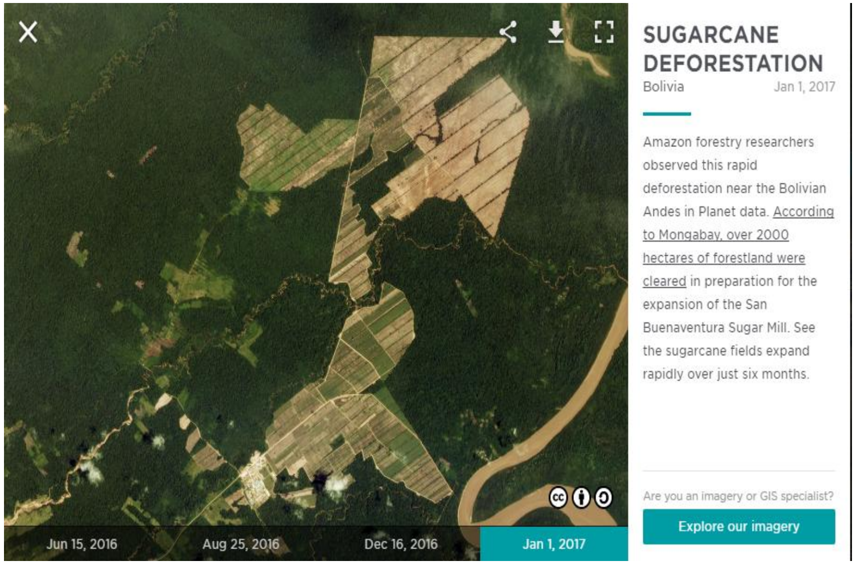


Most common nationalities of Mediterranean sea arrivals from January 2017

Country of origin	Source	Data date	Population	
Nigeria		31 Aug 2017	13.8%	16,624
Syrian Arab Rep.		30 Sep 2017	9.7%	11,654
Guinea		31 Aug 2017	8.5%	10,291
Côte d'Ivoire		31 Aug 2017	7.9%	9,544
Bangladesh		31 Aug 2017	7.3%	8,747
Gambia		31 Aug 2017	5.2%	6,294

NEW SERVICE PROSPECTS FOR SMALLSAT 2/2

- ***Security*** - The new geopolitical scenarios are pushing for growing security demand, both for civilian and military reasons. Particular emphasis should be placed on the management of migratory flows and their territorial distribution, both in terms of economic and cultural sustainability;
- ***Environment and Territory*** - Climate changes and previous environmental stress, also determined by human action, require increased attention both in monitoring and emergency management and after natural disasters.



Imagine acquired by Cubesat Doves (©Planet)

Control of Migratory Flows via Smallsat Mission

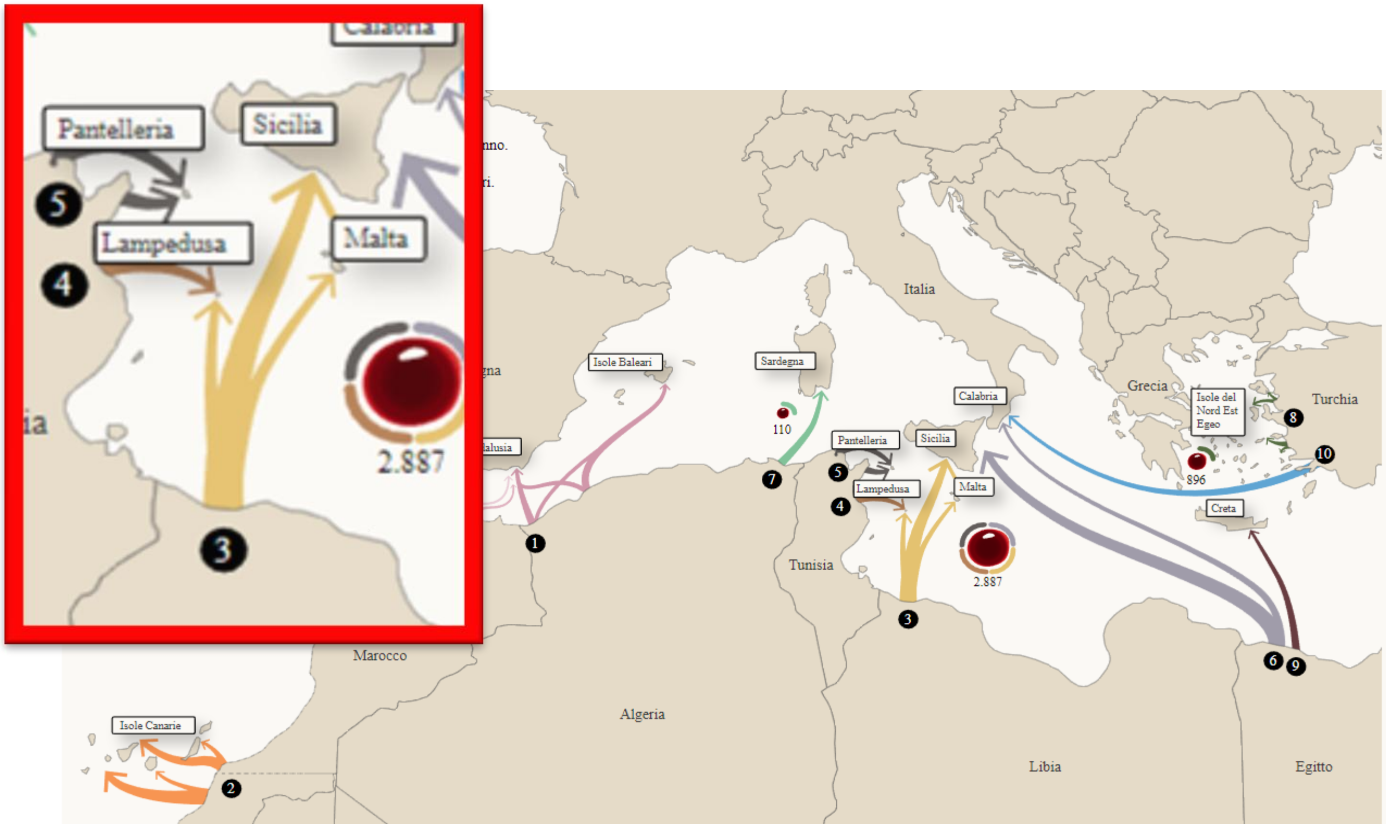
In recent years, one of the major social problems is the illegal immigration of refugees. This 'Exodus' does not concern individual states, but it involves the entire European Community at different levels:

- Humanitarian
- Safety

How to minimize or prevent a migratory stream now out of control ?
Is it possible to use smallsat platforms to support existing resources?

That is possible with smallsat mission having as a scenario of observation a portion of the Mediterranean Sea, with its sensitive areas, as a starting point for migratory flows.

Smallsat Mission – Area of Operation



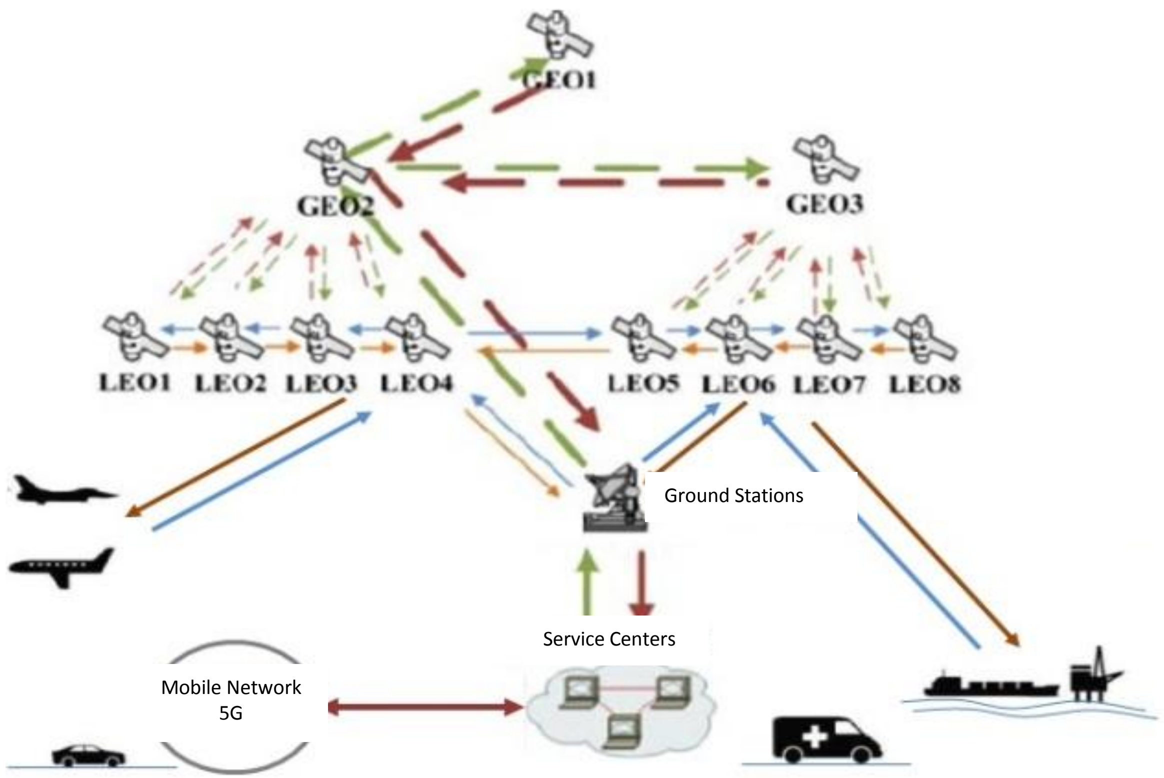
EXAMPLE OF SATELLITE MISSION

An example of a satellite mission consists of a constellation of 8 cubesat 6U that make Earth Observation with optical sensors on a helium-synchronous orbit 650-750 km away from the earth.

- Area considered: square of about 500 km per side
- Optimal orbit and Smallsat number
- No. of satellites: 8
- Inclination: 35 °
- Estimated time of observation of square area for orbit: 2.5 min
- The maximum time between one observation and another (GAP): 100 min
- Cubesat Operating Life: about 2 years

INTEGRATION WITH THE TERRESTRIAL NETWORK 5G 1/3

The Integration of the Satellite Network with the 5G Terrestrial Mobile Network can create a variety of Service and Application Opportunities for mobile users. The architectural scheme of this network is shown in the figure here below.



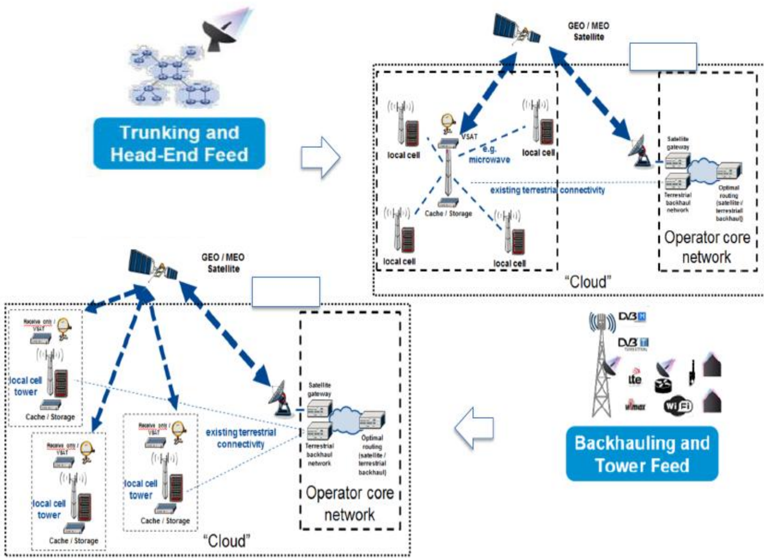
Integration with the Terrestrial Network 5G 2/3

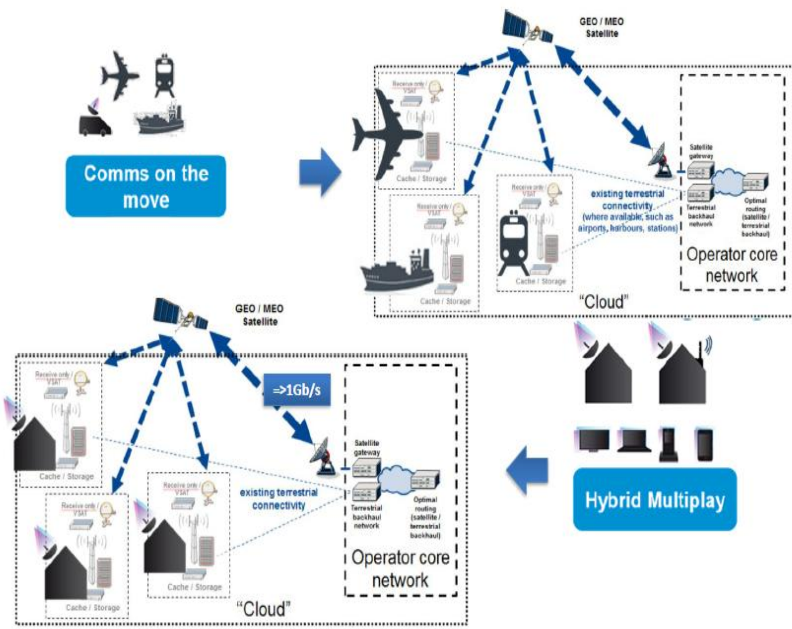
With this architecture and with Reliable Terrestrial Smart Gateways as an interface for 5G Mobile Terrestrial Network, several Services and Applications could be created, such as:

- Processing of Received Data from Smallsat;
- Dissemination of Received Data to End Users;
- Realization of Integrated Services Centers with the 5G Network;
- Data dissemination applications.

The development of new technologies in the terrestrial segment (such as low-cost and low-power satellite equipment, electronically controllable dynamic beam, phased-array satellite systems) will make the use of satellite interesting for the IoT. The future of satellite services and applications will be measured by the ability to integrate different technologies, constellations and spatial segments (GEO, MEO, LEO) with the next generation Terrestrial Network in order to reach the user directly.

INTEGRATION WITH THE TERRESTRIAL NETWORK 5G 3/3





Examples of Integration Satellite Network with the 5G Terrestrial Mobile Network

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