Satellite Systems and Future Internet

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- Satellite Role in Future Internet
- Introduction to Satellite Systems
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    - State of Art & Trends in Satellite Positioning Technology
    - Satellite Positioning Applications
- Satellite for Monitoring Systems
    - State of Art & Trends in Satellite Monitoring Technology
    - Satellite Monitoring Applications
- Trends in Satellite Systems
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Framework of Future Internet

Framework of Future Internet

- What is Future Internet?

  A concept still under way

  e.g. Future Internet Strategic Research Agenda (ICT X-ETP)

  eMobility – *wireless*

  ISI – *satellite*

  Photonics[21] – *optical communications*

  NEM – *multimedia*

  EPoSS – *smart systems*

  NESSI – *software and services*

Framework of Future Internet

➢ What must be taken into account

Speed and the dynamics of change are unprecedented

- By 2012 Internet traffic will reach ½ Zettabyte (10^{21}) 250000 times more than in 2003,
- By 2012, if current trends continue, Internet-delivered video will use more than half of the bandwidth to homes and by 2013 , online video viewers will reach 1 billion
- By 2010 the information on the net doubles approx every 11 hours
- By 2020 it will double every 11 seconds
- In 2020 you will be able to get 6 Petabytes (10^{15}) of storage for 100$
- Today, for under 500$ you get 2% of the computing power of the human brain. By 2020 will we be close to 100%?
- By 2020 the average individual's "information footprint“ will grow to 16 terabytes (10^{12}), (today we are at 1 terabyte)
- 4 Billion mobile subscribers end 2008.
- By 2011 there will be:
  - More than two billion people on the Web
  - One trillion connected objects (cars, appliances, cameras etc)

Framework of Future Internet

Video Traffic (in particular)

• Internet video traffic in North America and Europe in October 2008 exceeded the amount of traffic that crossed the entire global Internet in October 2001.
• YouTube remained the largest U.S. video source at over 30 petabytes per month. Hulu became the second largest source of Internet video traffic in the U.S. at over 15 petabytes per month.
• The volume of monthly Internet video traffic in 2008 is nearly an exabyte (10^{18}) higher than Internet video traffic during any month in 2007. In other words, monthly Internet video traffic in 2008 is 230 million DVDs higher than any month in 2007.
• Commercial video content will drive Internet video growth (i.e., video to PCs/laptops), with traffic of this type quintupling from 2008 and 2012. Commercial video content will become 80% of all Internet video viewed on PCs/laptops by 2012.
• Traffic associated with user-generated video content will triple from 2008 to 2012.

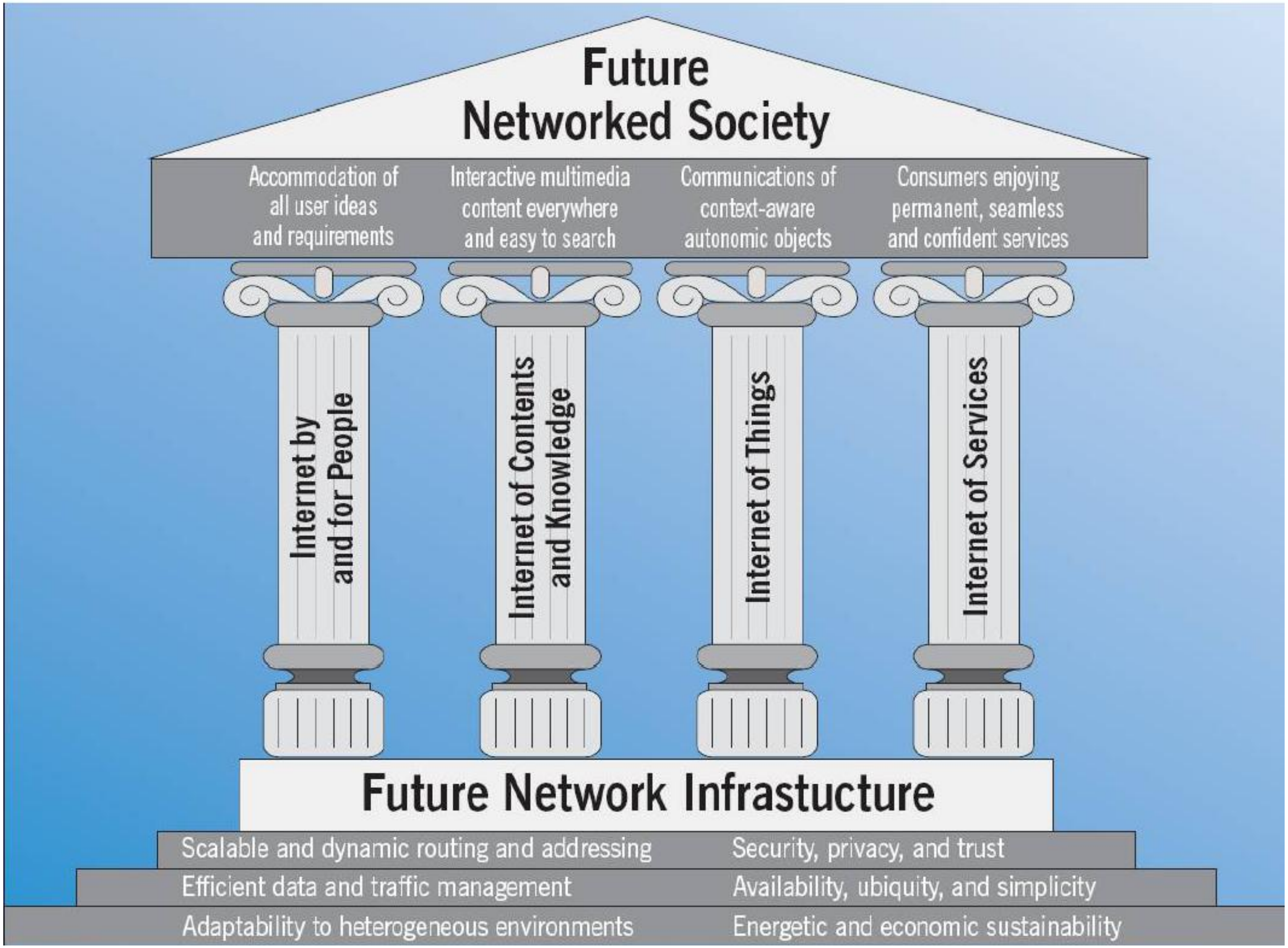
Source: http://www.cisco.com/en/US/netsol/ns827/networking_solutions_sub_solution.html

Framework of Future Internet

➢ *Concerns and questions are numerous*

•Growth in societal use and dependence on the Internet creates pressure to constrain what can happen at end-points or to track behavior, potentially from within the network.
•Current architecture is wide open to security breaches, privacy invasion and identity theft
•"Generative" properties of the net are resisted by the "establishment". Innovation risks being stifled.
•We witness the emergence of parallel, heterogeneous architectures, whose interoperability is diffifficult if not impossible to ensure, operate or maintain.
•Will the current infrastructures be able to handle scalability, mobility and bandwidth demands?
•Will the infrastructure be able to handle the expected service provisioning demands?

Framework of Future Internet (Vision)



Framework of Future Internet

The following 14 challenges

1) **Routing and addressing, scalability** :
    a. scalability of routing system,
    b. information-driven routing
    c. addressing and routing information management.
2) **Resource and data/traffic manageability** :
    a. configuration and upgrade management
    b. problem detection and root cause analysis
    c. network resource sharing and control
    d. seamless continuity between all networks
    e. event-driven architecture
    f. radio networks
    g. optical networks
    h. satellite networks
    i. exaflood management.
3) **Security, privacy, trust and accountability**:
    a. security
    b. privacy
    c. trust

Framework of Future Internet

The following 14 challenges (cnt'd)

4. **Availability, ubiquity, and simplicity**:
   a. resiliency against normal accidents and failures
   b. fast convergence/recovery of routing systems
   c. global connectivity coverage availability
   d. availability and reliability even in critical emergency situation
   e. quality of experience.
5. **Adaptability :**
   a. web 3.0
   b. seamless socialisation
   c. industry mobility
   d. adaptive interaction
6. **Operating system, application and host mobility / nomadicity**:
   a. cloud OS
   b. embedded OS
   c. cloud computing
7. **Energetic sustainability**:
   a. energy harvesting
   b. energy storage
   c. energy-efficient protocols.

Framework of Future Internet

The following 14 challenges (cnt'd)

8. **Conflicting interests and dissimilar utility**: Stakeholders positioning.
9. **Searchability/localisation**: Search engines.
10. **Beyond digital communication**:
    a. 3D communications
    b. behavioural communication
11. **Internet by and for people**:
    a. enabling e-applications
    b. social, economical, legal and cultural viability
12. **Internet of contents and knowledge**:
    a. virtual environment or virtual and augmented reality.
13. **Internet of things**:
    a. intelligence/smart and harsh environment and integration into material
14. **Internet of services**: open service platform

In few words: Anywhere, Anytime, Anymedia, Anything for Anyone

Satellite Role in Future Internet

Satellite Role in Future Internet

Satellite Communications (SatCom) systems provide the foundations of European and worldwide digital information networks. They refer to any system providing communication services via satellite. It encompasses stand-alone SatCom systems as well as solutions integrating SatCom with terrestrial access technologies. SatCom systems deliver their broadcast, broadband and narrowband services to fixed, portable and mobile terminals. They are based on Geostationary (GEO), Medium (MEO) or Low Earth Orbiting (LEO) satellite constellations and can operate in low frequency bands (<3 GHz, such as UHF, L and S band) or in higher frequency bands (> 3 GHz, such as C, X, Ku, Ka, Q and V bands). SatCom systems cover all the earth including north and south poles.

Source: Future Internet X-ETP Group Research Agenda v.1.0

Satellite Role in Future Internet

In the Future Internet, the role of Satellite Communications will be enlarged to provide global connectivity coverage to support the ambition of service continuity. Indeed, Satellite Communications inherently offer three undisputable characteristics:

- **All the time**: as a dependable solution, Satellite Communications are the key element to ensure a service continuity under natural or man made disasters. Given the increasing importance of Internet in our society, great emphasis will be given on robustness of the Future Internet infrastructure requiring a smart integration of Satellite Communications.
- **Everywhere**: thanks to their global coverage, Satellite Communications are the most economical access technology in low density populated areas (typically below 50 inhabitants/km^2) which represent more than 10% of European population distributed over 50% of the territory. Satellite Communications are therefore the key technology to fulfil the right of all citizens, being either fixed, mobile or nomadic onboard vessels, trains, cars or aircrafts, to have access to the Future Internet. They are also expected to play a big role in the emerging field of machine-to-machine communications, given their great scalability for low-traffic terminals.
- **Anything**: thanks to their global coverage, Satellite Communications are the key solution to connect all kinds of objects, such as, sensors, machines, devices, handsets, terminals, gateways, etc, thus constituting a cornerstone for the future Internet of Things.
- **Anymedia:** all kind of information

Satellite Role in Future Internet

In addition to the the current and traditional services offered by satellites:

- communications (broadcast, broadband including backhaul, mobile)
- positioning/navigation
- remote sensing

➢Hybrid terrestrial/satellite communication systems towards interoperability within NGN for ubiquitous coverage, even in emergency scenarios;

➢Integration of Satellite Communications (SatCom), Global Navigation Satellite Systems (GNSS) and Earth Observation (GMES) system components within the Future Internet:

- The development of a global security system which encompasses hybrid terrestrial/satellite-based communication, localization/navigation and remote sensing capabilities is essential for Future Internet.

➢Reconfigurable and interoperable terminal devices to adapt in the emergency scenarios:

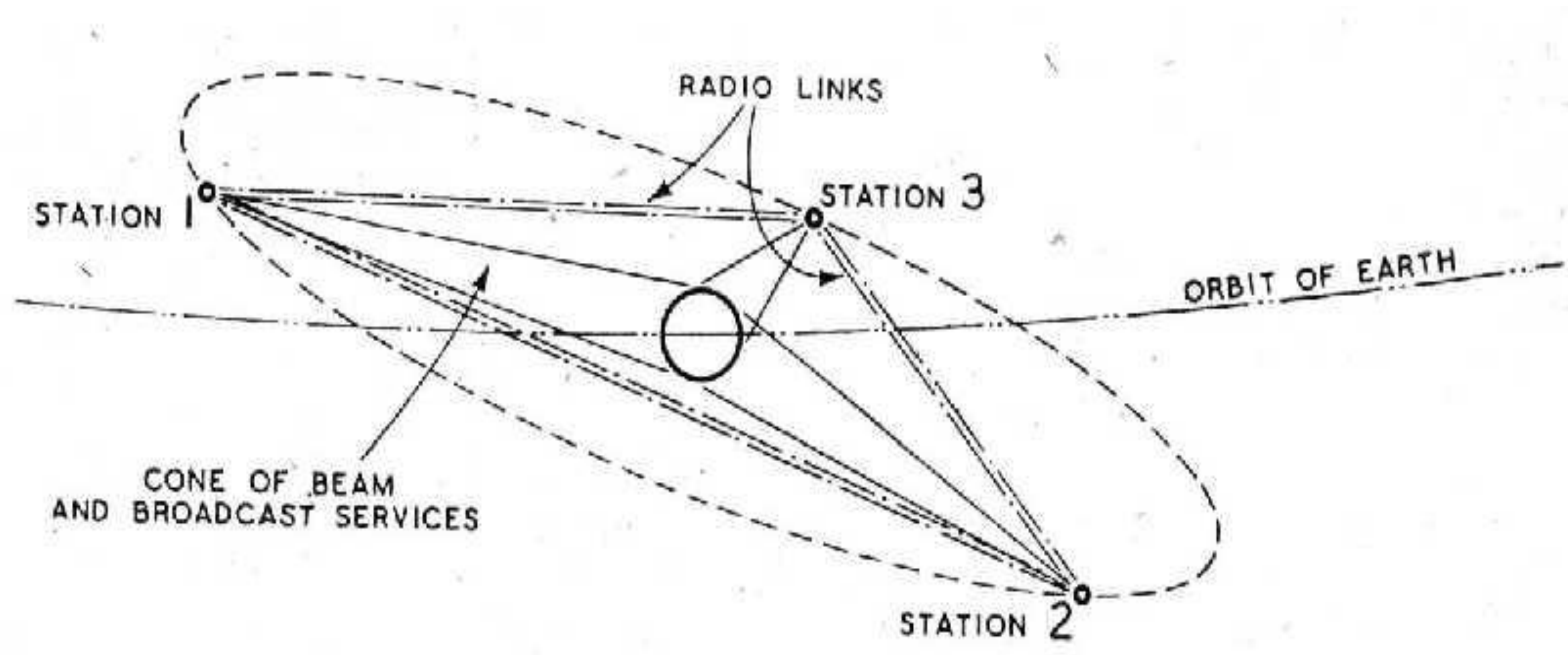
- A fully software controlled handset will have to reconfigure itself to cope with any communication, navigation, and remote sensing related requirements and services.

➢Robust crisis management communication mechanisms with self-healing and auto-configuring capabilities.

Introduction to Satellite Systems

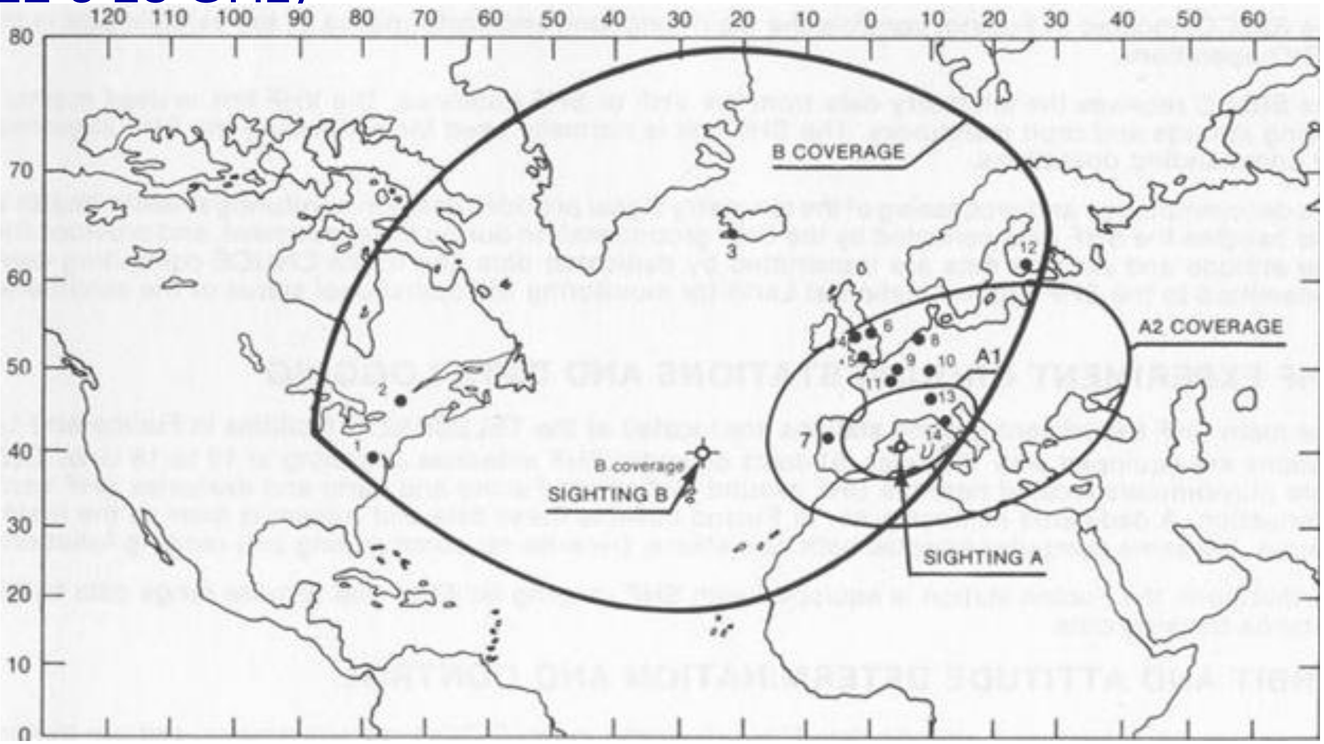
A bit of history

A.C. Clarke (1945) proposed the use of three geostationary satellites to provide radio communications all over the world..



A bit of history (cnt'd)

1965: *Early Bird* (INTELSAT I) first commercial communications satellite, with a capacity of 240 telephone circuits between Europe and USA at C band (4-6 GHz)
1964: launch of the first Italian experimental telecommunications satellite, San Marco 1.
1977: launch of the Italian experimental telecommunications satellite SIRIO (12 e 18 GHz)



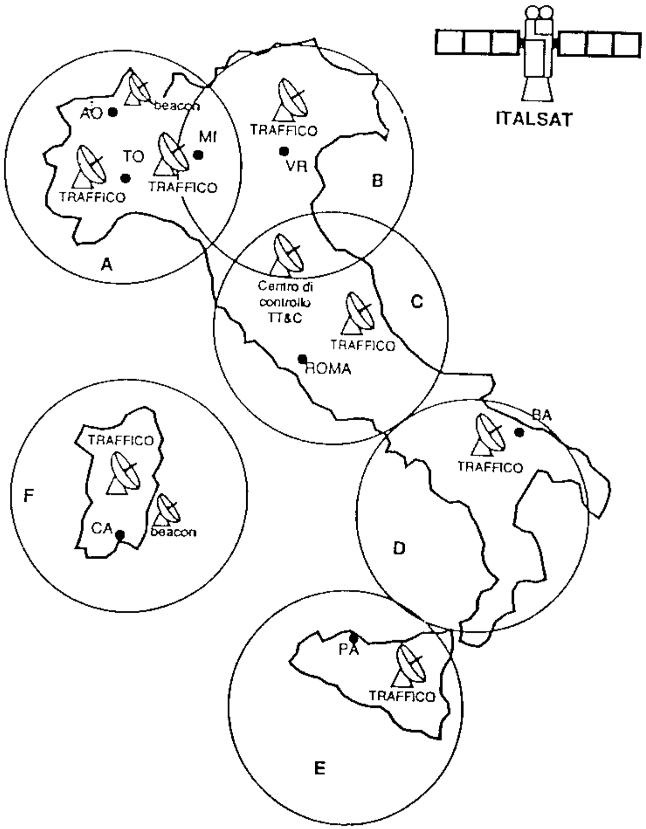
SIRIO coverage

A bit of history (cnt'd)

1991 e 1996: launch of the 1st and 2nd units of the ITALSAT

- new bands Ka (20-30 GHz) for operational use
- multi spot antennas
- regenerative on-board transponders
- on-board switching system with SS-TDMA (Satellite Switched Time Division Multiple Access)
- measurement of propagation characteristics of new frequency bands (40-50 GHz)
- ITALSAT was the most ambitious telecommunications Italian space programme
- before the similar US ACTS satellite (1993)

A bit of history (cnt'd)



Coverage of Italy by six ITALSAT spot beams

A bit of history (cnt'd)

Today:

- *CosmoSkyMed* for Earth observation
- *Galileo* UE programme
- *SICRAL 1A and SICRAL 1B* for military use
- participation to *Iridium* and *Globalstar* systems for mobile services

More info: G. Tartara, F.Marconicchio, TELECOMUNICAZIONI SPAZIALI, in *STORIA DELLE TELECOMUNICAZIONI,* in c.d.s. a cura della Conferenza dei Presidi di Ingegneria.

Satellite characteristics

- Coverage
  - Global, Regional, Spot
  - Delivery cost independent from number of users
  - Broadband Broadcasting
- Availability (fixed)
  - Line of sight
  - High elevation angles
- Interactivity (in perspective)
  - Traffic asymmetry
  - Shared uplink capacity → Limited population of users
  - Multicast capability

Satellite Orbits

- Telecommunication satellites orbits:
  - Geosynchronous Orbit
    - An orbit directly above the Earth's equator (0° latitude), with a period equal to the Earth's rotational period and an orbital eccentricity of approximately zero. A satellite in such an orbit is at an altitude of approximately <u>35.786 Km</u> above mean sea level.
  - Low Earth Orbit
    - An orbit around Earth between the atmosphere and below the inner Van Allen radiation belt. Given the rapid orbital decay of objects below approximately 200 km, the commonly accepted ranging altitude for LEO is between <u>160 – 2000 Km</u> above the Earth's surface.
  - Molniya Orbit
    - A highly <u>elliptic</u> orbit with inclination of 63.4° and orbital period of half of a sidereal day (roughly 12 hours). Such a satellite spends most of its time over a designated area of the planet.

Satellite Radio Channel

- Frequency bands (L,S,C,Ku,Ka)
- Large path losses (in particular for GEO)
- Ionospheric scintillation, rain fading (Ka), interference with other terrestrial services
- Need of bandwidth (C saturated, Ku close to saturation, Ka current perspective, higher frequency bands in the future)

Satellite Channel Models (mobile)

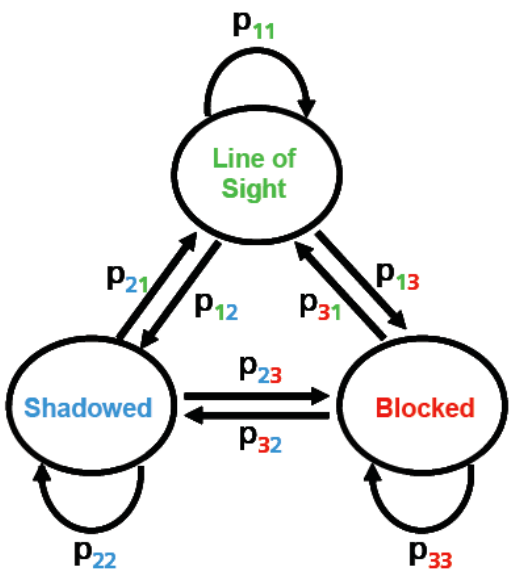
The transmission performance of the mobile satellite systems is mainly impaired by rapid amplitude and phase fluctuations of the received signal.

The main causes of these fluctuations are:

- multipath fading;
- shadowing (time varying attenuation).

The statistical properties of these signal variations are closely related to the considered propagation environment – 3 main different channel conditions:

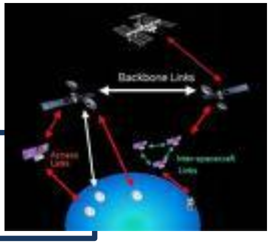
- **Line of Sight (LOS):** satellite-terminal direct link (Rice Distribution) ;
- **Shadow (NLOS):** absence of satellite-terminal direct link (Log-Normal Distribution);
- **Blocked:** no signal is received from the satellite.



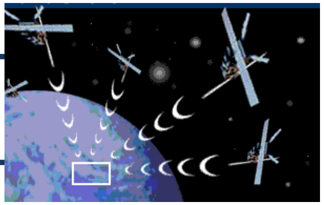
The Role of Satellite

The satellite technologies can be classified according to their purpose:

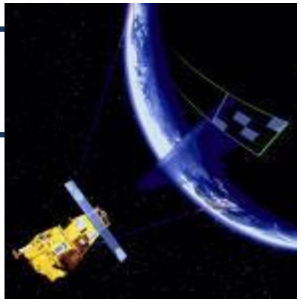
Communication



Positioning



Monitoring



Communication (broadcast), Positioning and Monitoring are complementary capabilities and their integration is very important.

Satellite for Fixed and Mobile Communications

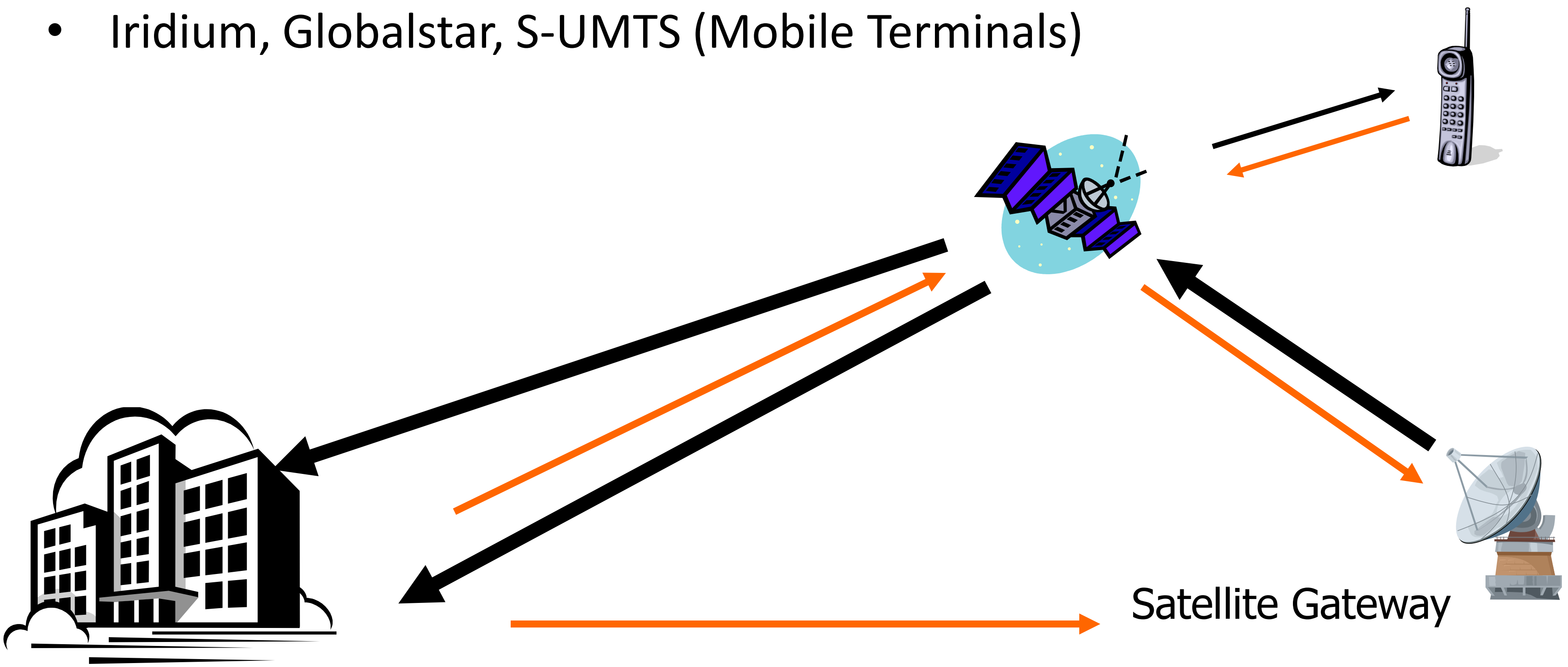
- State of Art & Trends in Satellite Communications Technology
- Satellite Communications Applications

Forward and Reverse Link

- Traditional satellites for telephony have symmetrical capacity

For data services (including digital TV)

- Return channel via PSTN
- Return channel via satellite
- Iridium, Globalstar, S-UMTS (Mobile Terminals)

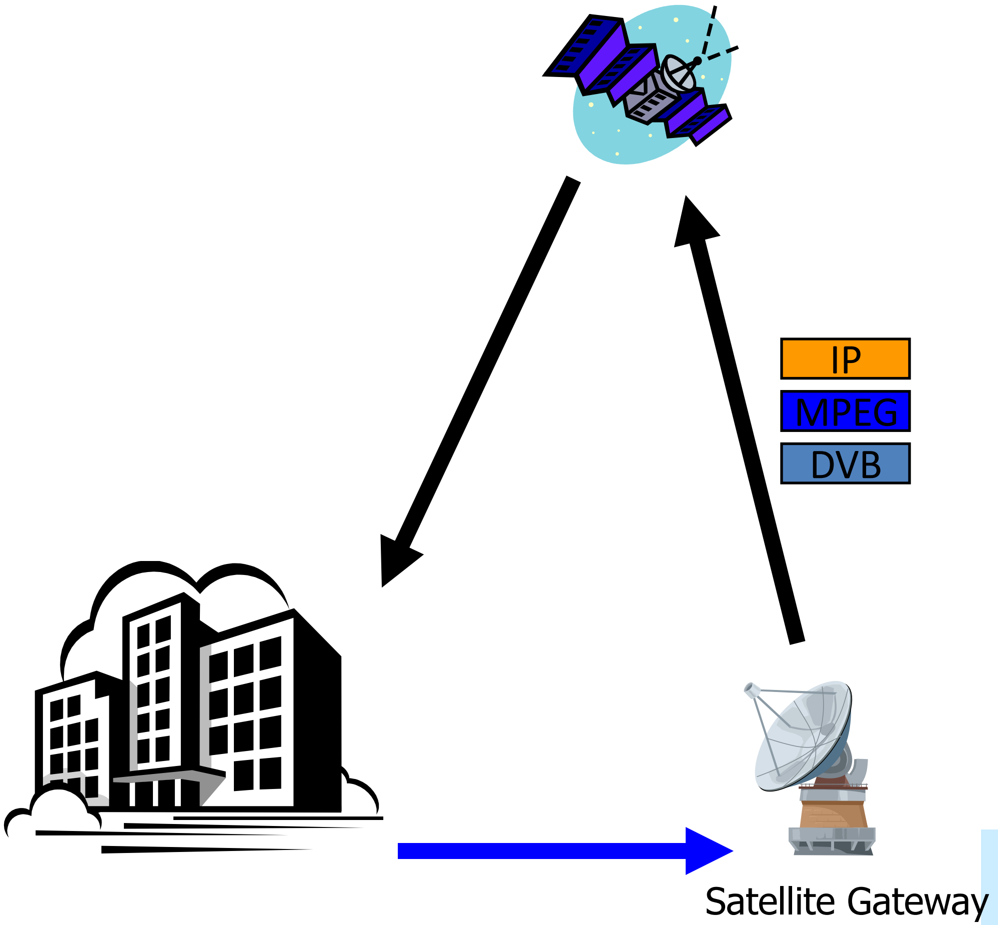


Satellite access modalities

- Receiving only (DVB-S)
  - Multicast delivery w/o return link
  - Terrestrial return link
- Two-Way access
  - VSAT (symmetry, transparent satellites)
  - DVB-RCS (asymmetry, switching sats)
  - S-UMTS (asymmetry, terrestrial mobiles)

Receiving only sat access

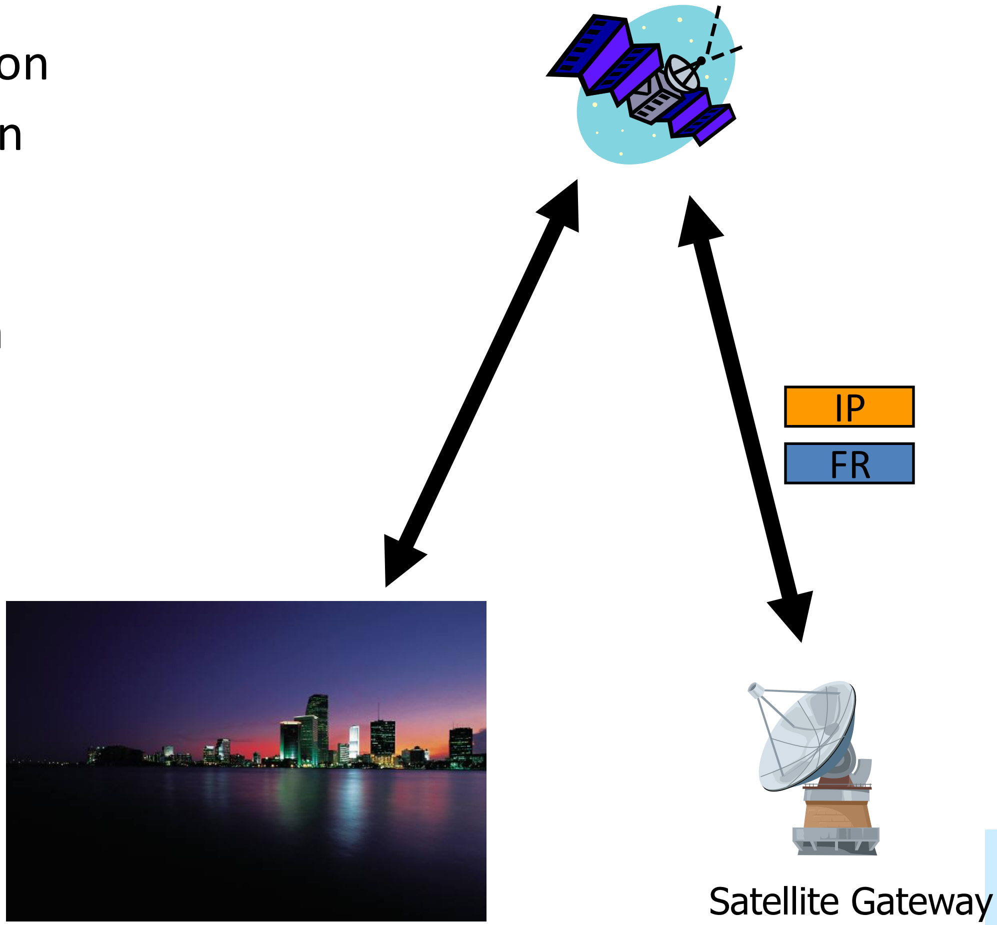
- IP encapsulation on MPEG Transport Stream
- FEC Techniques
- Low cost terminal



- **Terrestrial Return Link**
- **Large Asymmetry**

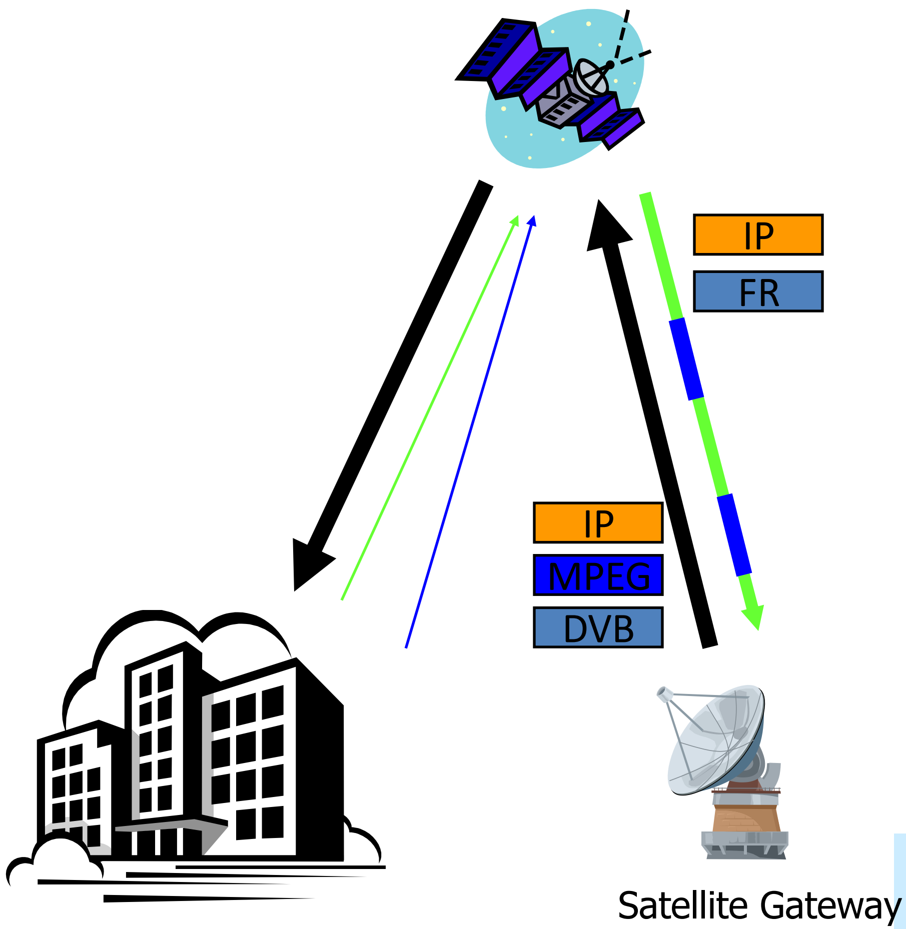
Two-Way Access: VSAT

- Proprietary multiple access technique based on MF-TDMA
- Native Frame Relay encapsulation
- High cost terminal depending on desired link capacity
- Transparent satellite (mostly)
- Master-based access regulation



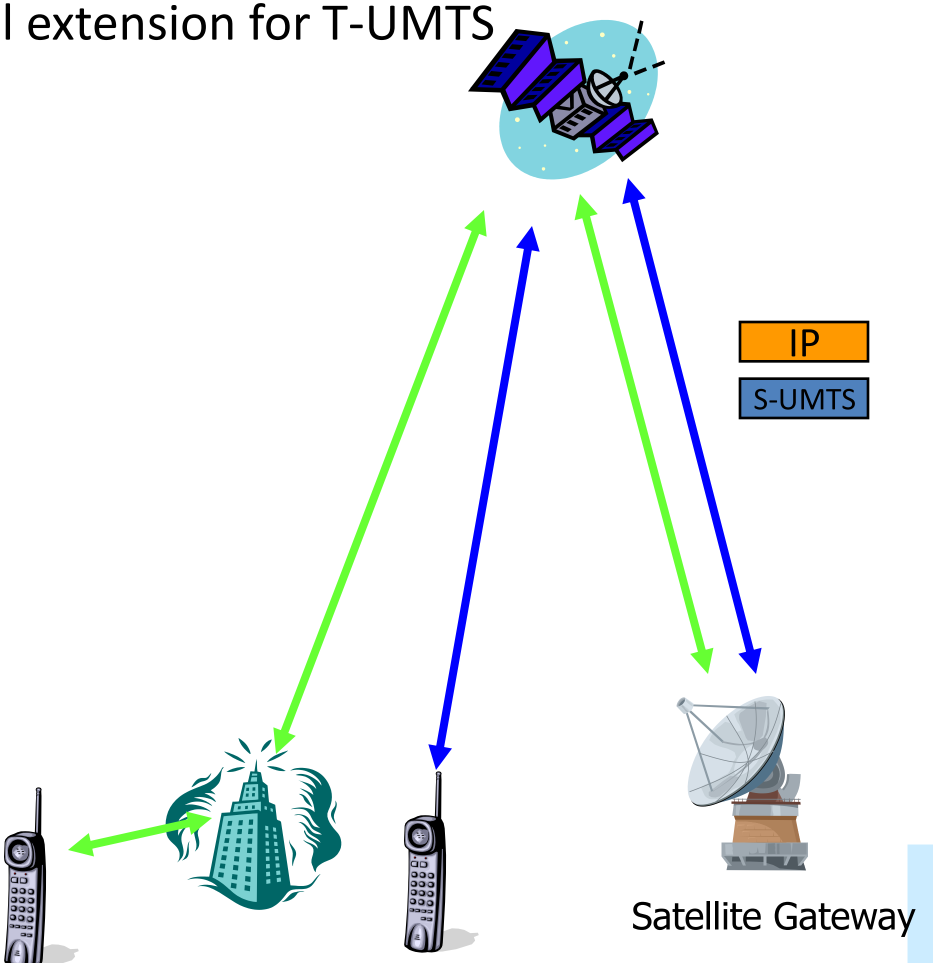
Two-Way Access: DVB-RCS

- Standard multiple access technique based on MF-TDMA
- DVB encapsulation (forward), Frame Relay (return)
- Low cost terminal
- Switching Satellite
- Master-based access regulation



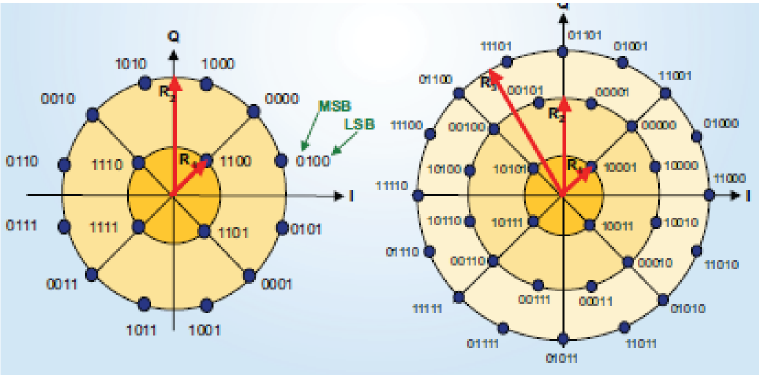
Two-Way Access: UMTS

- Standard multiple access technique based on CDMA
- Terrestrial repeater
- Service Integration and geographical extension for T-UMTS
- Switching Satellite
- Various orbits



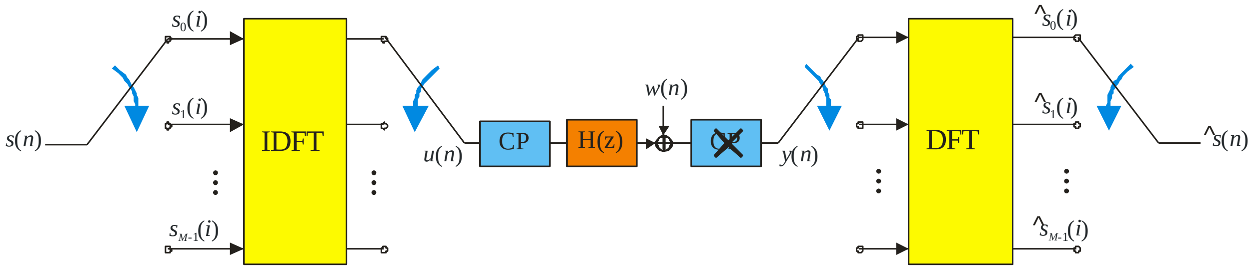
Digital Modulations for SatCom

- M-ary Amplitude and Phase Shift Keying Modulation (M-APSK)
  - High spectral efficiency
  - QPSK for DVB-S



16 APSK 32 APSK

- Continuous Phase Modulation (CPM)
  - Robustness against transponder non linearities: <u>constant envelope modulation</u>
  - Good Spectral properties Mitigation of ACI (Adjacent Channel Interference)
- Orthogonal Frequency-Division Multiplexing (OFDM)
  - Multicarrier technique, with orthogonal subcarriers

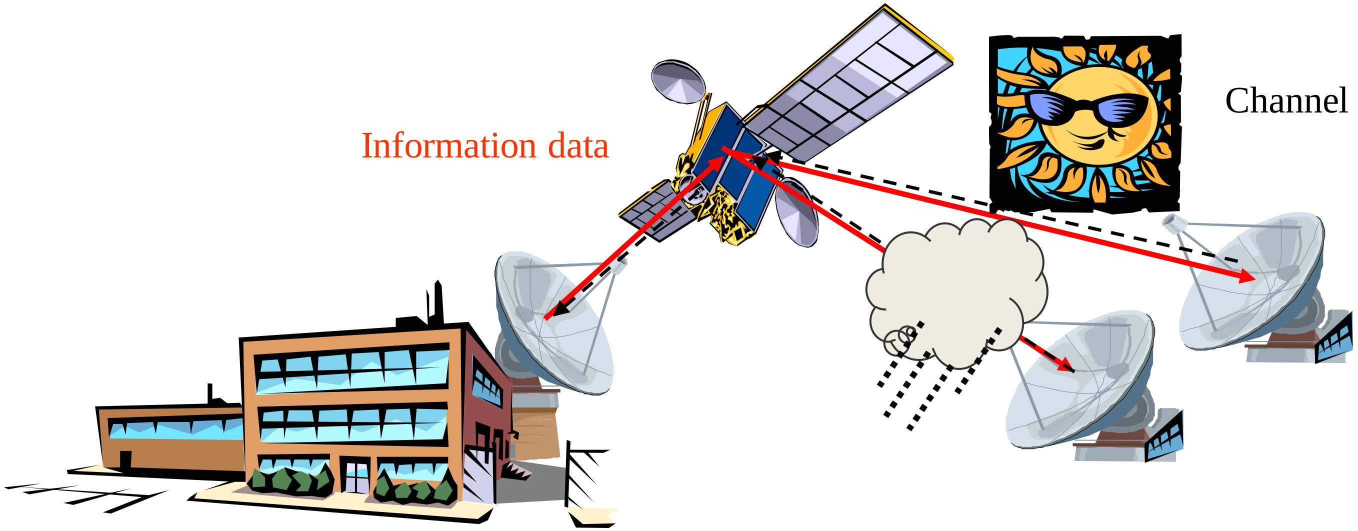


Channel Coding for Satcom

- LDPC (Low Density Parity Check) Codes
  - Block codes
  - Defined in terms of a sparse parity check matrix
  - Regular vs. irregular LDPC
  - Decoding based on a probability-based message-passing algorithm
- Turbo Codes
  - Parallel Concatenated Convolutional codes
  - Encoder based on two or more constituent codes
  - The decoding algorithm involves iterative decoding
  - This decoding algorithm is based on the MAP approach
- 3D Turbo Codes
  - The number of Component encoder increases
  - Combining parallel and serial concatenation

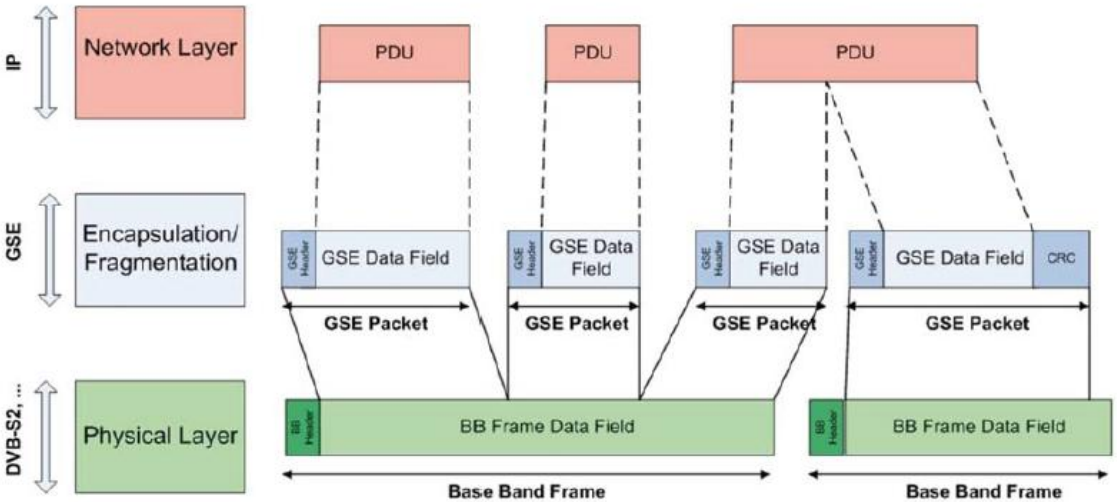
ACM (Adaptive Coding and Modulation)

- The ACM functionality allows the use and the change of <u>different modulation formats and different coding rates</u> on a frame-by-frame basis within the transmitted data stream.
- By means of a return channel, informing the transmitter of the actual receiving conditions, the transmission parameters may be optimized for each individual user, <u>depending on path conditions</u>.
- Powerful tool to increase system capacity.



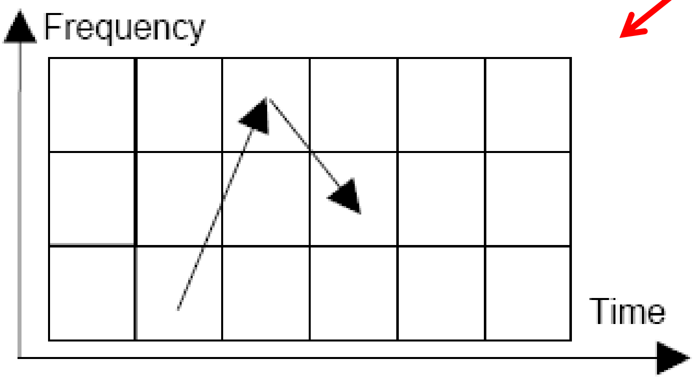
Generic Stream Encapsulation

- GSE protocol is devised as an adaptation layer able to provide network layer packet encapsulation and fragmentation functions over Generic Stream.
- GSE provides an efficient encapsulation of IP datagrams over variable length Layer 2 packets.
- GSE maximises the efficiency of IP datagrams transport reducing the overhead by a factor 2 to 3
- GSE Packets have variable length, in order to match the input IP traffic with minimum overhead.

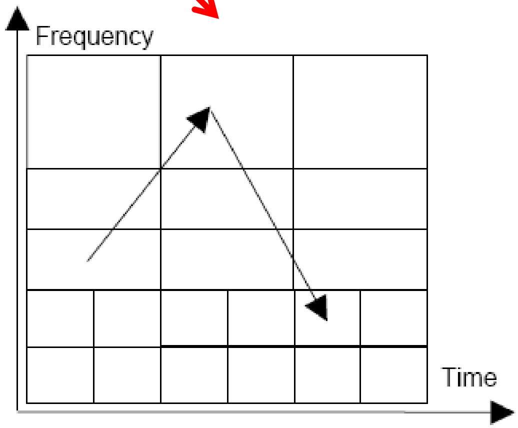


Multiple Access for SatCom

- Multi-Frequency Time Division Multiple Access (MF-TDMA)
  - MF-TDMA allows a group of satellite users to communicate with a Gateway using a set of carrier frequencies, each of which is divided into timeslots.
- The NCC allocates to each active satellite user a series of bursts, each defined by a frequency, a bandwidth, a start time and a duration.
- MF-TDMA scheme can be either fixed-slot or dynamic-slot.



Bandwidth and duration of successive traffic slots are fixed



Bandwidth and duration of successive slots allocated to a user can vary

Mobile Satellite Communications

- **Globalstar** and **Iridium** are the two main mobile satellite communication systems which allow satellite phone call and low-speed data communications; they both rely on Low Earth Orbit (LEO) constellations.

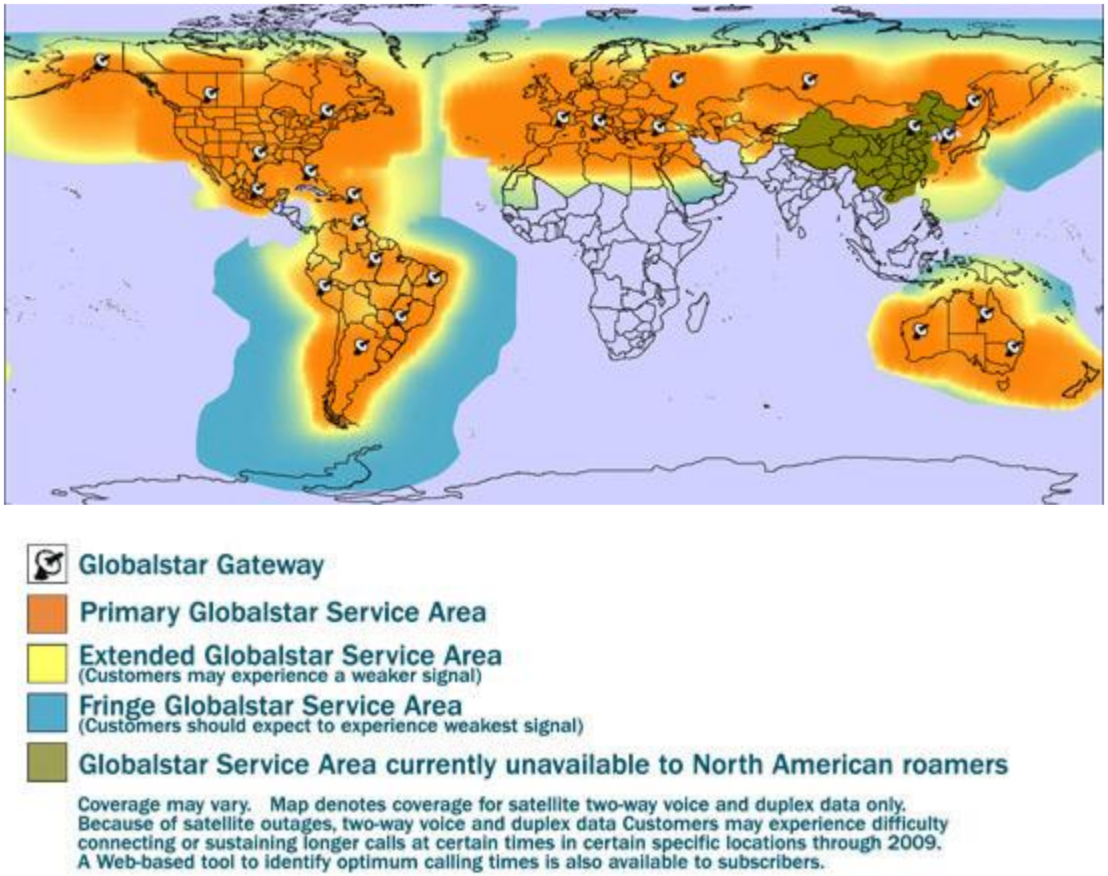
- With over 315,000 subscribers (as of June 2008), Globalstar is the world’s largest provider of mobile satellite voice and data services.

- Iridium has the most reliable, truly global mobile voice and data satellite communications network available.

Mobile Satellite Communications

Iridium is an autonomous system connecting users directly by the satellite network (switching satellites and ISL), i.e. does not rely nor depend on terrestrial infrastructures. The voice codec used is called Advanced Multi-Band Excitation. Latency for data connections is around 1800 ms round-trip, using small packets. Despite the bandwidth limitations, transparent TCP/IP is supported. Actual data rates remain at 2300 to 2400 bps for any compressed data such as a JPG image or ZIP file, but plain text or HTML may transfer "up to" 10kbps.

Globalstar Coverage and Gateways



- Globalstar satellites are simple "bent pipe" repeaters. A network of ground gateway stations provides connectivity from the 40 satellites to the public switched telephone network and Internet; users are assigned telephone numbers on the appropriate telephone numbering plan for the country that the overseas gateway is located in. Due to the lack of inter-satellite linking, a satellite must have a gateway station in view to provide service to any users it may see.

Satellite Telecommunication Applications

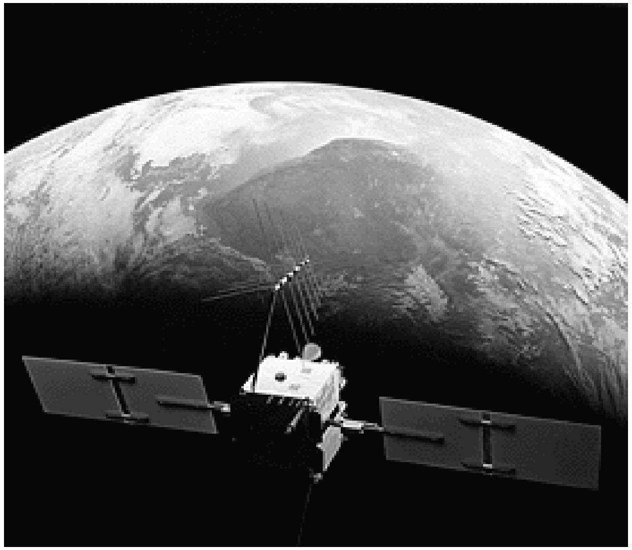
- Main Telecommunication Commercial Services:
  - Satellite systems for digital broadcasting (fixed and mobile services)
    - DVB-S/S2: open standard (Ku/Ka band)
    - DVB-SH: open standard (S band, frequencies below 3GHz)
  - Satellite systems for interactive services (fixed and mobile services)
    - IPoverSatellite: proprietary system (Ku band)
    - SurfBeam: proprietary system (Ku/Ka band)
    - DVB-RCS: open standard (Ku/Ka band)
    - DVB-RCS+M: open standard (railways, aircraft, ship, land-vehicular scenarios)

Satellite for Positioning Systems

- State of Art & Trends in Satellite Positioning Technology
- Satellite Positioning Applications

What is the GPS?

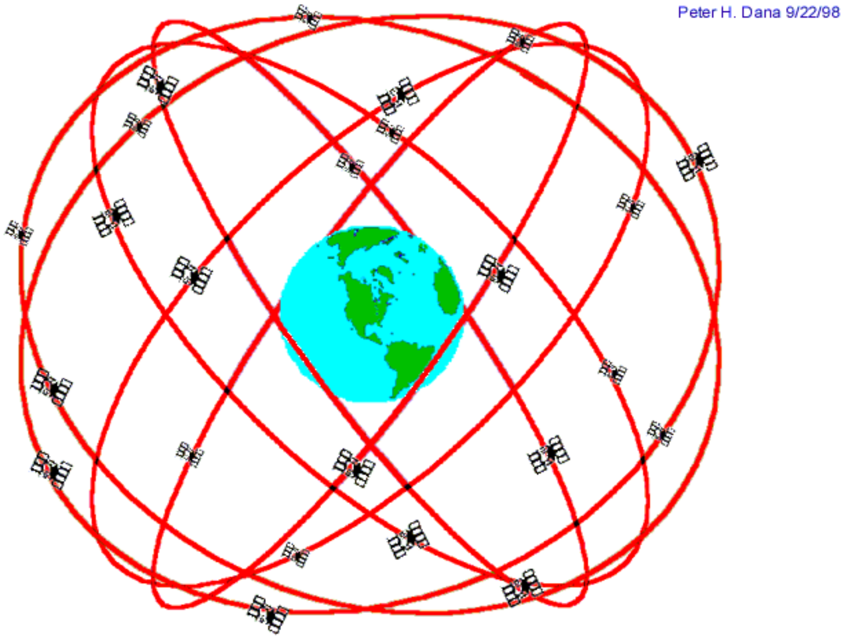
- Orbiting navigational satellites
  - Transmit position and time data
- Handheld receivers calculate
  - latitude
  - longitude
  - altitude
  - velocity
- Developed by US Department of Defense



Components of the System

Space segment

- 24 satellite vehicles
- Six orbital planes
  - Inclined 55° with respect to equator
  - Orbits separated by 60°
- 20,200 km altitude above Earth
- Orbital period of 11 hr 55 min
- Five to eight satellites visible from any point on Earth



GPS Nominal Constellation
24 Satellites in 6 Orbital Planes
4 Satellites in each Plane
20,200 km Altitudes, 55 Degree Inclination

GPS Satellite Vehicle

- Four atomic clocks
- Two solar panels
  - Battery charging
  - Power generation
  - 1136 watts
- S band antenna for satellite control
- 12 element L band antenna for user communication

GPS Satellite Vehicle

- Weight
  - 1.075 tons
- Height
  - 5 m
- Width
  - 12 m including wing span
- Design life—10 years

Components of the System

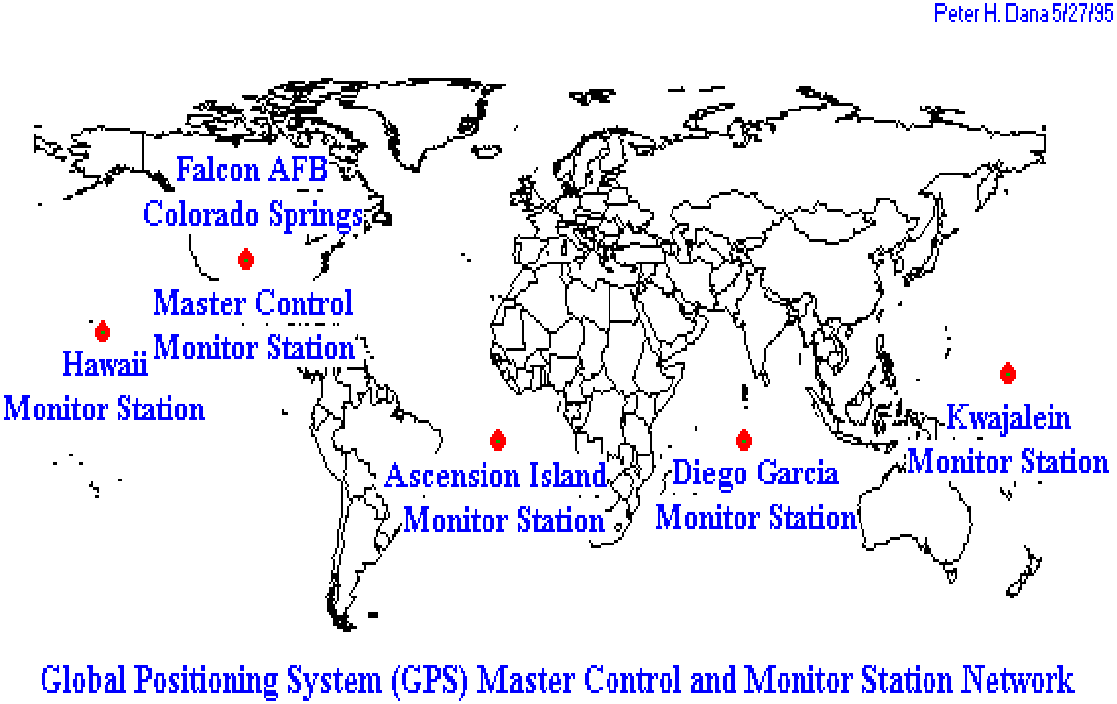
User segment

- GPS antennas & receiver/processors
- Position
- Velocity
- Precise timing
- Used by
  - Aircraft
  - Ground vehicles
  - Ships
  - Individuals

Components of the System

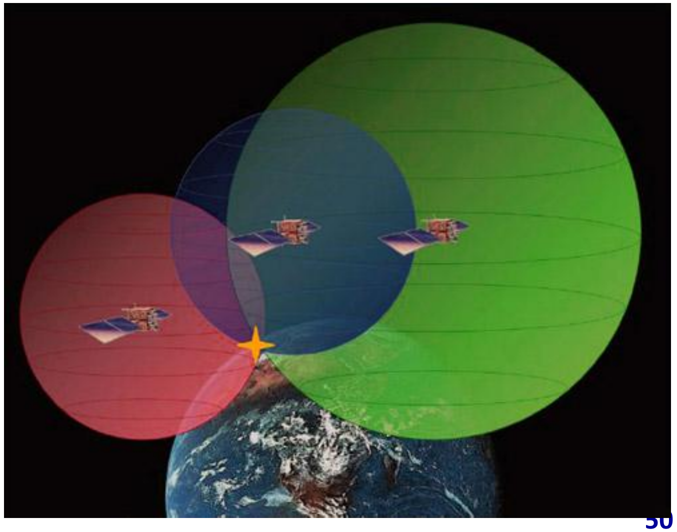
Ground control segment

- Master control station
  - Schreiver AFB, Colorado
- Five monitor stations



How does GPS work?

- A pseudo-random complex code is assigned to each satellite and transmitted on the same frequency
- Distance to a satellite is determined by measuring how long the radio signal takes to reach us from that satellite.
- To make the measurement we assume that both the satellite and our receiver are generating the same pseudo-random codes at exactly the same time.
- By comparing how late the satellite's pseudo-random code appears compared to our receiver's code, we determine how long it took to reach us.



How does GPS work?

- To use the satellites as references for range measurements we need to know exactly where they are.
- GPS satellites orbits are very predictable.
- All GPS receivers have an almanac programmed into their computers that tells them where in the sky each satellite is, every moment.
- Minor variations in their orbits are measured by the Department of Defense.
- The error information is sent to the satellites, to be transmitted along with the timing signals.

System Performance (civilian use)

- Initial Performance
  - 100 meters horizontal accuracy
  - 156 meters vertical accuracy
  - No user fee or restrictions
- Present performance
  - 22 meters horizontal accuracy
  - 27.7 meters vertical accuracy
- Selective availability
  - Intentional signal degradation controls availability of system full capabilities
  - Only outdoor with satellites visibility

DGPS-Differential Global Positioning System

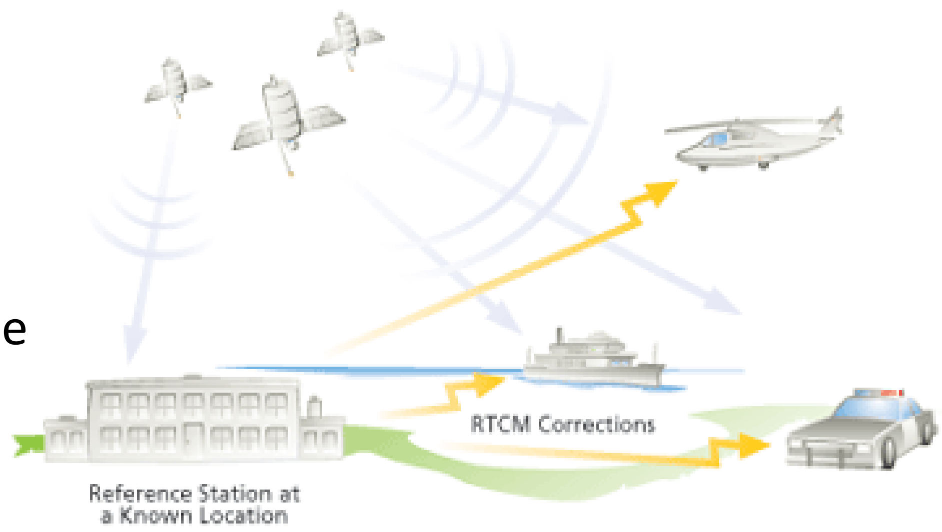
Differential Global Positioning System (DGPS) was developed with the aim to further improve the GPS accuracy.

DGPS uses a network of fixed, ground-based reference stations to broadcast the difference between the positions indicated by the satellite systems and the known fixed positions.

These stations broadcast the difference between the measured satellite pseudoranges and actual pseudoranges.

Therefore the receiver stations may correct its pseudoranges by the same amount.

DGPS is particularly helpful when atmospheric conditions interfere with reception.



DGPS System Performance

The use of a DGPS system permits to improve the GPS performance. In particular, even though the accuracy is a function of the distance from the ground station, the DGPS system can achieve:

- 7.6 meters horizontal accuracy
- 7.6 meters vertical accuracy

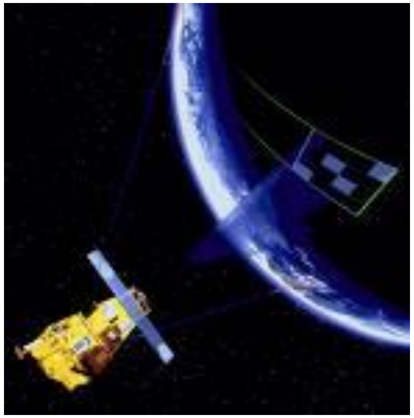
Satellite for Monitoring Systems

- State of Art & Trends in Satellite Monitoring Technology
- Satellite Monitoring Applications

Satellite for Monitoring Systems

Monitoring systems is becoming increasingly important both for understanding the environment and managing disasters.

The role of Satellite in Monitoring systems



The use of satellite for monitoring systems represented a breakthrough especially in the observation of large scale phenomena.

The satellite displays several specific properties in the framework of monitoring systems. In particular such characteristics are due to:

- Satellite-Space coverage → Capability of monitoring areas characterized by different levels of extension coverage (regional, national, earth and space level).
- Satellite-Time coverage → Capability of monitoring for long periods of time, highlighting changes occurring gradually.

Space and Earth Monitoring for … (I)

Environmental changes

Satellite images permit to monitor and forecast environments changes in:

▪ Land	→	Satellite sensors enable the global classification of land surface and can also be used to precisely measure surface topography.
▪ Oceans	→	Sea surface temperature measured from space is the most accurate means of discerning the extent of global warming and tracking ocean steams circulation.
▪ Ice	→	Entire cryosphere continuous monitoring enables to control alterations in response to climate and warning signs of changes in snow or ice reflectivity.
▪ Atmosphere	→	Space-based atmospheric sensors enable the 3D atmosphere mapping, with high-resolution cross-sections of chemicals, dust particles and clouds.

Space and Earth Monitoring for … (II)

Safety and Security

Satellite images permit to improve the safety and security of the citizen, monitoring crisis and assessing natural disasters both for:

- Emergency Response →

Civil Protection assistance. The wide-view satellite imagery enable the observation of the disasters effects (due to floods, volcanic eruptions, oil spills or earthquakes). This information represents the sources for planning and coordinating emergency responses .

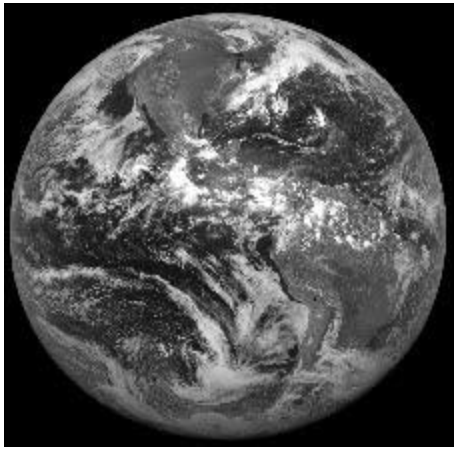
- Public Safety →

Humanitarian aid support. Satellite images can serve as a source for operational planning, such as timely distribution of emergency food and medicine or deciding emergency evacuation routes for personnel.

Epidemiology understanding. Satellite data can help forecasting disease outbreaks. This is very important, for example, in areas prone to malaria epidemics, where local environmental factors impact on the character of outbreaks (increase of rainfall and temperature levels).

Weather Monitoring Systems

- Weather monitoring and forecasting was one of the first civilian applications of satellite remote sensing (TIROS-1, launched in 1960 by the US).
- In 1966, NASA launched the geostationary ATS-1 which provided **hemispheric images** of the Earth's surface and cloud cover every half hour: the temporal resolutions were generally quite high, providing frequent observations of the Earth's surface, atmospheric moisture, and cloud cover, which allows for near-continuous monitoring of global weather conditions, and hence - forecasting.



Land Monitoring Systems

- Although many of the weather satellite systems are also used for monitoring the Earth's surface, they are not optimized for detailed mapping of the land surface.
- The first satellite designed specifically to monitor the Earth's surface, Landsat-1, was launched by NASA in 1972.
- **Landsat** was designed as an experiment to test the feasibility of collecting multi-spectral Earth observation data from an unmanned satellite platform.
- In 1985, the program became commercialized, providing data to civilian and applications users

Land Monitoring Systems

- All Landsat satellites are placed in near-polar, sun-synchronous orbits.
- The first three satellites have an altitude around 900 km and have periods of 18 days while the later satellites are at around 700 km and have periods of 16 days. All Landsat satellites have equator crossing times in the morning to optimize illumination conditions.
- A number of sensors have been on board the Landsat series of satellites, including the **Return Beam Vidicon (RBV)** camera systems, the **MultiSpectral Scanner (MSS)** systems, and the **Thematic Mapper (TM)**.
- The **TM** sensor provides seven spectral bands higher spatial and radiometric resolution and an increase in the number of detectors per band. Spatial resolution of TM is 30 m for all but the thermal infrared band which is 120 m. All channels are recorded over a range of 256 digital numbers (8 bits).

Land Monitoring Systems

TM Bands

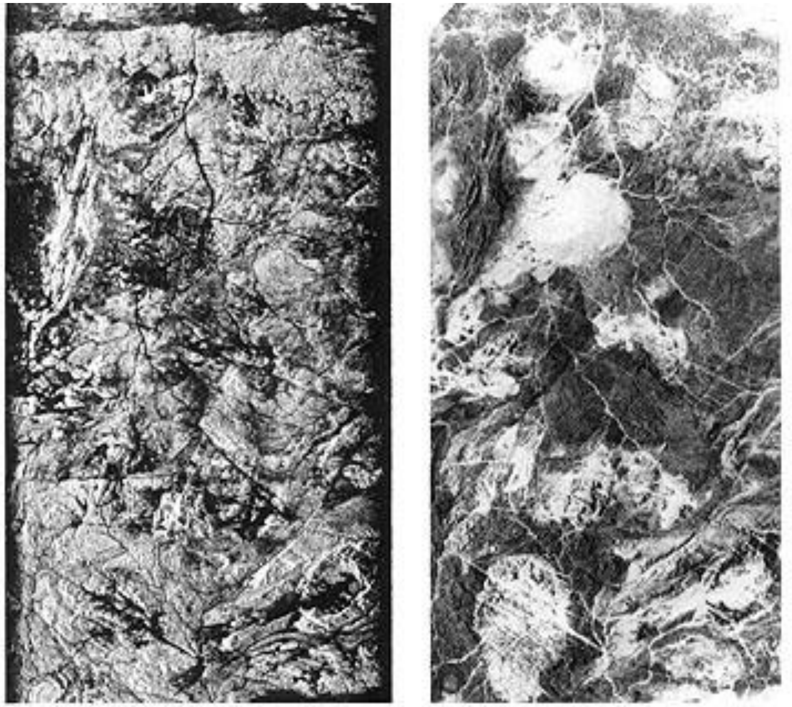
Channel	Wavelength Range (μm)	Application
TM 1	0.45 - 0.52 (blue)	soil/vegetation discrimination; bathymetry/coastal mapping; cultural/urban feature identification
TM 2	0.52 - 0.60 (green)	green vegetation mapping (measures reflectance peak); cultural/urban feature identification
TM 3	0.63 - 0.69 (red)	vegetated vs. non-vegetated and plant species discrimination (plant chlorophyll absorption); cultural/urban feature identification
TM 4	0.76 - 0.90 (near IR)	identification of plant/vegetation types, health, and biomass content; water body delineation; soil moisture
TM 5	1.55 - 1.75 (short wave IR)	sensitive to moisture in soil and vegetation; discriminating snow and cloud-covered areas
TM 6	10.4 - 12.5 (thermal IR)	vegetation stress and soil moisture discrimination related to thermal radiation; thermal mapping (urban, water)
TM 7	2.08 - 2.35 (short wave IR)	discrimination of mineral and rock types; sensitive to vegetation moisture content

SAR Monitoring Systems

- COSMO-SkyMed (COnstellation of small Satellites for the Mediterranean basin Observation) is an Earth observation satellite system, intended for both military and civilian use.
- COSMO-SkyMed is a constellation of four satellites equipped with Synthetic Aperture Radar (SAR) operating at X-band. The first satellite of COSMO-SkyMed constellation has been launched on June 2007. Full constellation operational by mid 2010.
- The space segment of the system provides global coverage of the planet. Observations of an area of interest is repeated several times a day in all-weather conditions. The imagery will be applied to defense and security in Italy and other countries, seismic hazard analysis, environmental disaster monitoring, and agricultural mapping.

Radar Monitoring System

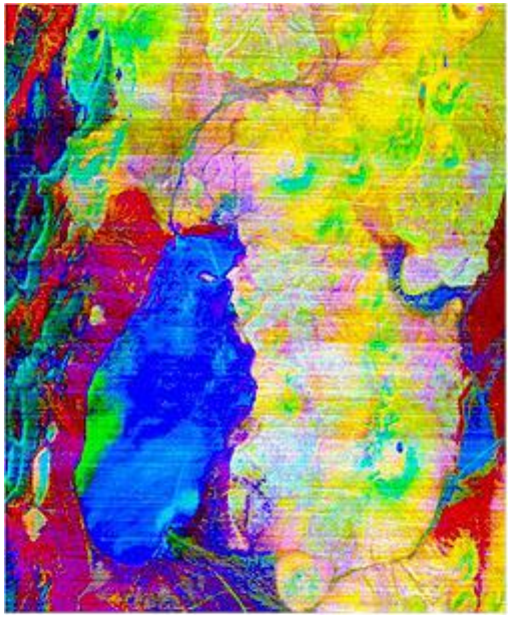
- Radar commonly provides a very different view of the same landscape compared with a visible image.



This pair of images show an ancient terrain in Egypt : left image (SIR-A radar) and right image (Landsat visible)

Thermal Monitoring System

- Thermal data, especially from the 8-14 µm region, are valuable in classifying different materials subdividing this spectral interval into bands, giving multispectral capability. NASA's JPL has developed an airborne multiband instrument called TIMS (Thermal IR Multispectral Scanner) that is a prototype for a system eventually to be placed in space. The images it produces color richness.



This scene includes a desert landscape around Lunar Lake in eastern California.

Trends in Satellite Systems

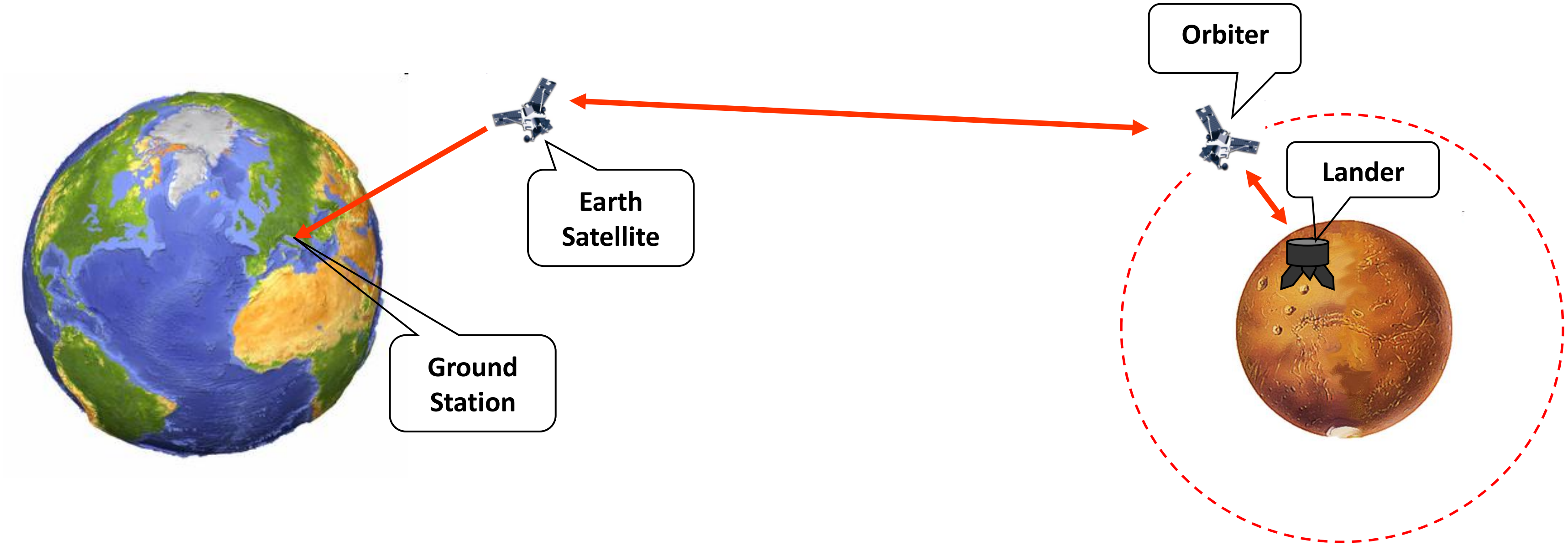
- Trends in Satellite System Architectures and Services
- Current Perspectives and Open Research Topics

Planetary exploration missions

Space Missions

Satellites play a major role, as they represent the only way to send mission information to Earth. Three different kind of links can be identified:

1. Lander – Orbiter
2. Inter-Satellite link (Orbiter – Earth Satellite)
3. Downlink (Earth Satellite – Ground Station)

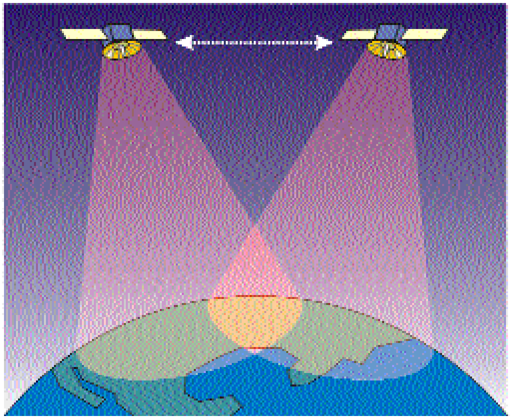


Inter-Satellite links (ISL)

With the rapid growth in LEO and MEO communications satellite constellations, ISL are likely to perform multiple functions:

- selecting lowest-cost terrestrial routing
- by-passing of local and international carriers
- bypassing busy satellites and terrestrial gateways
- improving spare transponder capacity utilization

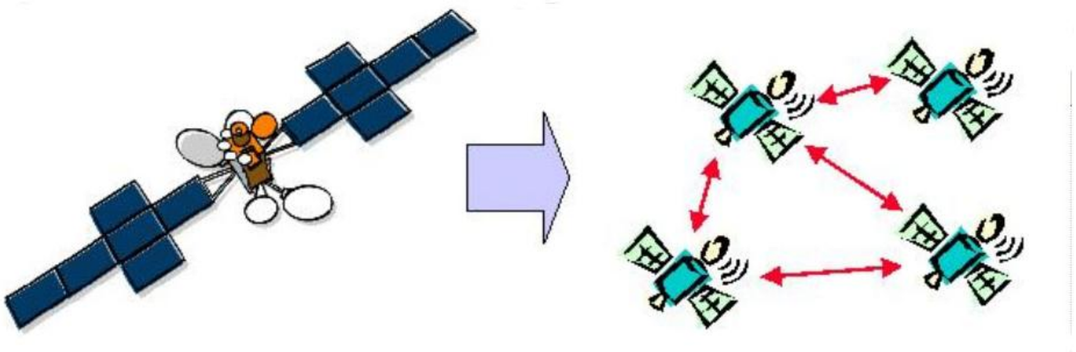
For geographically large countries or regions unable to obtain uniform high-elevation coverage from a single satellite, as few as two ISL-linked (and differently positioned) GEO spacecrafts can provide a virtual single satellite.
Multiple interconnected satellites allow the use of smaller higher gain spot-beams, while continuing to maintain good elevation angles.



Fixed Satellite Systems

An example: “SkyLAN”

The SkyLAN concept consists in splitting functions usually performed by a single large telecommunication satellite among a number of closely-located and interlinked smaller satellites.
In other words, SkyLAN is a cluster of relatively small satellites that perform an integrated function through a coordinated exchange of information via Inter-Satellite links (ISL).
Cost savings and reliability increase



Mobile and Fixed Satellite Systems

Internet in the sky

Pros

- Provides worldwide access by using low Earth-Orbit Constellation of satellites (~2000 km).
- Consists of terminals, network gateways, network operations, and control centers, along with the satellite-based switching network that provides the communication links among terminals.
- Communicate directly with a satellite network and support a wide range of data rates. The terminals can interface with a wide range of standard network protocols such as IP, ISDN, and ATM.

Mobile and Fixed Satellite Systems

Internet in the sky

Cons

- High latency
    - 250 ms for propagation (Earth → Satellite → Earth)
    - Latency for information processing (including time for coding/decoding)
- Bad performance of TCP-based applications

EGNOS and Galileo

Europe and Satellite Navigation

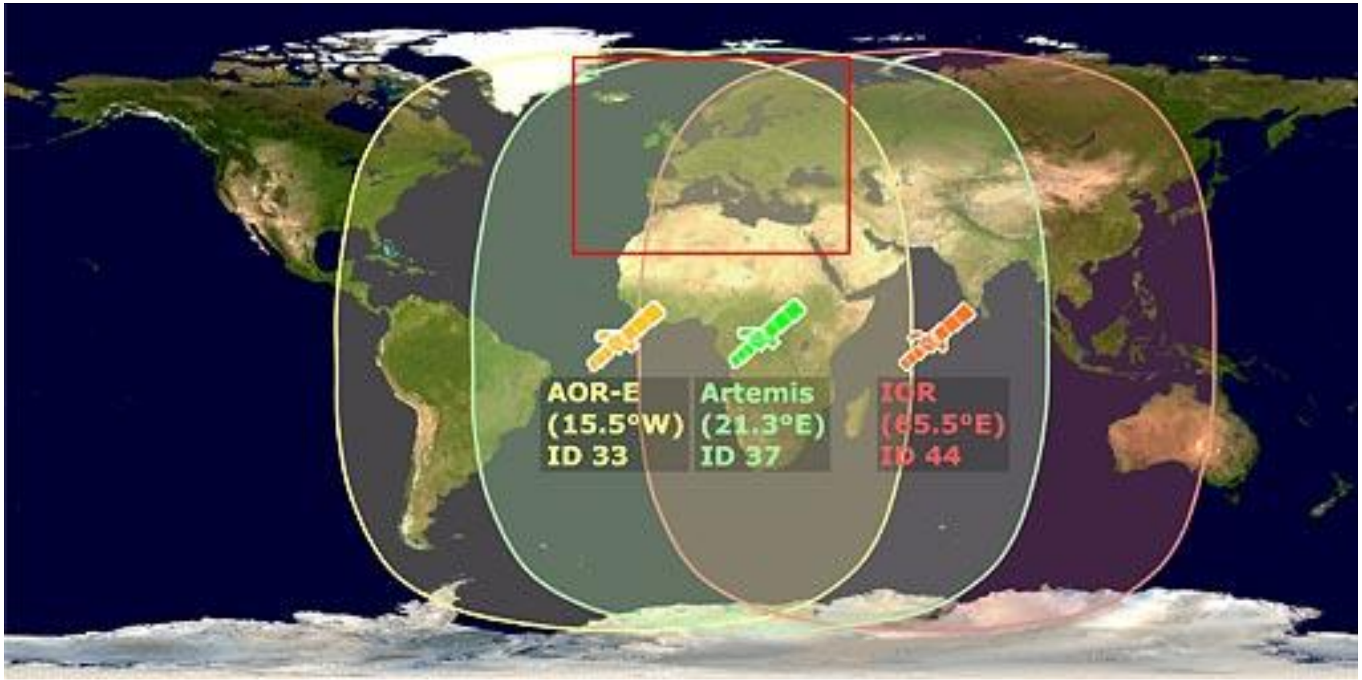
- Search for an autonomous system started in 1995
- Developed the framework for EGNOS
- EGNOS into operation in 2004
- EGNOS technology will be integrated into Galileo

EGNOS

- European Geostationary Navigation Overlay Service
- Precursor to Galileo
- Enhances GPS/GLONASS
- 3 segments:
  - Space Segment
  - Ground Segment
  - User Segment

EGNOS Space Segment

- 3 GEO satellites
- Coverage over Europe, the Mediterranean Sea and Africa



EGNOS User Segment

- Two receivers: one for GPS or one for GLONASS.
- EGNOS programmed into that receiver.
- EGNOS helps sharpen the receiver’s position from 20 meters of error to as little as few meters of error.

Satellite Navigation Accuracy Comparison

System	Horizontal Acc.	Vertical Acc.	Notes
GPS	22 m	27.7 m	Selective Availability off
GLONASS	50-70 m	70 m	
EGNOS	1-3 m	7 m	
GALILEO	< 1 m	< 1 m	Commercial service

EGNOS in Galileo

- EGNOS will be used when Galileo is operational in order to decrease errors.
- The systems will use independent technology to ensure that both systems will not fail at the same time if an error occurs.
- This will ensure that Europe will always have some form of functioning satellite navigation.

Europe and GALILEO

- Europe own system started in 1998.
- By 1999, planning was under way, and the name Galileo was chosen for the system.
- Was supposed to be fully operational by the end of 2008; looks like 2012 more realistic

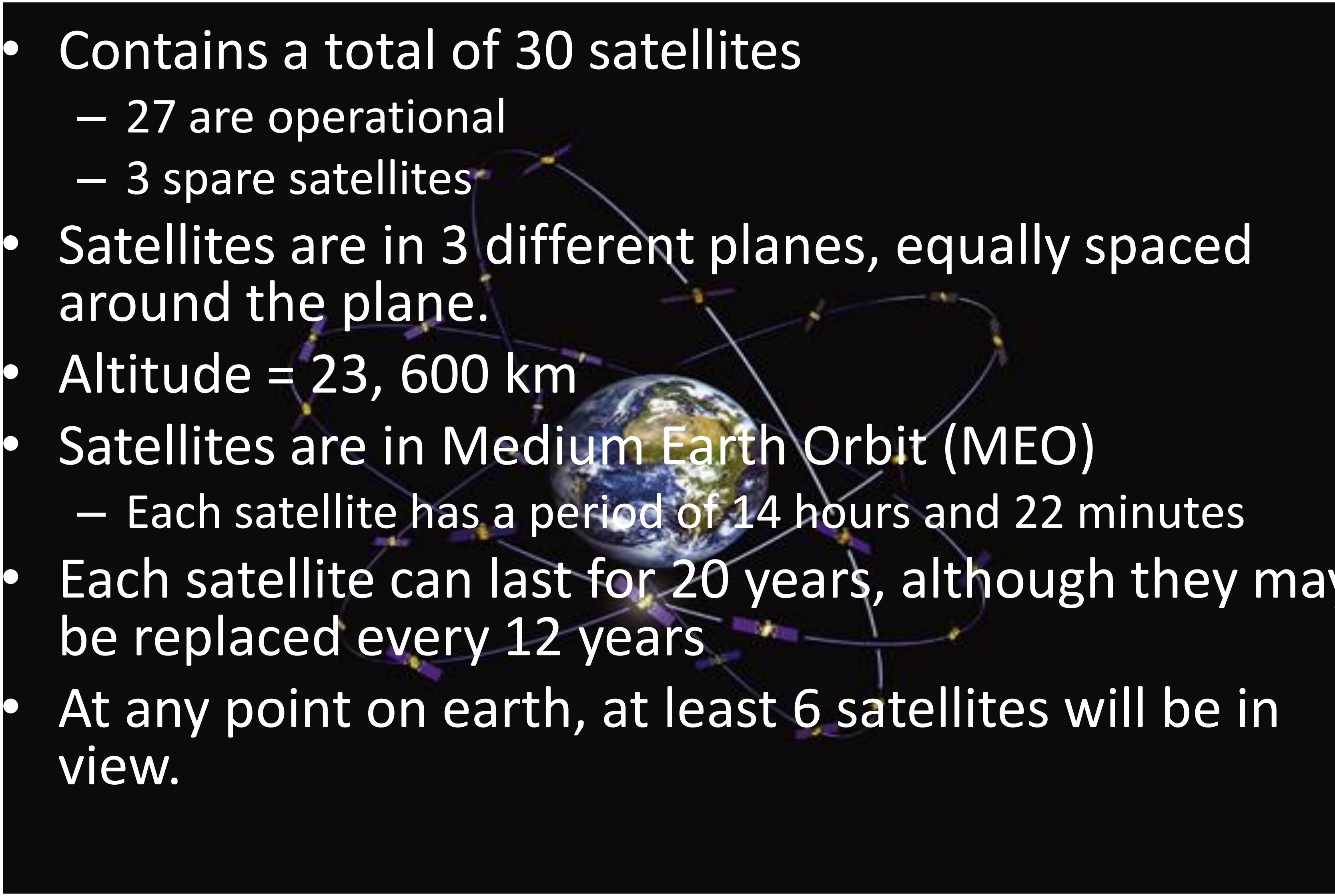
Why was it developed?

- As opposed to GPS, which was developed primarily for military uses, Galileo was developed exclusively for civilian use.
- Independent European navigation system.

Galileo

- Joint venture of European Space Agency (ESA) and European Union (EU)
- Estimated cost of 3.2 billion euros (probably more!)
- 1.1 billion euros for the development.
- 2.1 billion euros for the deployment.
- 2 phases: EGNOS and Galileo

Space Segment



- Contains a total of 30 satellites
  - 27 are operational
  - 3 spare satellites
- Satellites are in 3 different planes, equally spaced around the plane.
- Altitude = 23, 600 km
- Satellites are in Medium Earth Orbit (MEO)
  - Each satellite has a period of 14 hours and 22 minutes
- Each satellite can last for 20 years, although they may be replaced every 12 years
- At any point on earth, at least 6 satellites will be in view.

Ground Segment

- 2 Galileo Control Centres (GCCs).
  - The Control Centres will be situated at Fucino in Italy and Oberpfaffenhofen in Germany.
- Satellite control – monitors if the satellite orbits are on path
- Mission control - maintains the synchronization of satellite clocks

Galileo Services

- Galileo's transmitted signals are used to provide 5 distinct services:
  - Open Service (OS)
  - Safety of Life Service (SOLS)
  - Commercial Service (CS)
  - Public Regulated Service (PRS)
  - Search and Rescue Support Service (SAR)

Open Service

- OS can determine speed, velocity, and timing information
- Is free of charge and can be used on a handheld receiver
- Can also be used in car navigation systems
- Will never be intentionally jammed
- Will have few ionospheric and tropospheric delays
- Accurate to 15 meters

Safety of Life Service

- Utilized mainly for marine, rail or aeronautical purposes
- Guarantees a level of accuracy and authenticity that OS does not.
- Offered openly, just like OS.
- Accurate to 4-6 meters

Commercial Service

- Is encoded
- Must pay fee in order to get encryption key
- Is much more precise than Open Service (1 m)
- Generates revenue for Galileo

Public Regulated Service

- The PRS is used for governmental purposes
- PRS is encoded; can be utilized by intelligence services, law enforcement, etc...
- Is guaranteed to always have a guaranteed signal; this is its main strength over OS.
- By utilizing "appropriate interference mitigation technologies", the PRS is more accurate than OS, but only to about 10 m.

Search and Rescue Support Service

- Detects emergency beacons
- Indicates the location of incoming distress signals
- Allows rescuers to know exactly where a victim is.
- 10 minute period between distress signal and Galileo response.

Galileo Frequencies

- Each satellite transmits 6 navigational signals over 4 carrier frequencies
- The Carriers are:
  - E5a (1176.450 Mhz)
  - E5b (1207.140 Mhz)
  - E6 (1278.75 Mhz)
  - E2-L1-E1 (1575.42 Mhz) (same frequency as GPS L1)
- Signals:
  - L1F Signal- OS; unencrypted
  - L1P Signal- PRS; encrypted
  - E6C Signal- Commercial Service; encrypted
  - E6P Signal- PRS; encrypted
  - E5a- OS; unencrypted
  - E5b- OS; unencrypted

Satellite Signals

- Consist of a ranging code and data
- Ranging code – sequence of +1 and -1 with accurate characteristics in time (code length) and frequency (chip rate)
- Each satellite transmits a ranging code, but part of that sequence will always be unique to one satellite, so a receiver can identify from which satellite the data came from.

http://site.ebrary.com/lib/princeton/Doc?id=10081977

Navigation Data

- Ephemeris data
- Time parameters
- Using this data, positioning for any user on earth can be derived.

Ephemeris Data

- Indicates the position of the satellite which is nearest the user.
- Provides 17 different parameters from each satellite

#	Parameter	Definition	Bits	Scale factor	Unit
1	M_0	Mean Anomaly at Reference Time	32	2^{-31}	Semi-circles
2	Δn	Mean Motion Difference From Computed Value	16	2^{-43}	Semi-circles/s
3	e	Eccentricity	32	2^{-33}	N/A
4	$(A)^{1/2}$	Square Root of the Semi-Major Axis	32	2^{-19}	$\text{Meters}^{1/2}$
5	$(OMEGA)_0$	Longitude of Ascending Node of Orbit Plane at Weekly Epoch	32	2^{-31}	Semi-circles
6	i_0	Inclination Angle at Reference Time	32	2^{-31}	Semi-circles
7	ω	Argument of Perigee	32	2^{-31}	Semi-circles
8	OMEGADOT	Rate of Right Ascension	24	2^{-43}	Semi-circles/s
9	IDOT	Rate of Inclination Angle	14	2^{-43}	Semi-circles/s
10	C_{uc}	Amplitude of the Cosine Harmonic Correction Term to the Argument of Latitude	16	2^{-29}	Radians
11	C_{us}	Amplitude of the Sine Harmonic Correction Term to the Argument of Latitude	16	2^{-29}	Radians
12	C_{rc}	Amplitude of the Cosine Harmonic Correction Term to the Orbit Radius	16	2^{-5}	Meters
13	C_{rs}	Amplitude of the Sine Harmonic Correction Term to the Orbit Radius	16	2^{-5}	Meters
14	C_{ic}	Amplitude of the Cosine Harmonic Correction Term to the Angle of Inclination	16	2^{-29}	Radians
15	C_{is}	Amplitude of the Sine Harmonic Correction Term to the Angle of Inclination	16	2^{-29}	Radians
16	t_{oe}	Ephemeris Reference time	14	60	seconds
17	IODnav	Ephemeris and clock correction IOD	9	N/A	N/A
		Total Ephemeris Size	**363**		

Time Parameters

- By accurately measuring the time between transmission and reception, the location of a receiver can be determined.
- Galileo Standard Time (GST) is the reference time that Galileo uses.
- Each satellite broadcasts a Time of Transmission (TOT)
- Satellite Time Corrections are foreseen

GMES

(Global Monitoring for Environment and Security)

GMES

- GMES (Global Monitoring for Environment and Security) is the name of the Earth Observation initiative launched by the European Commission and the European Space Agency.
- The objective of GMES is to monitor the state of the environment on land, at sea and in the atmosphere and to improve the security of the citizens in a world facing an increased risk of natural and other disasters.

GMES

- Thematic areas of GMES:
  - land, marine and atmosphere information – ensuring systematic monitoring and forecasting the state of the Earth's subsystems at regional and global levels;
  - climate change information – helping to monitor the effects of climate change, assessing mitigation measures and contributing to the knowledge base for adaptation policies and investments;
  - emergency and security information – to provide support in the event of emergencies and humanitarian support, in particular to civil protection authorities, and to provide accurate information on security related aspects (e.g. maritime surveillance, border control, global stability, etc.)

GMES - Observational Infrastructure

The GMES service component depends on Earth observation data, collected from space (satellites), air (airborne instruments, balloons to record stratosphere data, etc.), water (floats, shipboard instruments, etc.) or land (measuring stations, seismographs, etc.).

These facilities are called the GMES infrastructure component.

We have:

- **Space infrastructure**
  - The space component shall ensure sustainable provision of satellite derived Earth observation data to all GMES services.
- **In-situ infrastructure**
  - The in situ component is based on an observation infrastructure owned and operated by the large number of stakeholders coordinated, in some cases, in the frame of European or international networks. In situ observation activities and associated infrastructure derive from a range of national, EU and international regulatory requirements and agreements or form part of research processes. None was created to meet the needs of GMES, and they cover a much wider field than the GMES services. By this reason European Environmental Agency was appointed to co-ordinate the consolidation of in-situ networks for GMES purposes.

GMES SERVICES

- Marine
  - Maritime Safety and Transport
  - Oil Spill Monitoring
  - Extreme Metereological Events
  - Seasonal Weather forecasting
  - Climate and Environement
  - Water Quality and Ecosystems
- Atmosphere
  - UV services
  - Ozone Services
  - Air Quality Services
- Land
  - Nature Protection services
  - Water services
  - Soil erosion
  - Forest Monitoring
  - Food security and crop monitoring
  - Global Carbon
  - Spatial Planning
  - Urban planning services
  - Sustanaible Management of Africa

GMES SERVICES

- Climate Change study support
- Emergencies
    - Flood
    - Fire
    - Earthquakes
    - Humanitarian Aid
    - Man Made Distasters
    - Large Scale Natural Disasters
- Security
    - Infrastructure Surveillance
    - Maritime Surveillance
    - Support to peace-keeping

- They should enter into initial operations during the period 2011-2013, with the objective to be fully operational by 2014

GMES

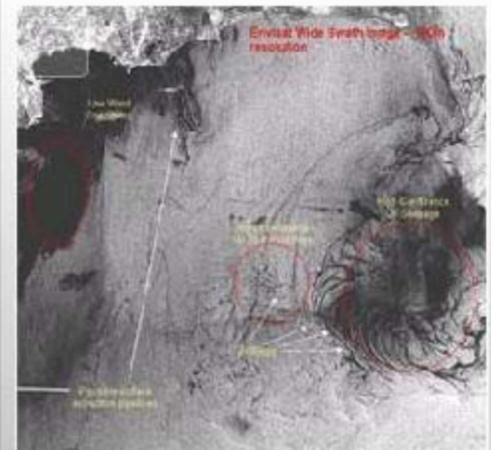
GMES Marine Services

Oil Spill Monitoring

EMERGENCY RESPONSE SERVICES | LAND | MARINE | ATMOSPHERE | SECURITY

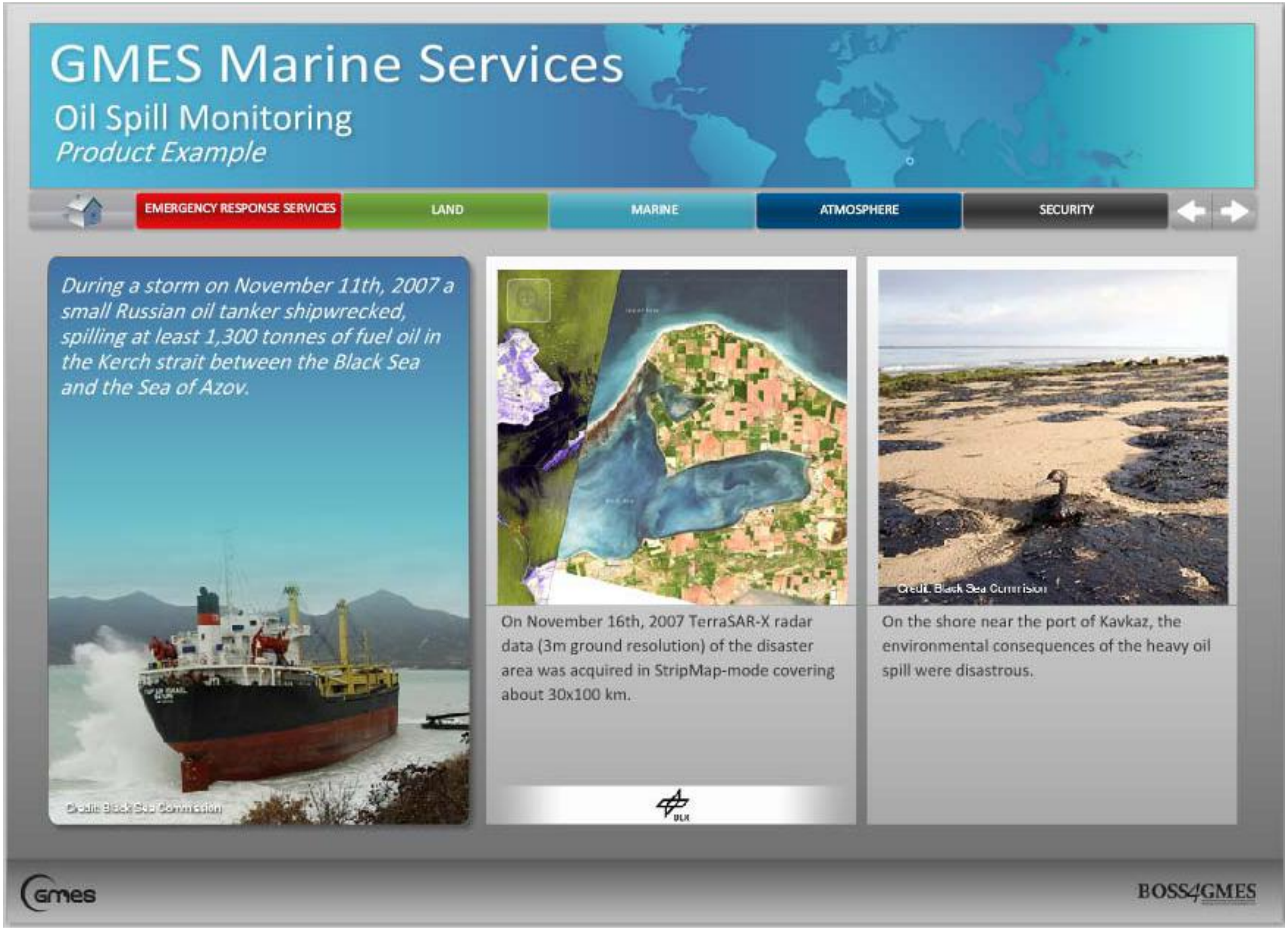
Satellite based radar sensors can contribute greatly to the detection of oil spills, and to the identification of responsible vessels.

Map of illegal discharges detected in 1999-2004.
SAR images = 18947.
Oil spill number = 9299.



Detecting oil spills with satellite-based radar: ENVISAT wide swath image

GMES


GMES Marine Services
Oil Spill Monitoring
Product Example
EMERGENCY RESPONSE SERVICES
LAND
MARINE
ATMOSPHERE
SECURITY
During a storm on November 11th, 2007 a small Russian oil tanker shipwrecked, spilling at least 1,300 tonnes of fuel oil in the Kerch strait between the Black Sea and the Sea of Azov.
Credit: Black Sea Commission
On November 16th, 2007 TerraSAR-X radar data (3m ground resolution) of the disaster area was acquired in StripMap-mode covering about 30x100 km.
DLR
Credit: Black Sea Commision
On the shore near the port of Kavkaz, the environmental consequences of the heavy oil spill were disastrous.
gmes
BOSS4GMES

GMES Maritime Surveillance

GMES Security Services

Maritime Surveillance

EMERGENCY RESPONSE SERVICES | LAND | MARINE | ATMOSPHERE | SECURITY

"The [GMES] experimentation in the Maritime Surveillance field is characterized by a very innovative approach, providing integrated information from different sources in a reliable and user-friendly mode.

The Italian Coast Guard found the new services very useful to support the maritime patrolling operations in a mid-term perspective, both in coastal zones and over the open sea areas."

Italian Coast Guard

Demand

Safety at sea, especially in busy shipping lanes, monitoring of illegal immigration and trafficking, fight against piracy, and surveillance of sensitive cargo can be greatly improved by the combination of Earth Observation and in situ assets (radars, tracking systems, etc).

GMES products and services

Monitoring, Intelligence & surveillance services and products such as:

- Large area Near Real Time monitoring
- "Hot Spots" surveillance and Alarms
- Open ocean routes monitoring
- Large area Near Real Time monitoring

Users

- Coastguard and Border Guard organisations
- Martitime police and Drug Enforcement Organisations
- Member States Navies
- Ship owners
- International organisations such as the International Martime Organisation

GMES

BOSS4GMES

CREDITS

GMES Maritime Surveillance

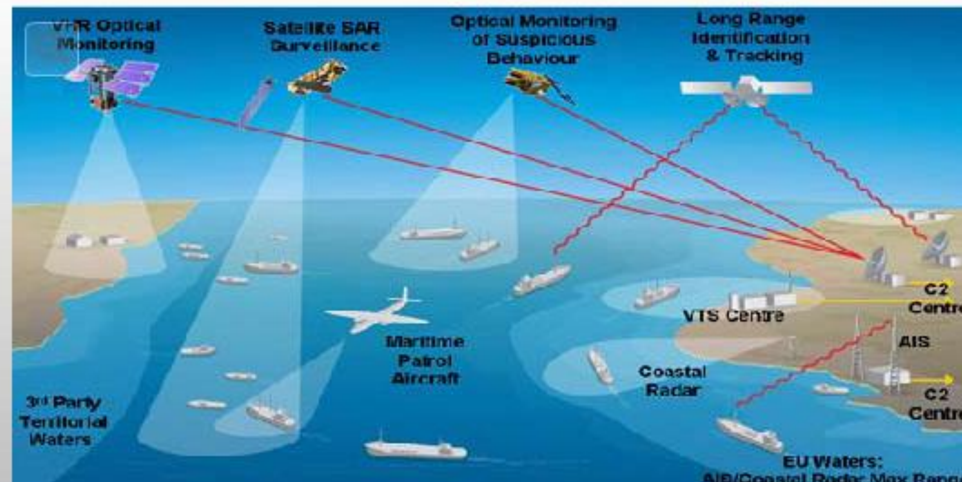
GMES Security Services

Maritime Surveillance

Product Example: Surveillance of shipping lanes

EMERGENCY RESPONSE SERVICES | LAND | MARINE | ATMOSPHERE | SECURITY

A cargo grounded on a French beach.



Integration of data from many different sources (satellites, radar, patrol aircraft, naval vessels, etc.) will contribute to make the maritime transport as safe as the air transport (MARISS illustration).

gmes

BOSS4GMES

GMES Maritime Surveillance

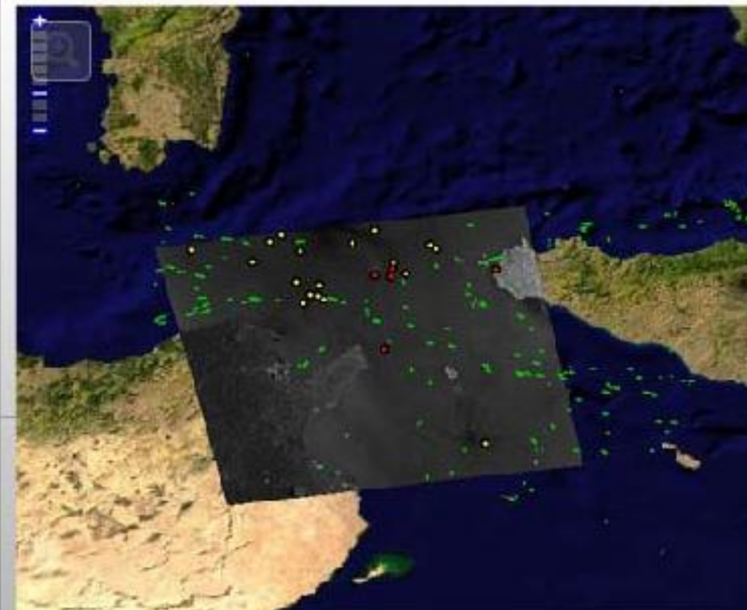
GMES Security Services

Maritime Surveillance

Product Example: Support to Illegal Immigration Control

EMERGENCY RESPONSE SERVICES | LAND | MARINE | ATMOSPHERE | SECURITY

Optical and radar Earth Observation resources are a complement to in situ detection and intelligence techniques.



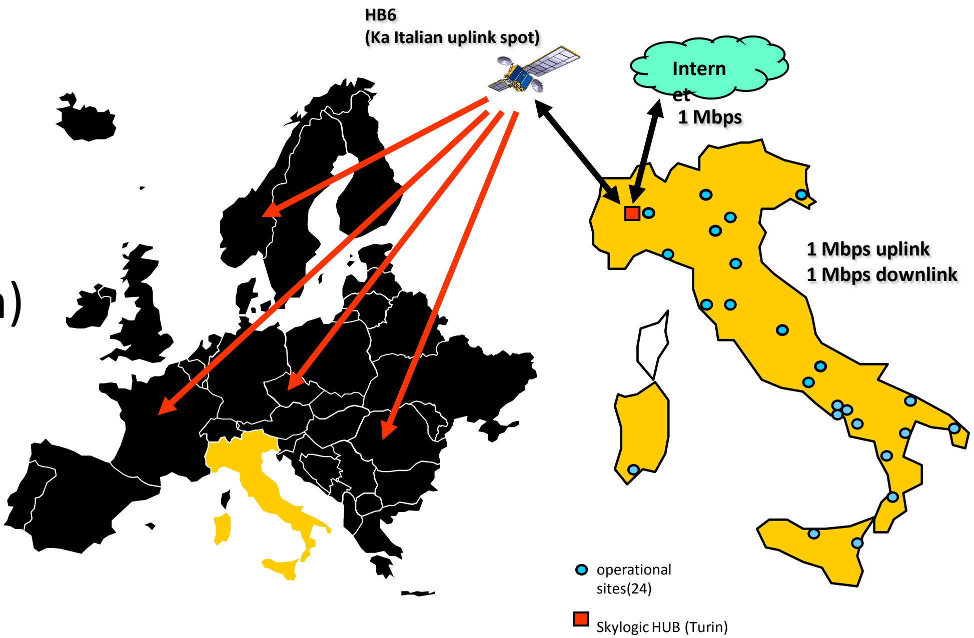
Maritime Surveillance Geographical Information System.

Current Perspectives & Open Research Topics

CNIT Satellite Network

Features and Capabilities:

- 24 TX/RX Stations
- Provider: EUTELSAT (HB6 sat)
- Ka-band Star network (HUB in Turin)



- CNIT Profile:
  - 1 Mbit/s bidirectional tx
  - 1 Mbits/s Internet connectivity at Network Control Center (displaced in Turin)
  - 2 profiles for return links :
    - A low bit rate profile at 640 kbit/s QPSK FEC 1/2 (#400kbit /s with one terminal taking the full bandwidth)
    - A high bit rate profile at 1280 kbit/s QPSK FEC 1/2 (#800 kbit/s with one terminal taking the full bandwidth)
  - Multicast support.

HB6 Ka coverage

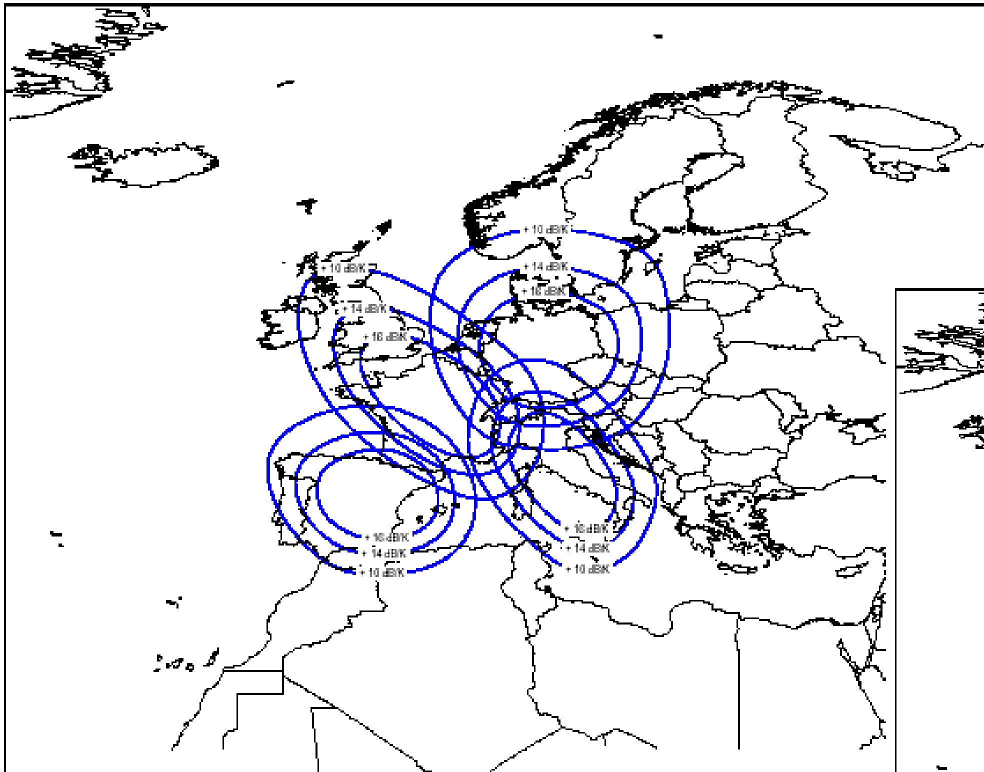


Figure 16 . HOT BIRD™ 6 Ka-band Receive Coverage

UPLINK

DOWNLINK

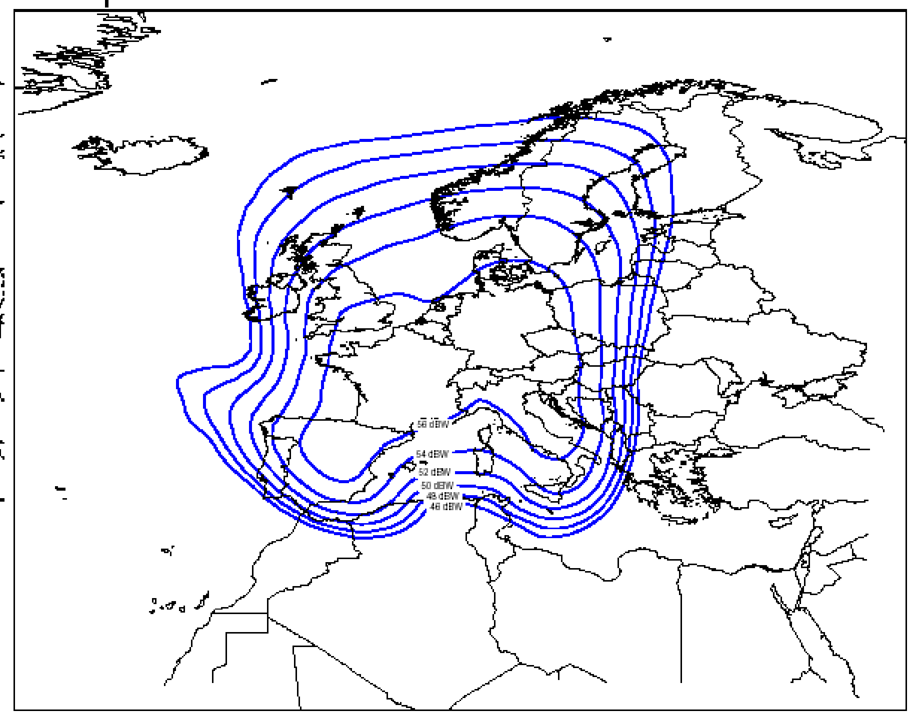


Figure 17. HOT BIRD™ 6 Ka-band Transmit Coverage

National Research Projects (I)

STEEL Project

Sistemi, tecnologie abilitanti E mEtodi per la formazione a distanza

National Project: Sistemi, tecnologie abilitanti E mEtodi per la formazione a distanza

Duration: July 2007 – Dec 2010

Funding Source: Italian Ministry of University and Research (MIUR)

Web link: http://steel.cilea.it/

Project Objective:

STEEL aims at developing an e-learning system for university training, able to integrate different media and communication techniques based on an innovative technological satellite-terrestrial infrastructure.

SALICE Project

Satellite-Assisted LocalIzation and Communication systems for Emergency services

National Project : Satellite-Assisted LocalIzation and Communication systems for Emergency services

Duration: October 2008 – October 2010

Funding Source: Italian Ministry of University and Research (MIUR)

Web link: http://lenst.det.unifi.it/salice

Project Objective:

SALICE aims at identifying the solutions which can be adopted in an integrated reconfigurable NAV/COM device and studying its feasibility in realistic baseline emergency scenarios, where several rescuers are organized in Teams.

National Research Projects (II)

EMERSAT Project

European Project : Satellite solutions for applications and communications services

Duration: February 2009-February 2012

Funding Source: ASI (Italian Space Agency)

Project Objective:

EMERSAT aims at developing, integrating and testing satellite solutions for applications and communications services to national institutional agencies dedicated to security and emergency management. The main objective is to give the institutional agencies operators devoted to emergency security and management all the technology for receiving and transmitting the information needed for the most effective and safest management of emergency interventions.

European Projects (I)

TESHEALTH Project

European Project : TElemedicine Services for HEALTH

Duration: February 2010 – September 2011

Funding Source: ESA (European Space Agency)

Project Objective:

TESHEALTH aims at specifying and developing an integrated system of e-Health applications and services in order to: increase the person's control on safety, assure the exchange of heterogeneous health data among different healthcare service, automate the complex healthcare workflow and deploy an integrated heterogeneous telecommunication network which will promote satellite.

TANGO Project

European Project : Telecommunications Advanced Networks for GMES Operations

Duration: December 2006-December 2009

Funding Source: EC (European Commission)

Project Objective:

TANGO aims at developing, integrating, demonstrating and promoting new satellite telecom services dedicated to GMES (Global Monitoring for Environment & Security) requirements. TANGO is the first project under EC FP6 focusing on the use of satellite telecom to serve the needs of the whole GMES community. The project addresses key environment and security applications in domains such as marine services and emergency response including risk & crisis management and humanitarian aid.

European Projects (II)

WISECOM Project

European Project : Wireless Infrastructure over Satellite for emergency communications

Duration: September 2006- June 2008

Funding Source: EC (European Commission)

Project Objective:

WISECOM aims at studying, developing and validating by live trials candidate rapidly deployable lightweight communications infrastructures for emergency conditions (after a natural or industrial hazard). The system integrates terrestrial mobile radio networks over satellite systems, using lightweight and rapidly deployable technologies and including location-based services.

NeT-ADDeD Project

European Project: New Technologies to Avoid Digital Division in e-Divided areas

Duration: 2007-2009

Funding Source: EC (European Commission)

Project Objective:

NETADDED aims at developing and validating technical features to improve the performance of deployment and operation of hybrid satellite-wireless technologies, in coherence with the growing demand of broadband communications in the INCO countries. In particular the project aims at supporting education & health development in Africa & Asia, providing a sustainable technical solution adapted to the specific environment.

European Projects (III)

SISTER Project

European Project:

Duration: December 2006- November 2009

Funding Source: EC (European Commission)

Project Objective:

SISTER aims promoting the integration of satellite and terrestrial communications with GALILEO to enable mass market takeup by road transport applications. It addresses the ITS and SATCOM markets by better understanding the needs of both.

SATNEX/SATNEX2 Network of Excellence

European Project:

Duration: April 2004 Marzo 2006 / April 2006 Marzo 2009

Funding Source: EC (European Commission)

Project Objective:

The primary goal of SatNEx, is to achieve long-lasting integration of the European research in satellite communications and to develop a common base of knowledge.

European Initiative

ISICOM - Integrated Space Infrastructure for Global Communications

- Global, Trusted and Resilient infrastructure that can be fully operated from Europe
- Integration with Terrestrial networks
- Capability to operate without the terrestrial networks
- Scalable and modular infrastructure for incremental deployment in coverage and capacity
- Capability to offer synergy and telecommunications services to GMES and Galileo
- Security capability for the institutional users
  e.g. authentication and encryption fully embedded in the system design
- Based on GEO constellations
- High frequency bands
  - e.g. Ka and possibly Q and V bands for global coverage
  - e.g. S and L band for local mobile services

ESA's SAT Telecommunication Programmes

The **ARTES programme** enables to explore, through research and development activities, innovative concepts to produce leading-edge satcom products and services.

- ARTES 1: strategic analysis, market analysis, technology and system feasibility studies and to the support of satellite communication standards.
- ARTES 3-4: development, qualification, and demonstration of products.
- ARTES 5: long-term technological development, either based on ESA's initiative, or on the initiative of the satcom industry.
- ARTES 7 – EDRS: development and implementation of an European Data Relay Satellite (EDRS) system.
- ARTES 8 – Alphasat: development and deployment of Alphasat satellite, which incorporates innovative on-board processing technology and promote development of user services.
- ARTES 10 – Iris: development of a satellite-based communication system that will complement the future generation of an air traffic management system currently being developed under the SESAR programme of the EU, by Eurocontrol and the European Aeronautical community.
- ARTES 11 – Small GEO: development and implementation of the Small GEO System.
- ARTES 20 – IAP: development, implementation and pilot operations of Integrated Applications. These are applications of space systems that combine different types of satellites, such as telecommunications, earth observation and navigation. Integrated Application projects offer solutions that range from secure transport systems to developing emergency/disaster management systems.

IPoS - IP over Satellite (I)

The IPoS system delivers “always on” IP services and is targeted at residential, SOHO (Small Office/ Home Office) and enterprise markets.

The primary services offered to these segments are:

- Broadband Internet access
- Wide Area Networking

Additionally IP Multicast services (e.g. audio/video streaming and distance learning) can be offered through the IPoS system.

IPoS - IP over Satellite (II)

The IPoS implements a **star topology** satellite network, where multiple remote terminals communicate bi-directionally with a hub.

✓ **SPACE SEGMENT:**

• allows the transmission in both directions between the hub and remote terminals through a Ku-band transponders.

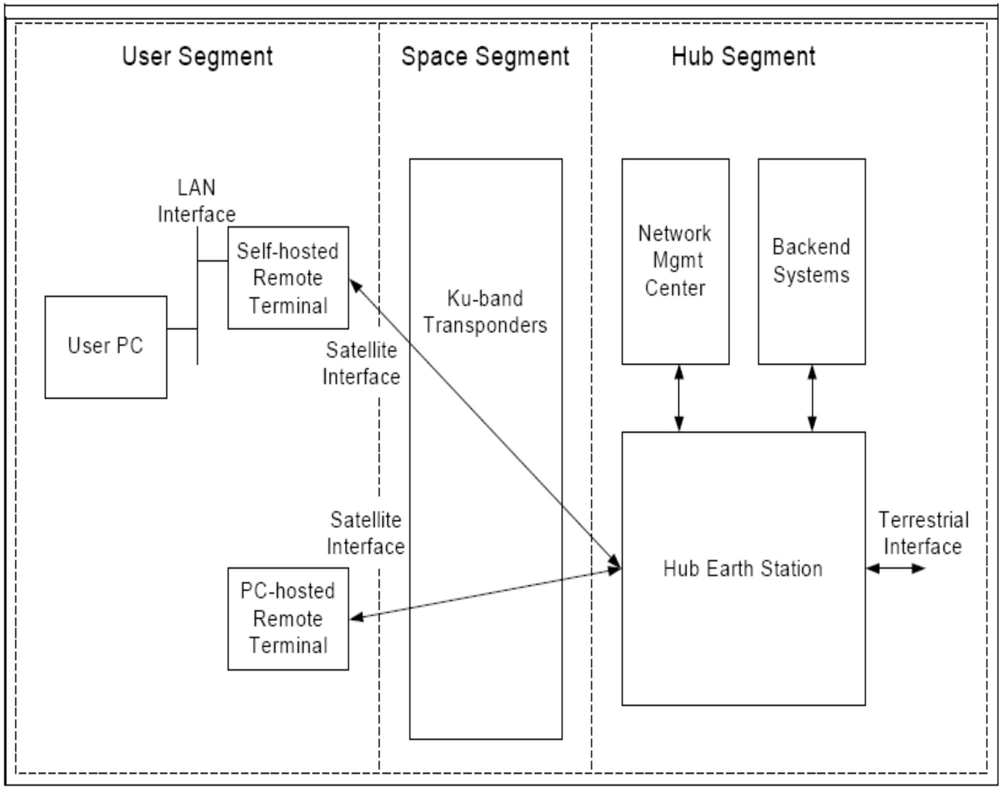
✓**HUB SEGMENT:**

•interconnects the satellite access network with the external networks (e.g. Internet, private packet networks).

•Traffic aggregation, protocols conversion, satellite network routing and management.

✓ **USER SEGMENT:**

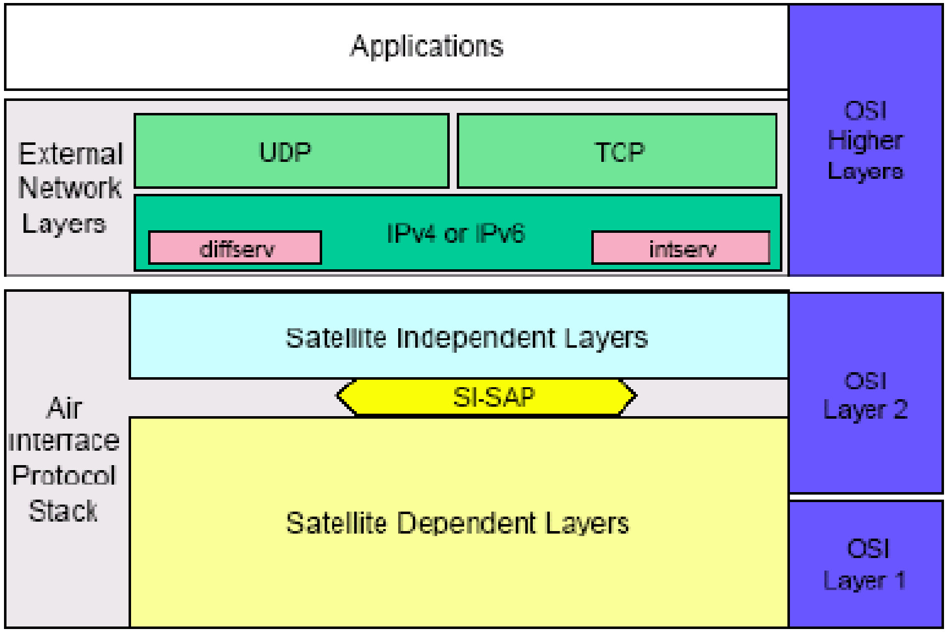
• is responsible for interfacing the user hosts.



IPoS - IP over Satellite (III)

•The architecture provides a split between satellite-dependent and satellite-independent functions, through the Satellite-Independent Service Access Point (SI-SAP) interface

• The return channel is DVB-RCS like, but it involves the use of O-QPSK and variable burst size.



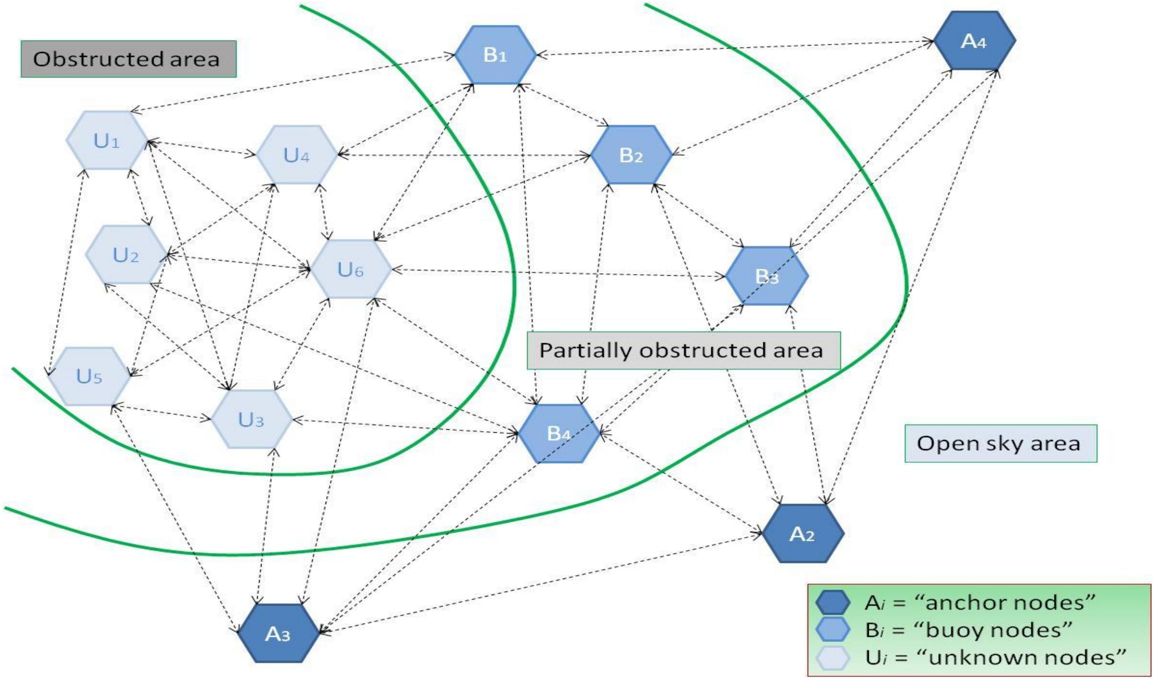
Trends in Satellite Frequency

- Currently Ka band communications are the high level standard for broadband satellite services;
- Experimentation of Q (30 to 50 GHz) and V (50 to 75 GHz) band systems are in the pre-operative phase for military applications (i.e.: Italian Defense Minister SICRAL satellite) and in the development phase for scientific applications (i.e.: the TDP#5 payload which will be embarked Alphasat platform): these bands are taken into account as an industrial research field for consumer and civil applications.
- W (75 to 110 GHz) band is considered as the most important scientific frontier for the broadband satellite applications.

Trends in Satellite Frequency

Mission	*Agency*	*EHF Payload*	*Life time*	*Launch/Orbit*	*Scientific Goals*
ITALSAT	ASI	Beacon (@ 40 and 50 GHz)	End: 2001	Gen 1991 – GEO orbit	Attenuation and de-polarization measures
Sicral	Italian Minister of Defense	Transponders (20-44 GHz bands)	10 year	Feb 2001 – GEO orbit	EHF tactic communications for aero, nautical and terrestrial systems
Alphasat TDP#5	ESA/ASI	Transponder (38-48 GHz bands) and beacon (@ about 40 GHz)	15 year	2011 (TBC) – GEO orbit	Per-operative experimentation and validation of the channel attenuation mitigation techniques (ACM, site diversity), propagation data collection
DAVID	ASI	Tx / Rx section (W band, @ 75.7 GHz e 85.5 GHz respectively)	TBD	TBC - LEO eliosynch. orbit	Per-operative experimentation for W band W connection and remote propagation measurements acquisition
QZSS	JAXA	Transponder (W band 74-84 GHz) for backbone connectivity and support services	TBD	TBD – constellation of 3 geosynch. sats with high elevation(>70°)	Support to connections VSAT-VSAT with 45 Mbps data rate
WAVE	ASI	Transparent and regenerative payloads in W band (both uplink and downlink	TBD	TBD – both LEO and GEO orbits and Stratospheric platforms	Per-operative experimentation for W band connection, propagation measurements database set-up

Cooperative Localisation



- WSNs can be deployed to aid localization accuracy in indoor environments where the satellite channel cannot provide range estimation.

- Cooperative localization in WSNs

  Types of nodes:

  Open Sky → Anchor nodes

  Partially Obstructed Zone → "Buoy" nodes

  Totally Obstructed Zone → Unknown nodes

Hybrid Satellite/Terrestrial Cooperative network

Particular attention given to the integration of satellite and terrestrial segments, with the aim of providing telecommunication capabilities in critical scenarios.
As an example the DVB-SH standard [use of multicarrier modulation (OFDM) and lower frequency band (below 3 GHz)], is based on a Hybrid satellite/terrestrial network architecture.

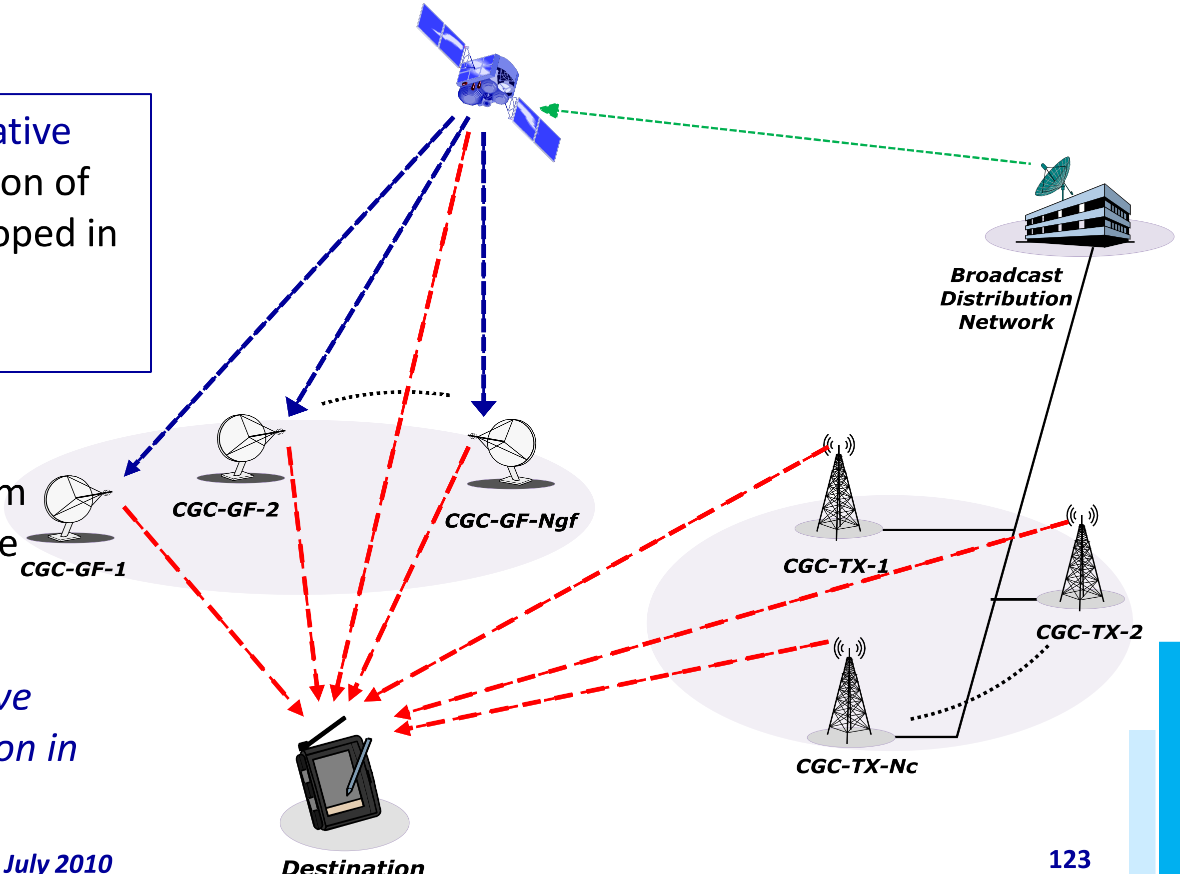
NLOS propagation remains one of the main causes of performance degradation.

Hybrid satellite/terrestrial Cooperative schemes, which involve the adoption of diversity techniques, can be developed in order to provide a reliable communication in NLOS condition.

Achieved Performance:

- significant gain w.r.t. the satellite system
- interesting BER improvements w.r.t. the terrestrial stand alone system

The implementation of hybrid cooperative schemes can be seen as promising solution in public emergency situation.



Future Prespective: Integration

The future telecommunications systems will be characterized by the integration of the satellite complementary capabilities:

Communication — Positioning — Monitoring

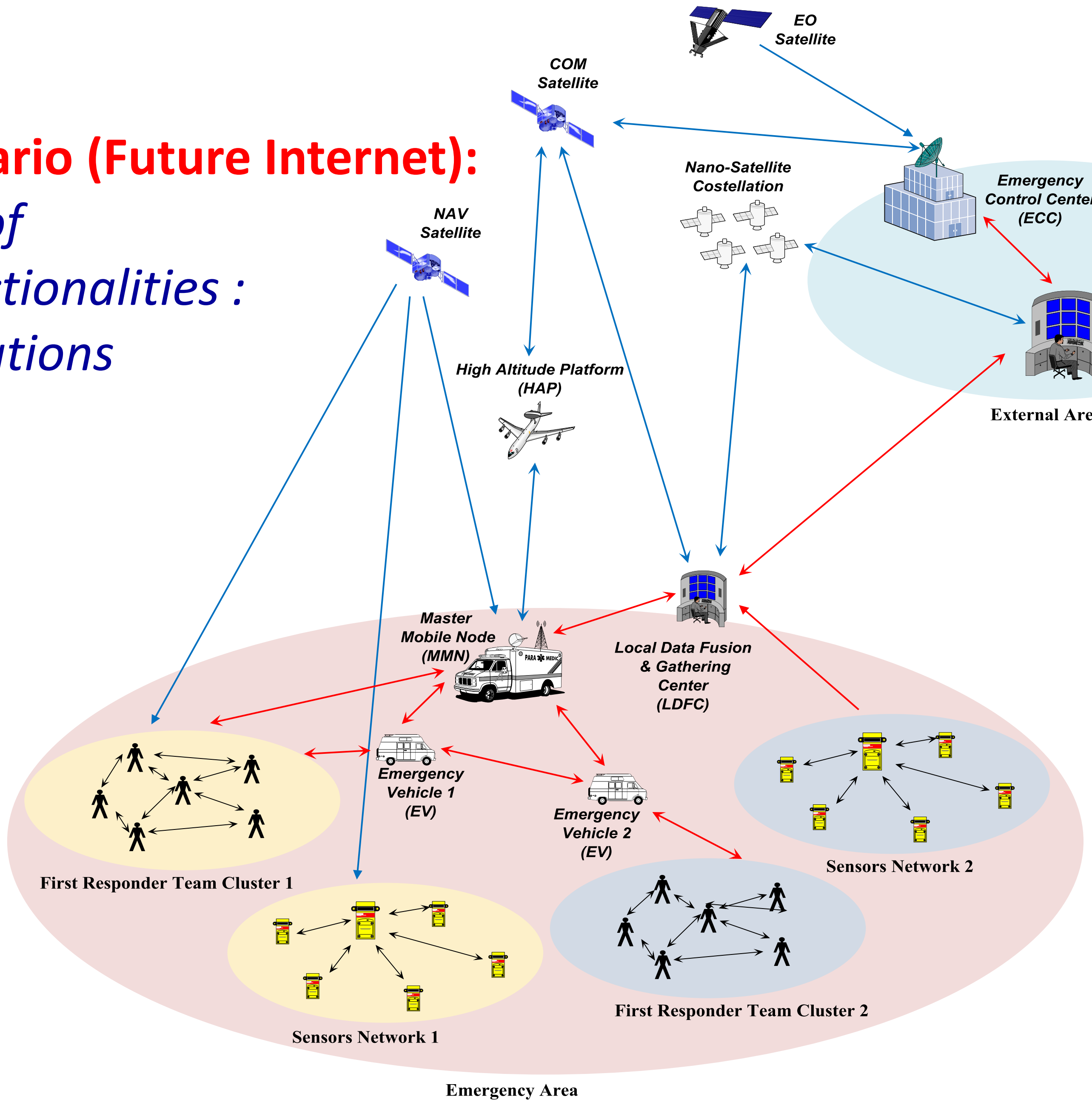
The need of this integration is required in many applications scenarios as:

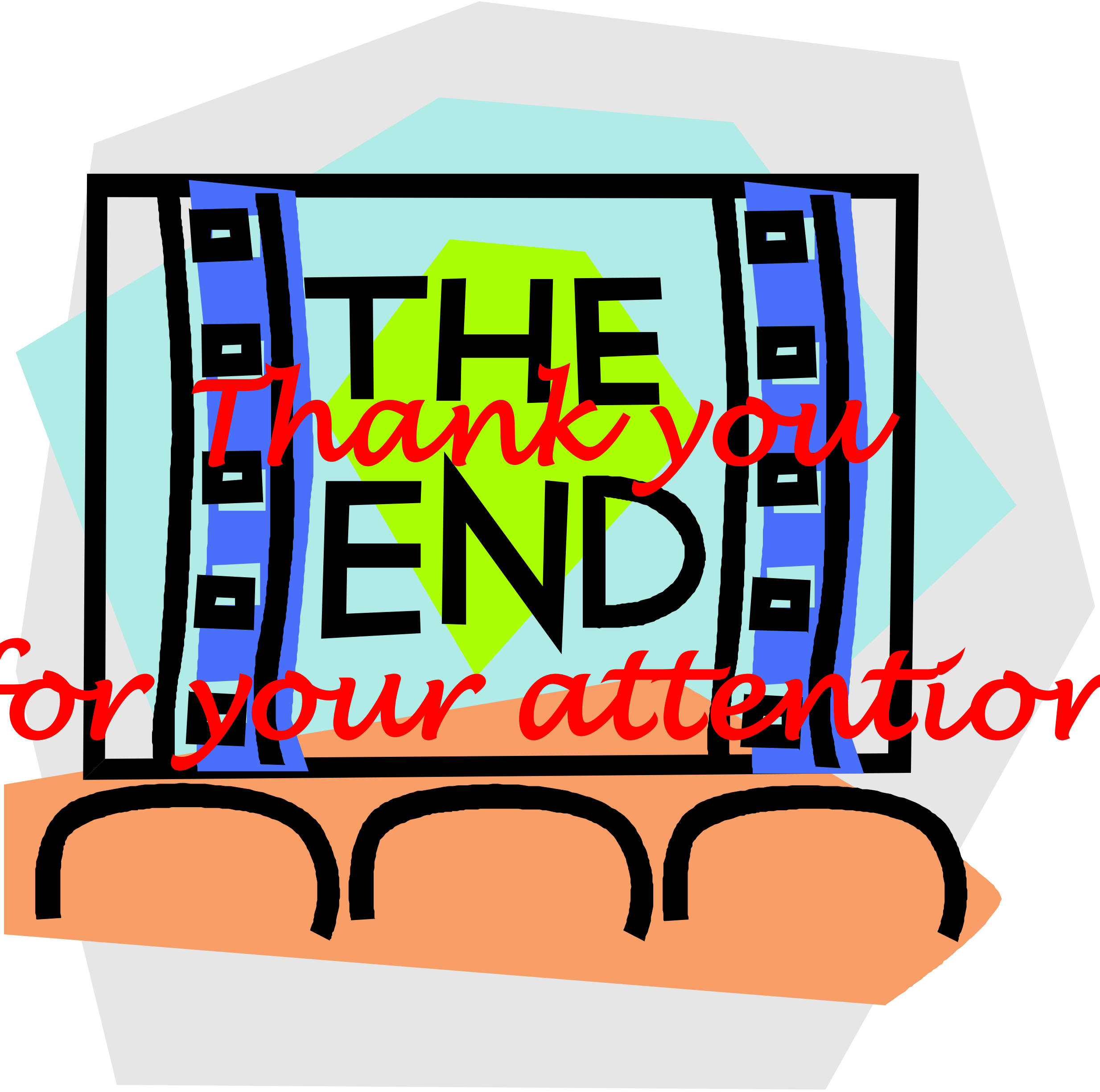
- Safety
- Emergency and Crisis Management
- Peace keeping
- Health

Future Scenario (Future Internet):

Integration of satellite functionalities :

- *communications*
- *positioning*
- *GMES*





Thank you
for your attention