Ground Geolocation Challenges

Workshop - 10 June Geneva - Preventing harmful interference to satellite systems

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Ref.:

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Agenda

- 1- Why Geolocate ?
- 2- Geolocation principle & issues
- 3- Geolocation Performances
- 4- Limitations of standard Geolocation systems
- 5- Conclusion

1- Why Geolocate

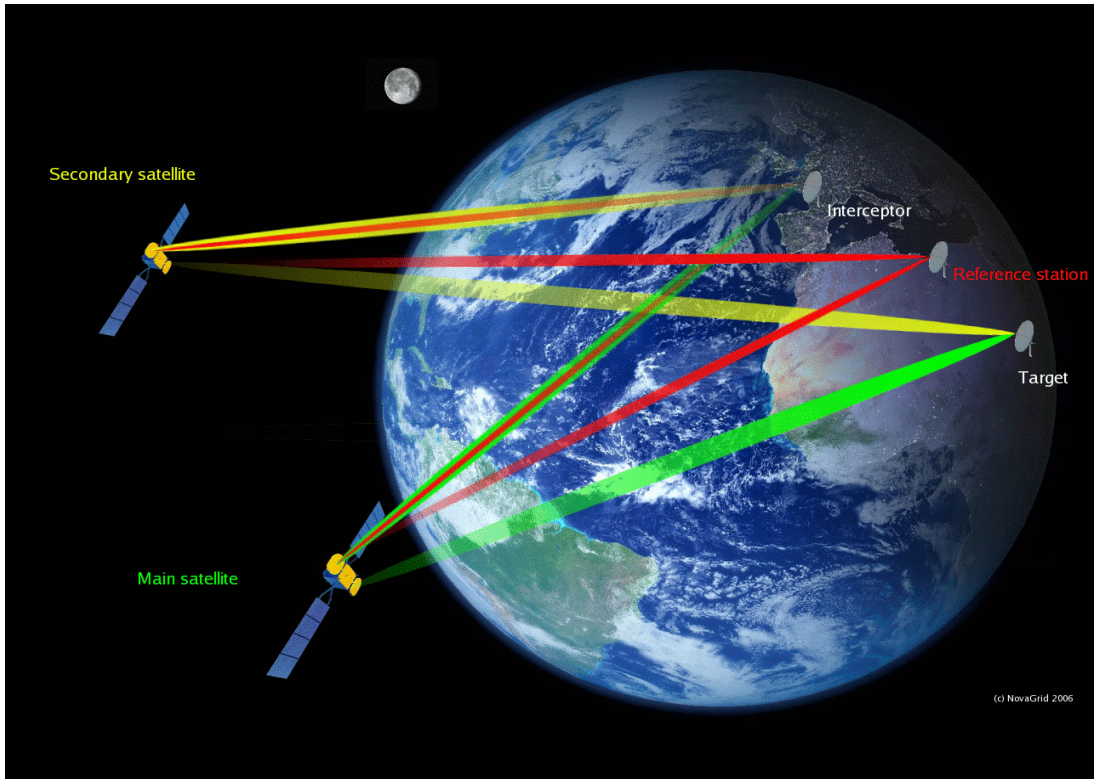
Why Geolocate ?

- More and more interferences (more traffics, more conflicts, more users…):
  - Intentional jamming (political or commercial reasons)
  - Non intentional (ASI, ACI, Xpol, IM, sun interf, scintillation)
  - Many interferences caused by VSAT, SNG…
- But also illegal or unauthorized users transmitting
- Can be used to localize network terminals in mobile networks
- Can localize transmitters for registration and licensing purpose

2- Geolocation principles and issues

Geolocation principle

- The Geolocation principle is based on:
  - The Frequency Difference Of Arrival (FDOA)
    - The measure of the difference of frequency due to Doppler effect on the two different path (main and mirror satellite)
  - The Time Difference Of Arrival (TDOA)
    - The measure of the difference of time due to the propagation time and distance on the two different paths (main and mirror satellite)



•Use the (TDOA, FDOA) couple, the satellites ephemeris and the local earth surface to compute the position of the target / interferer

•FDOA and TDOA are computed with the cross-ambiguity function (CAF) which is 2D cross-correlation in the time and frequency domains

•At least one Reference Station is needed, several will improve the geolocation accuracy

3- Performances

- Depends on many conditions :
  - Frequency band of interest
    - FDOA accuracy increases with the Frequency, but C/N on mirror satellite decreases
  - Uplink Station (Target and References)
    - The bigger the antennas are, the harder the location is
  - Type of signal
    - The wider the signal bandwidth is, the better the TDOA accuracy is
    - Modulation/Power
  - Time duration of the signal
    - The longer the time duration is, the better the FDOA accuracy is
  - Mirror transponder occupation
    - Free or occupied, type of carriers if occupied
  - Satellites angular spacing and relative movement
    - Accuracy vary during the day, better when satellites have opposite movement

- Depends on many conditions (con't) :
  - Coverages
    - Overlapping beams for the Uplink with Target and Reference in the intersection
    - More flexible for the Downlink but more complex and costly with several receiving stations to be deployed
  - Ephemeris
    - Best accuracy if provided by the Satellite Operator compared to published TLEs
  - Known references
    - Number: several known stations can compensate bad ephemeris,
    - Location: reference close to the target reduces the size of the ellipse

Accuracy

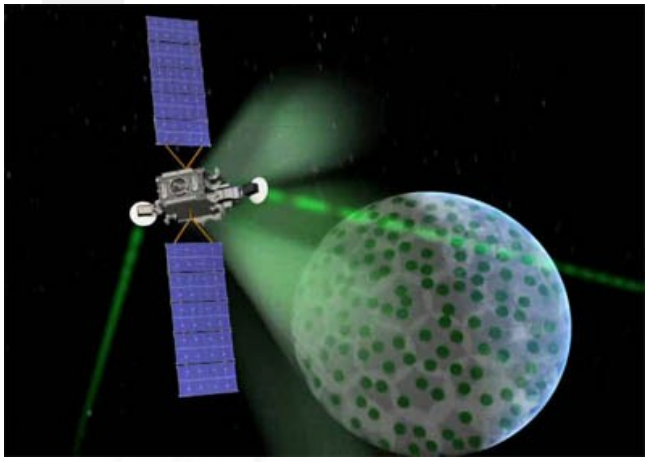
- With all best conditions, geolocation accuracy can be ~1km
- “Good” result should be considered <10km
- Fast degradation of accuracy depending above conditions with position results varying between hundreds or thousands of km
- One satellite geolocation solution performances ?

4- Limitations of standard Geolocation

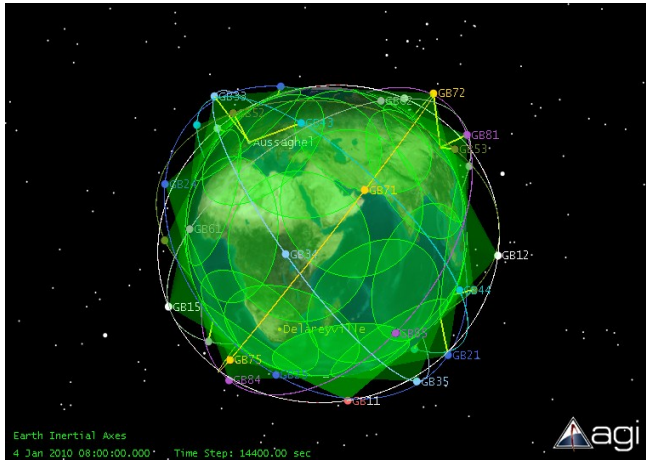
LEO Satellites and Constellations?

⇒ Mostly use On Board Processing or recording (scientific or observation satellites), inter-sat communications (Iridium)

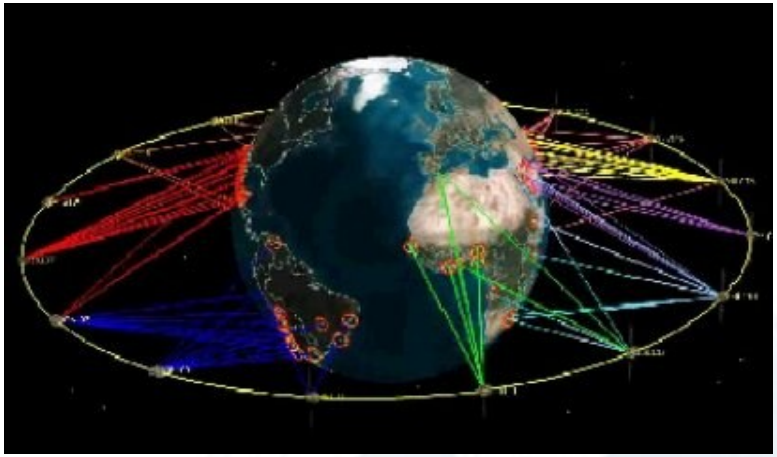
⇒ When transparent, O3B (Ka band), Globalstar (L/C band), limited by the visibility time or the size of the downlink beam and accuracy of FOA measurement alone



Iridium



Globalstar

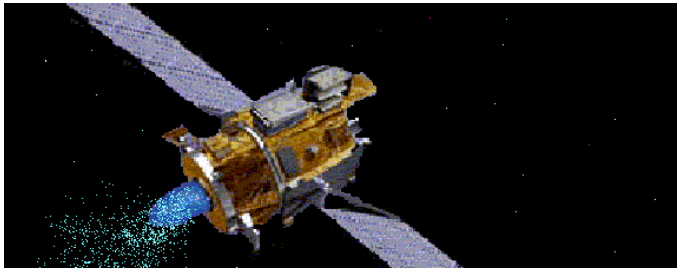


O3B

Particular cases

- Flexible payloads (frequency, power, coverage), Digital Transparent Payload (on board flexible switching/routing of transmissions)
  - ⇒Modifies the transmit signal and induces delay
  - ⇒Impossible if used on the mirror satellite

- Ionic propulsion
  - ⇒Continuous maneuvers imply uncertainty on Satellite position



- Specific waveforms: more complex to process
  - ⇒frequency hopping and RCS, sweeping carriers, CW, spread spectrum

- Multispot satellites?
  - ⇒May be difficult to have compatible Mirror Satellite and/or References

5- Conclusion

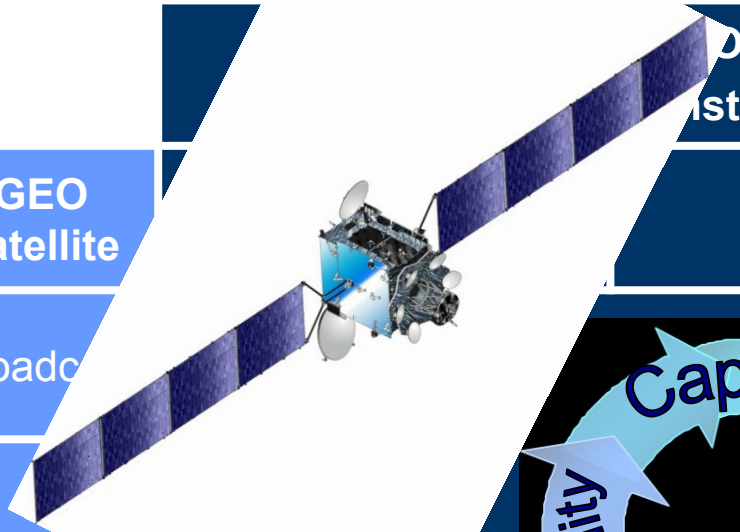
ITU recommendation

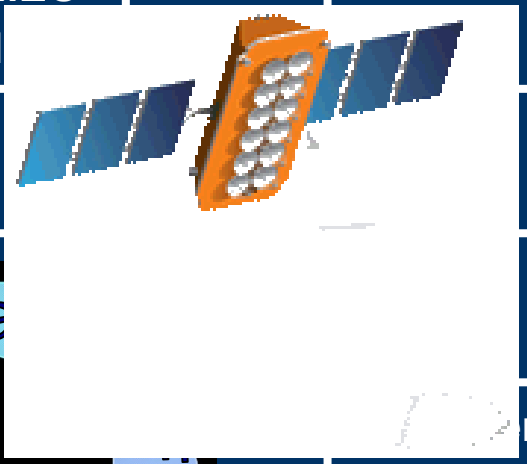
- Requests for Satellite Radio Monitoring System issued by Regulators refer to ITU-R Spectrum Monitoring Handbook Chapter 5.1

⇒ This describes well the theoretical Geolocation process but:

- Type of Satellites and Missions for which Geolocation is meaningful should be added
- Level of acceptable accuracies should be given
- typical acceptance scenarios should be proposed (band, mirror satellite configuration, quality of ephemeris, references…)

Why THALES ? atcom end to end system solution





GEO satellite

Broadc

Flexible payload

Broadband / HTS

Signal Intelligence

Satellite & Mission Control Centers

O/MEO

stel

End to end System design and integration

Earth Stations

(Telemetry Control & Ranging ; Communications)

Narrowband

r segment design & integration

Fixed Broadband solutions

Mobile Broadband solutions

Satellite-based IP Network

DVB S2

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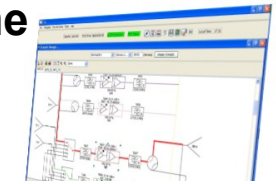
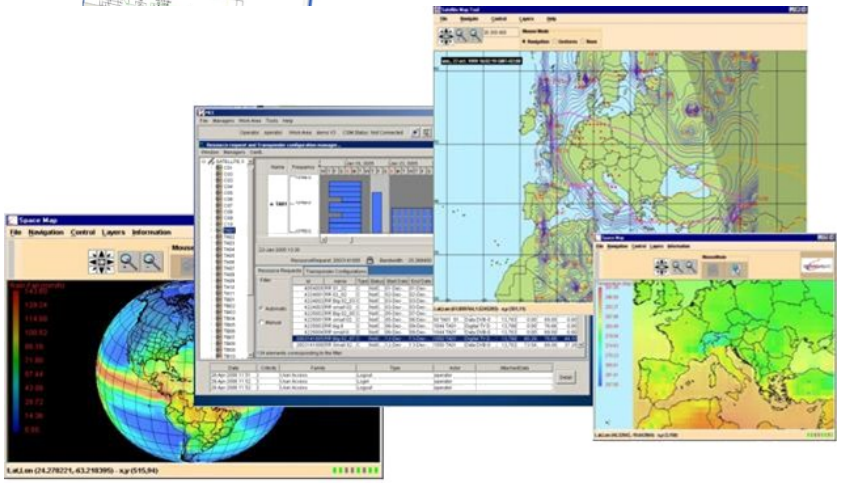
Why THALES ? Mission Control Centre

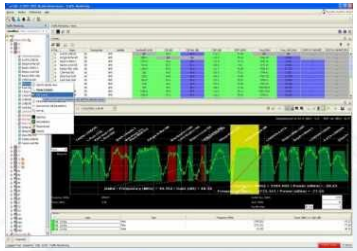
- **Continuous optimization of the system along the life time**
  - Schedule of satellite resources allocations
  - Payload / Ground configurations coherency
  - Optimization of transponders loads



- **Easy system configuration**
  - Payload Configuration *(PCM - Carrioca)*
  - Payload resource allocation to Traffic *(PTM)*
  - Earth station configuration



- **Permanent monitoring of the system**
  - 24-7 cyclic frequency plan monitoring *(CSM)*
    - Jammer detection & characterization
    - Identify any carrier in any frequency range
    - Geolocation
  - Earth station monitoring



The flexible turn-key solution to ease system operations:
a set of functions to conduct all the operations on your satcom system

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