



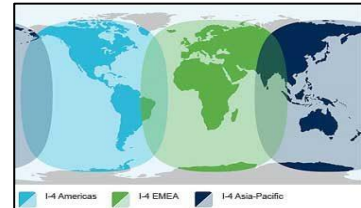
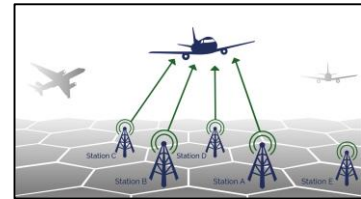
From ground-based to space-based

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From Ground to Satellite CNS Systems

Context and Scope



Legend

Ground-based CNS Technology

Satellite-Based CNS Technology



LDACS

FCI



AEROMacs



SATCOM



VHF Voice



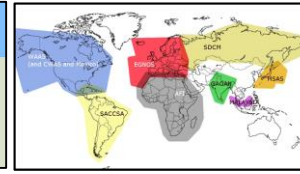
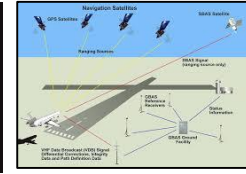
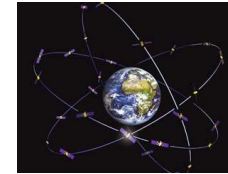
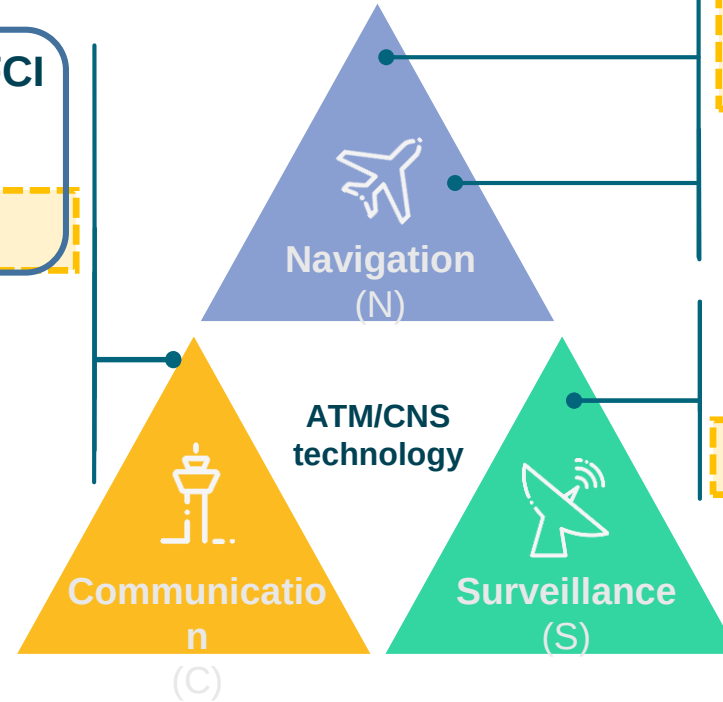
VDL Mode 2/0



Datalink



HF



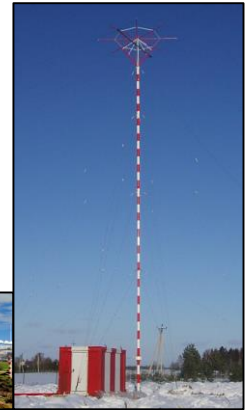
GNSS (GPS, GALILEO, GLONASS, BEIDOU)
GBAS CAT I-II-III
SBAS systems (WAAS, EGNOS,)



ILS CAT I-II-III



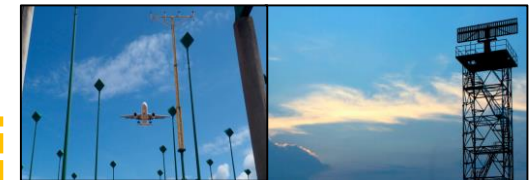
DME-VOR-NDB



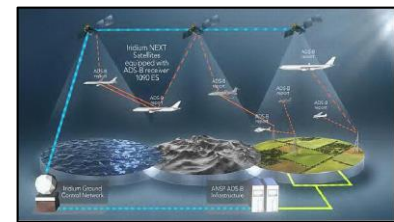
PSR-SSR



MLAT-WAM



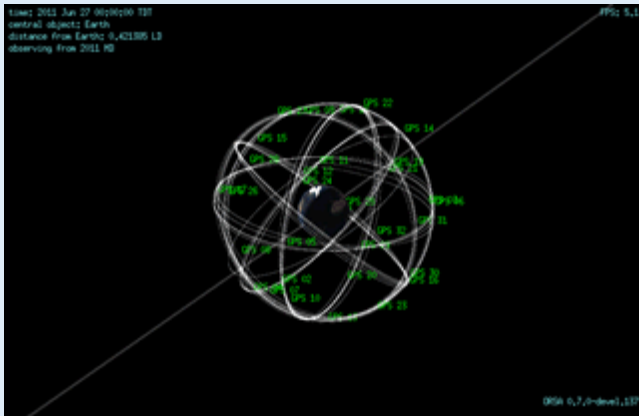
ADS-B



First satellite step for CNS

MEO Satellites for NAVIGATION: GPS

Global Positioning System (GPS)



- GPS was developed by U.S. for Military application.
- In 90' FAA certified the first GPS unit for use in IFR operations.
- Characteristics:
 - 24 satellites (4x6 orbits)
 - 20,200 Km
 - Period: 12 h
 - Global coverage
 - Unlimited usage

Global Navigation Satellite Systems

- GALILEO – Europe
- BEIDOU – China
- GLONASS - Russia



Applications:



Second satellite step for CNS

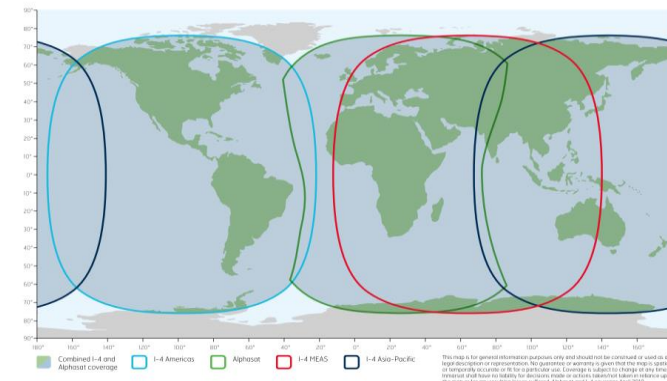
GEO Satellites for Communication: Inmarsat

Inmarsat

- Global mobile communications services via GEO satellite infrastructure
- **Classic Aero** (90's) services in operation for over 25 years (I3/ I4)
- **SwiftBroadband Safety service (SB-S)**
 - I4 / Alphasat, more than 200 spot beams
 - BGAN (2007), broad range of services (maritime and non-safety aeronautical communications)
 - Safety services from 2018
- Evolution to be part of multilink concept and future IPS

Applications:

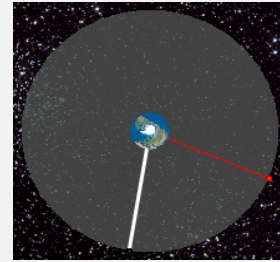
- ATS data services CPDLC / ADS-C over ACARS and ATN/OSI
- Satvoice
- AOC voice and data services (EFB, weather.), passengers and non critical cabin



CNS satellite systems

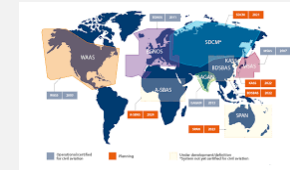
Current Non-ATM focused

GEO	Characteristics
Weight	$\cong 4000 / 6000$ Kg
Constellation	< 10 satellites
Orbit	$\cong 36000$ km
Lifespan	>20 years

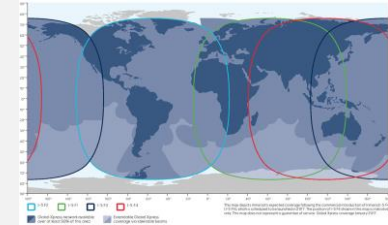


GEO – Geostationary Orbit

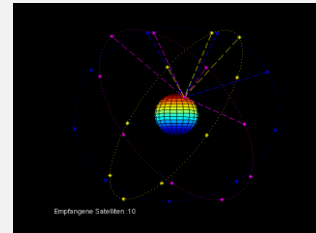
- **NAV:** Satellite Based Augmentation System (SBAS) – EGNOS, WAAS, GAGAN



- **COM:** Inmarsat

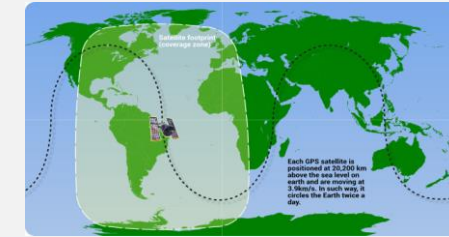


MEO	Characteristics
Weight	$\cong 700 / 1500$ Kg
Constellation	$\cong 30$ satellites
Orbit	3000-30000 Km
Lifespan	>15 years

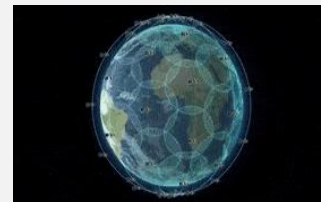


MEO – Medium Earth Orbit

- **NAV:** GNSS: GALILEO, GPS, GLONASS, BEIDOU

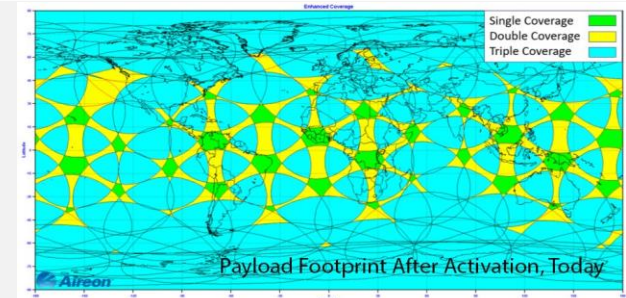


LEO	Characteristics
Weight	< 900Kg
Constellation	> 60 satellites
Orbit	160-2000Km
Lifespan	<15 years



LEO – Low Earth Orbit

- **COM:** Iridium
- **SUR:** Aireon Payload in Iridium Satellites



CNS satellite systems

Current Transition of LEO constellation

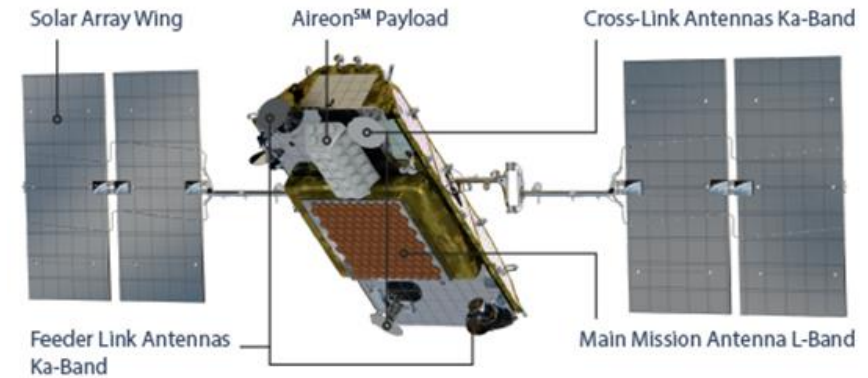
IRIDIUM

Non-ATM focused: non ATM specific design providing COM (SATCOM) and SUR (ADS-B Satellite)

Safety voice and data services (FANS1A / ACARS)

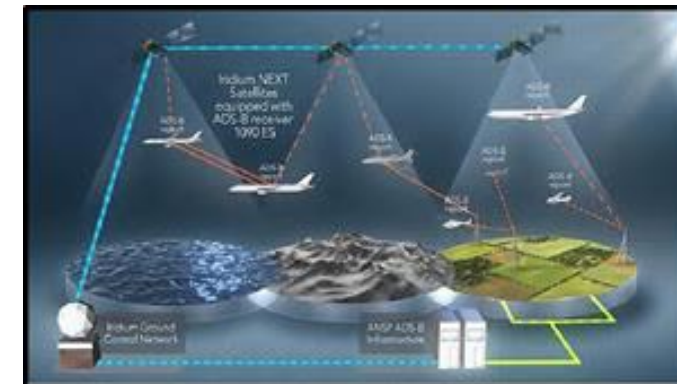
Expanding **Surveillance coverage** to the poles and to the remote/oceanic areas.

First ones implementing **Intersatellite link concept**



Iridium NEXT Satellite Specifications

Deployed Wingspan	9.4m
Weight	860 kg (approx.)
Stowed Dimensions	3.1m x 2.4m x 1.5m



CNS satellite systems

NEW SPACE CONCEPT

There are many more launchers in the market, meaning more competition (SpaceX, RocketLab, PSLV, PLD, ...)

This results in an increased number of launches decreasing the price of new constellations.

CubeSat use standard elements, making it easier to go to market.
1U / 100 x 100 x 100 mm. Mass: 1 kg to 10's of kg

Advanced technologies facilitates the reduction of the cost of small satellites.

New constellations can be deployed for specific uses, i.e. ATM.

Short lifespan, easy to deploy new technologies in a short time (5/8 years).



Graph: Jordi Puig-Suari, Cal Poly, Spanish Small Satellite International Forum 2020

CNS satellite systems

LEO NEW SPACE EXAMPLE



Spire – Lemur 2 Constellation

81 satellites deployed, total number of satellites still unknown.

Non-ATM dedicated: Meteo service (non-ATM) and AIS services.

Some ADS-B data recollection: satellites including ADS-B receivers.

Small size satellites, around 4kg launched as secondary payload in different vehicles (Cygnus, Soyuz, Electron....).

Low altitude Orbit 487-500 km, 92 minutes period, 16 orbits/day

CNS satellite systems

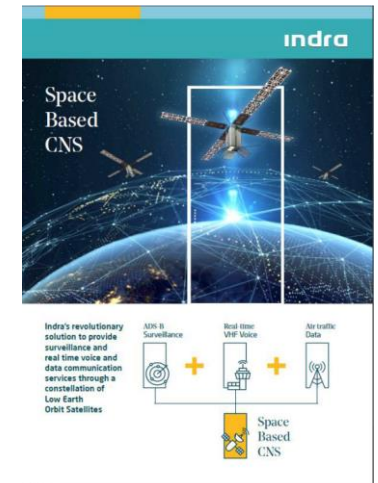
NEW SPACE BENEFITS

- It can be tailored to support global integrated CNS systems for ATM applications
- Lower satellite manufacturing & launching cost
- Due to the short lifespan, **faster deployment of new technologies**
 - Space based system using new terrestrial standards
- **Surveillance services in Oceanic / Remote Areas** and complementing continental (Space based ADS-B)
- VHF data and voice in Oceanic / Remote areas using **existing on-board equipment**
- SALSA PJ recommendation of **VHF Voice** to better exploit the ADS-B satellite in oceanic airspace
- RESOLUTION COM6/6 (WRC 19): studies on a possible **new allocation of VHF band** to the aeronautical mobile satellite (R) service.

New initiatives

Singapore, SITAONAIR Researching HAPS, Satellites for Space-based VHF

By Woodrow Bellamy III | November 5, 2019
Send Feedback | @WBellamyIIIAC



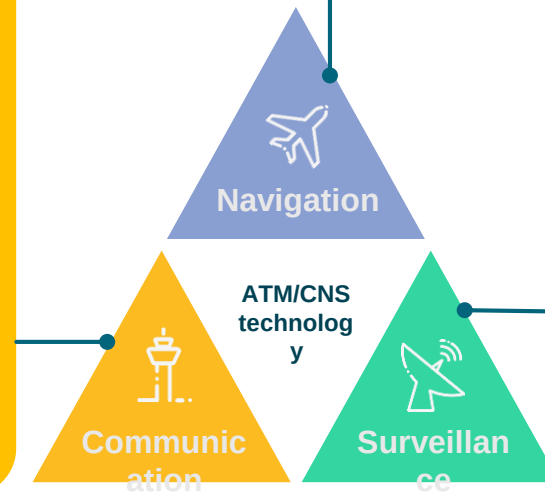
CNS satellite systems

SPACE BASED SYSTEMS POTENTIAL EVOLUTION

- Part of the evolution towards an **integrated CNS** system to support ATM applications
- **Global** (including poles), primary in oceanic and complementary in continental

- Part of the FCI working in a multilink concept (continental & oceanic).
- GEO and LEO systems supporting a broad portfolio of services, including safety services.
- New LEO constellations, ATM focused (lower latency, global coverage including poles)

- Navigation Services based on MEO GNSS constellations
- Augmentation systems with SBAS using GEO
- Trend toward Dual Frequency Multi-Constellation



- LEO constellations supporting global ADS-B
- Potentially towards a space based WAM



From ground-based to space-based

Questions?

