

SATCOM and CNS

ESA Iris Team

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→ THE EUROPEAN SPACE AGENCY

Presentation Content



 Aviation communications services, requirements and impacts

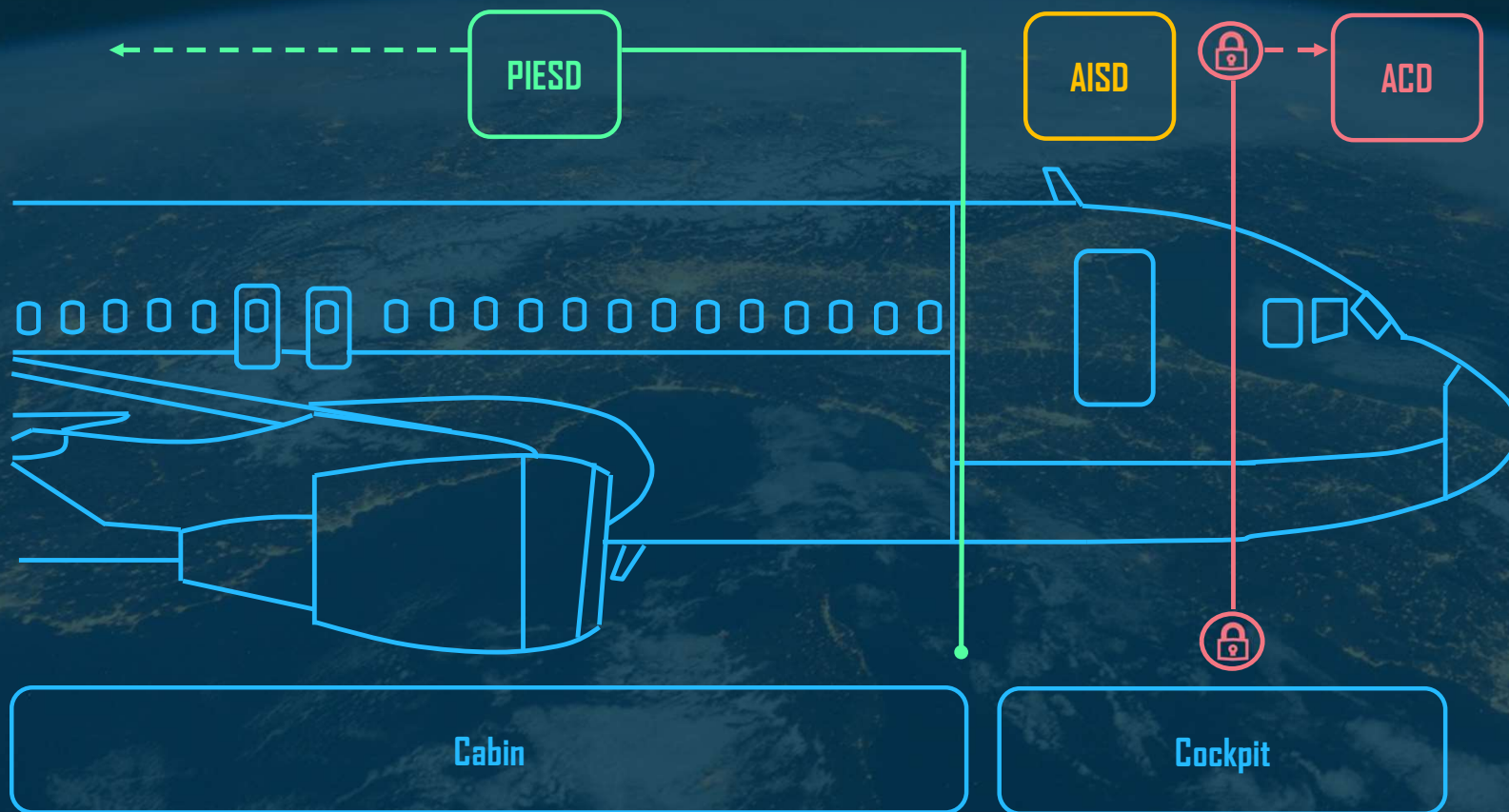
 SATCOM systems characterization

 Existing and future SATCOM systems and services for aviation

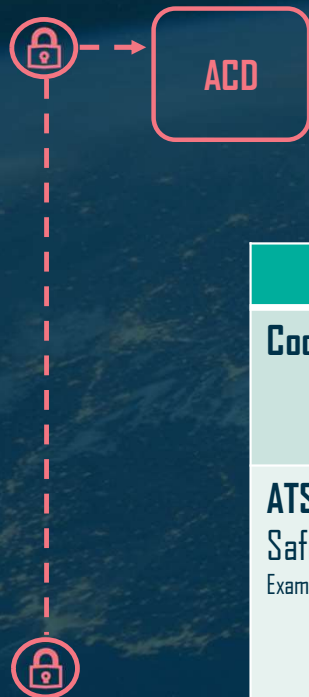
 SATCOM for CNS

 Conclusions

Aviation Communications Domains



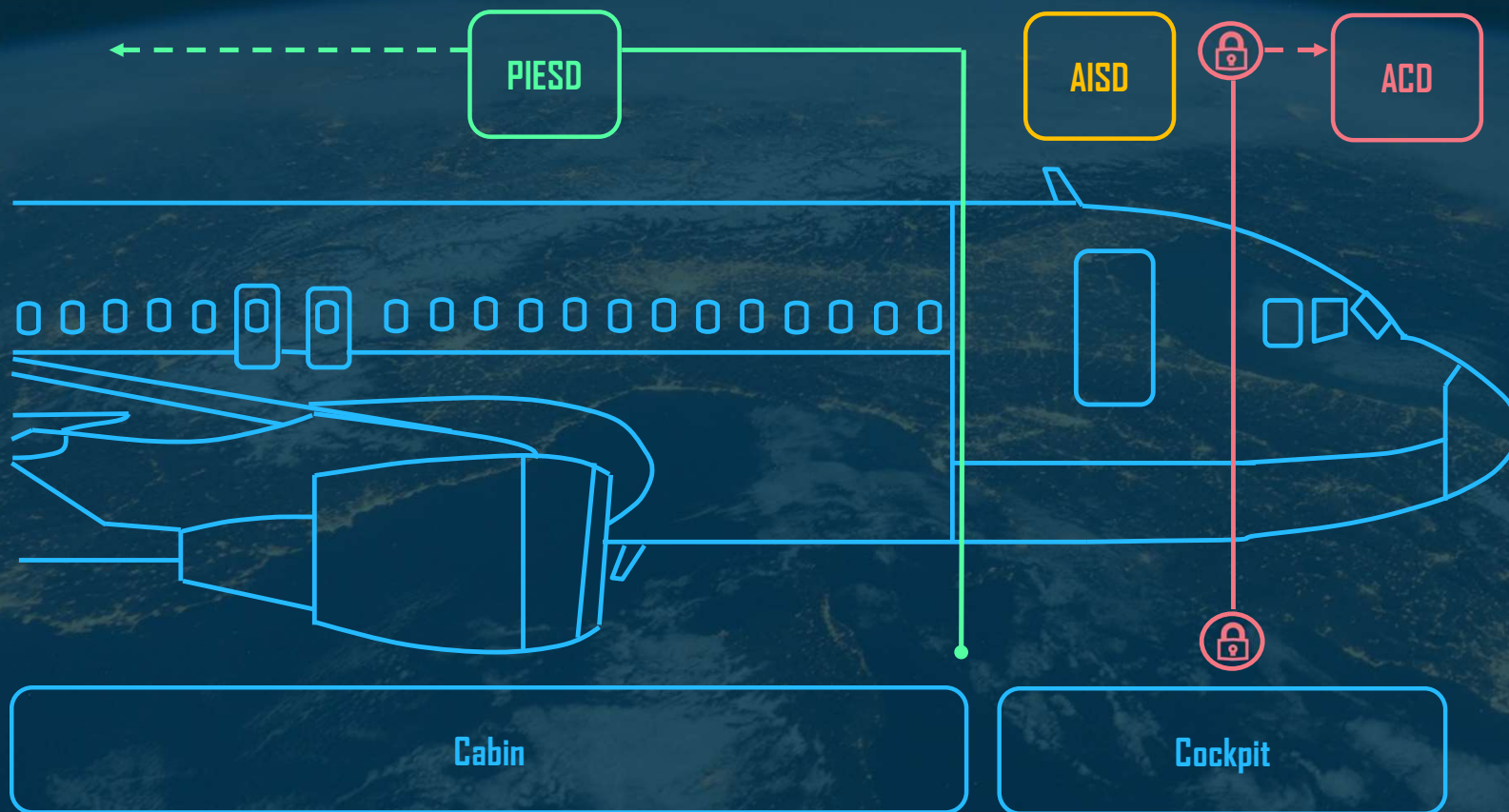
Aircraft Control Domain (ACD): Safety



- The ACD consists of systems and networks whose primary functions are to support the safe operation of the aircraft
- ACD connects to high-priority safety communications such as those supporting Air Traffic Services (ATS) and some Airline Operational Comms (AOC) to the cockpit

Aeronautical Service	Requirements	Main impact as system driver
Cockpit Voice	Safety, reliability, availability	Low latency Redundancy [Secured system]
ATS: Safety and time critical Examples: CPDLC, ADS-C	Safety, Reliability/Continuity, Availability, Integrity Segregation/Prioritization Stringent Latency performance requirements Low/Medium Data-rate	Secured system Low Latency Efficient access scheme Redundancy Global
AOC/ACD: Regularity of flight	Medium/High Data-Rate Integrity, Reliability No latency performance requirements	[Secured system] Efficient access scheme

Aviation Communications Domains



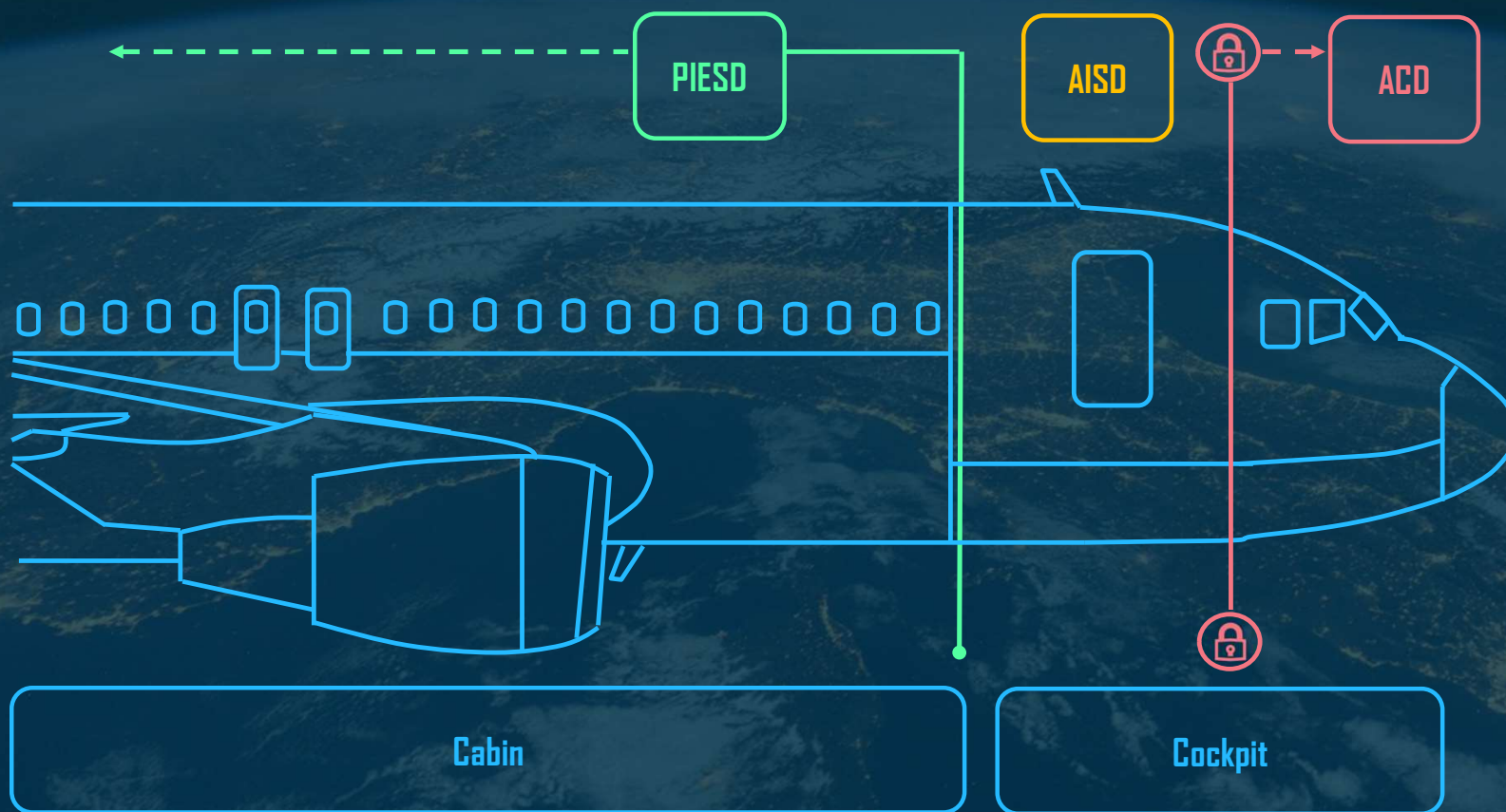
Airline Information Services Domain (AISD)

AISD

- Airline administrative and non-safety related communications
- Data for the operation of the aircraft, important but not critical/essential.
- Requires reliable connectivity to receive e.g. weather data, engine and system performance reports, etc.
- Examples: Electronic Flight Bag (EFB)

Aeronautical Service	Requirements	Main impact as system driver
ADC/AISD Non-safety critical Examples: weather info, fuel data, engine data, pilot reports...	Medium-High Data-rate Lower Integrity requirements Lower availability requirements as compared to ATS communications	Latency tolerant Bandwidth and Capacity hungry Efficient transmission Data protection

Aviation Communications Domains



Passenger Information & Entertainment Domain (PIESD)



PIESD

- Cabin connectivity, entertainment and communications for passengers
- Non-Safety services
- Require a certain QoS but are not critical
- Comprises multiple systems that interconnect, such as passenger device connectivity systems, broadband television, and message systems

Aeronautical Service	Requirements	Main impact as system driver
PIESD Non-safety critical Examples: Web browsing, messaging, video streaming, etc.	High Data-rate Low integrity Lower availability requirements as compared to ATS communications	Latency non critical Bandwidth and Capacity hungry



SATCOM in the aviation safety today



- ✦ Satellite communications (SATCOM) are today widely used in **oceanic airspace** and are becoming an important complementary component for **continental aeronautical** communications.
- ✦ The **Future Communications Infrastructure (FCI)** and the ATM Masterplan foresee SATCOM as a key complementary component to meet the current and future aviation data-link communication needs.
- ✦ INMARSAT, and IRIDIUM are SATCOM systems that are/will be operational and compliant with the ICAO SATCOM Standards and Recommended Practices (SARPS)
- ✦ INMARSAT Iris (ready for deployment) and Iridium Certus service (based on Iridium NEXT constellation) are expected to offer AMS(R)S* services



*ASMRS= Aeronautical Mobile Satellite En Route Services

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SATCOM systems characteristics: frequency bands



Characteristic	VHF	L-Band	C-Band	Ku/Ka
Frequency allocation	- Part of the VHF-band has a primary allocation for AMS(R)S together with ARNS - larger bands are used with MSS allocation	- Part of the L-band has a primary allocation for AMS(R)S - larger bands are used with MSS allocation	- Part of the C-band has a primary allocation for AMS(R)S - larger bands are used with MSS allocation - UAS satellite comms	Shared band with other SATCOM MSS/FSS services
Atmospheric Impairments	Very low (<1 dB)	Low (around 1 dB)	Low (around 3 dB)	High (up to 20 dB in equatorial areas); ACM needed
Capacity				
Terminal Antenna				
Satellite Antenna	(GEO) Multi-beam solutions require extremely large antenna	Large antenna for multi beam (9 - 12m)	Medium antenna	Multi-beam with 2-5 m antenna Smaller beams

Appropriate for high availability requirements

DIRECTIVITY

ANTENNA SIZE

SATELLITE ANTENNA SIZE



The Future of safety communications: FCI and Multi-link



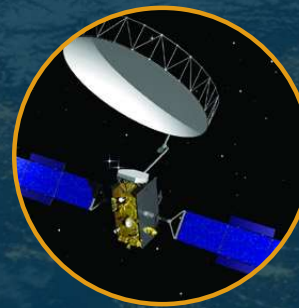
- The **Future Communications Infrastructure (FCI)** will provide ATS and AOC datalink, initially using existing satellite technology based on Satcom Class B, to support initial four-dimensional (i4D) and ATS-B2 services.
- **Long-term FCI** key technologies complementing VDL-m2 in **MULTI-LINK**:

➤ **SATCOM, LDACS and AeroMACS**

- Global, seamless support **4D** and Trajectory-Based Operations (**TBO**)
 - Based on an **ATN/IPS** infrastructure and **ATS-B3** performance
 - interoperability with legacy **ATN/OSI** systems
- 
- Currently being validated in SESAR Wave-2 PJ 14 sol 77;
 - Solution PJ.14-W2-107: Development of Future Satellite Communications Data Link, or long term - SATCOM Class A
 - At present the Iris solution (SATCOM Class B) is ready for deployment and approaching pre-commercial flights



- Classic Aero and SwiftBroadband-Safety (SB-S) certified services for Oceanic
- Global coverage, fully redundant and cyber-secured, 99.9% availability
- **Safety communications (FANSI/A CPDLC and ADS-C) and airline operations** (e.g. EFB)
- Broadband-speed IP connection for **voice**
- Wi-fi in Flight entertainment based on IV-GX
- UAVs connectivity



Alphasat + I4; I6 satellite launched end 2021



On-board processor



Uses Broadband Global Area Network (B-GAN)



630 channels of 200 KHz in L-Band ; up to 400 kbit/s.

The Future: Iris

- Safe, Secure and efficient ATM communications in Continental Europe
- Ready for pre-commercial flights 2022. Target entry into service mid-2023.
- Builds on Inmarsat SATCOM infrastructure: Alphasat and I4. I6 coming next. SwiftBroadband-Safety (SB-S)
- Legacy SB-S capabilities for oceanic: FANSI/A, SATVOICE and ACARS AOC
- New capabilities: continental **ATN/OSI** via SATCOM, enabling i4D and TBD.
- On-going developments **ATN/IPS**, validation in collaboration with SESAR PJ.14-W2-77 and 107



Iridium

- Iridium Certus is a multi-service platform offering, among others, cockpit voice and in-flight aircraft communications (e.g. FANS data service, ADC, weather, EFB...)
- Iridium is working for the introduction of AMS(R)S services, targeting to provide ATN-B1/B2 services via IP in line with ICAO PBCS performance
- Weather resilient due to the use of L-band
- Global coverage and Data and voice communications with low latency (~20-50ms excluding processing)
- Hosts various payloads including Aireon service for ADS-B
- Terminals in development for ACARS and ATS



66 cross-linked satellites in orbit at approximately 781 km



Global Coverage



Overlapping spot-beams



IP data speeds up to 352 Kbps uplink and 704 Kbps downlink



Credits: Iridium

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SATCOM systems for In Flight Connectivity (IFC)



There are a multitude of companies offering IFC services: Panasonic avionics, Gogo, Intelsat, Global Eagle, SITAONAIR, Thales, Viasat, Inmarsat...

- **Gogo (Intelsat) IFC** in flight Wifi



- C and Ku band: inflight connectivity for business and commercial aviation, targeting 5G and IoT via satellite

- **Panasonic Avionics IFC**

- Partners with SES, Eutelsat, Inmarsat and Viasat to rely on Ku and Ka band GEO



- **SITAONAIR:**



- flight planning and passenger connectivity for entertainment and internet (in partnership with Inmarsat using both L-band and Ka GEO)

- **Viasat:**

- Ka band GEO in flight connectivity, high data rate: Wifi, EFB, real-time weather, real-time flight data for maintenance operations (non safety critical ACARS over IP), digital documents management for crew



- **Eutelsat Advance**

- IFC Ku and Ka GEO/LEO



Future potential SATCOM systems for In Flight Connectivity

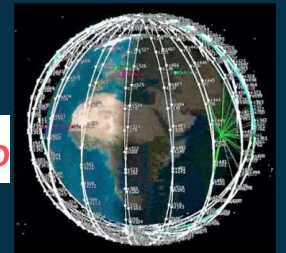


Ku Band LEO:

- **Starlink:** Since May 2019, Space X has been launching its new Starlink internet satellites in batches of 60, with the goal of creating a "megaconstellation" with 30,000 small satellites with Ku band user links
 - 4 Ku Direct Radiating Array per satellite
- **OneWeb** The Gen 1 OneWeb satellite constellation consists of 648-satellite constellation To be completed by 2022



Credits: www.businessinsider.nl



Credits: www.satnews.com

UHF/S Band LEO

- **ATS SpaceMobile:** providing 4/5G building a constellation of 243 low-orbit satellites to provide 4G/5G links directly to unmodified smartphones. The plan is to start launching its fleet in late 2022. User link frequencies in UHF and S band.



Satellite-based VHF

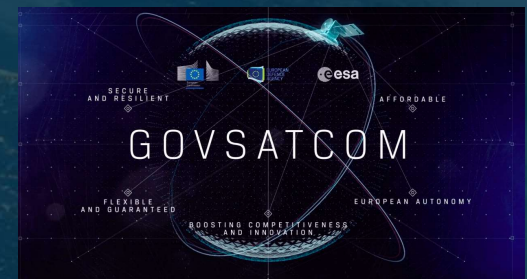
- Indra/ENAIR and SESAR Research and Innovation phase for voice and data-link extension over oceanic integrated with surveillance

ESA Telecom pillars and plans for future secure connectivity



■ System Solutions:

- Design and consolidation of Next Gen SatCom system Infrastructure to support EU Secure Connectivity
- Several parallel ESA initiated and Industry initiated activities enabling Pooling & Sharing of Commercial and Governmental Satcom Resources
- Development of Next Generation commercial constellations (e.g. SUNRISE addressing OneWeb Next Gen)
- Next Generation of CNS solutions specifically addressing new Surveillance solutions
- Activities related to enabling Arctic coverage and addressing seamless continuous connectivity between GEO and non-GEO systems for maritime and aeronautical users



ESA Telecom pillars and plans for future secure connectivity



- **Technology Developments** (among others):
 - Next generation multi-band-multi-orbit Ground antennas, airborne antennas and Terminals
 - Anti-jamming Solutions for Institutional users
 - Interference analysis for coexistence of GEO and non-GEO satellite systems
 - Development of elements to sustain interoperable services like **5G/6G**, Multi Frequency band ground elements, terminals addressing a wide range of application (e.g. Civil aviation, RPAS UAV , Maritime, Rail, cars and autonomous operations)
- **Applications domain:**
 - Wide range of application using Space infrastructure and systems: Virtual Black Box, weather dashboard , Drones applications, Space Enabled Digital and Green Economy



Satellite for integrated CNS Services



Communication



IRIS

Satellite-based datalink (voice & data services)
4 Geostationary Satellites – Global coverage except polar
Iris offers satellite-based safe and secure broadband communications supporting current Controller Pilot Data Link Communications (CPDLC) and upcoming advanced services and concepts like Trajectory Based Operations. Service in Europe starting 2023.

C

Navigation



Galileo (GPS / GLONASS / BeiDou)

Global Navigation Satellite Systems (GNSS)

24 Medium Earth Orbit Satellites (6 spares) – Worldwide Service

Offers aircraft a high precision positioning virtually everywhere anytime.



EGNOS satellite-based augmentation system (SBAS)

European Geostationary Navigation Overlay Service

3 Geostationary Satellites – Service in Europe

Improves accuracy and reliability of GNSS positioning information increasing safety in critical flight phases such as final approaches.

N

Surveillance



Aireon Space-based ADS-B

66 Low Earth Orbit Satellites – Global coverage

Worldwide dependent cooperative surveillance of aircraft equipped with 1090MHz ADS-B transponders. ADS-B signals periodically broadcast by aircraft are received at the satellites and made available real-time to ANSPs
Based on the Iridium NEXT satellite constellation

S

Independent Cooperative Surveillance

ESA new initiative



Conclusions



- ✱ Critical Air Traffic Services present stringent requirements in terms of Safety, Reliability, Continuity, Availability, Integrity and Latency
- ✱ This results in the need for low latency, efficient and most of all **secured communication** system, available on a **Global scale**
- ✱ SATCOM is **intrinsically compliant**: ubiquitous, scalable, flexible, secure and resilient
- ✱ Represents a key **FCI complementary** component and will enable i4D (short term) and TBD (long term)
- ✱ SATCOM will have a key role as interoperable element for a **multi-service approach**, especially offering segregation for critical services, and will act also as an enabler for **integrated CNS** services
- ✱ **SATCOM** can enable multi-orbit and multi-frequency systems, and systems extending in-flight connectivity to non-safety airline comms
- ✱ ESA is working on technological developments to support this trend (security, antennas, terminals, satellite technologies)
- ✱ Satellite service cost will reach a level that will make it a viable option considering its benefits



Thank You

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