Iris

“A Satellite-Based Solution for the Modernization of Air Traffic Management”

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Summary

- **Air Traffic Management (ATM)**
- **CNS/ATM Systems**
- **SESAR (Single European Sky ATM Research)**
- **Aeronautical Communications**
- **ESA Iris Program**
- **THAUMAS Solution**
- **ANTARES Solution**

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Air Traffic Management (ATM)

- The objective of **Air Traffic Management** is to enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints, without compromising agreed levels of safety.
- ATM includes procedures, technology and human resources which make sure that:
  - aircraft are guided safely through the sky and on the ground *and*
  - airspace is managed to accommodate the changing needs of air traffic over time.

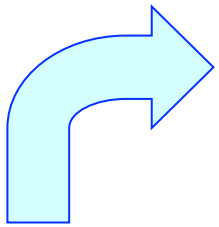
CNS/ATM Systems 1

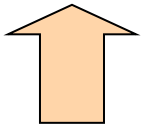
- CNS: Communications, Navigation, and Surveillance systems, employing digital technologies, including satellite systems, together with various levels of automation, applied in support of a seamless global Air Traffic Management system.
- Mission: To foster implementation of a seamless, global ATM that will cope with world-wide growth in air traffic demand while:
  - improving upon the present levels of safety;
  - improving upon the present levels of regularity;
  - improving upon the over-all efficiency of airspace and airport operations, leading to increased capacity;
  - increasing the availability of user-preferred flight schedules and profiles; and
  - minimizing differing equipment carriage requirements between regions.

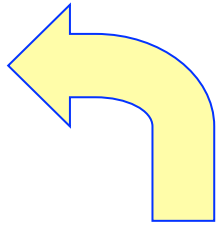
CNS/ATM Systems 2

ATM

- Enhanced Safety
- Increased System capacity
- Optimized use of airport capacity
- Reduced Delays
- Reduced Flight operating costs
- More efficient use of airspace; more flexibility; reduced separations
- More dynamic flight planning; better accommodation of optimum flight profiles
- Reduced controller workload/increased productivity







Communications

- More direct and efficient air-ground linkages
- Improved Data Handling
- Reduced Data congestion
- Reduced communications error
- Interoperability across applications
- Reduced Workload

Navigation

- High integrity, high reliability all-weather navigation services world-wide
- Improved 4-dimensional navigation accuracy
- Cost savings from reduction or non-implementation of ground-based navigation aids
- Better airport and runway utilization
- Reduced pilot workload

Surveillance

- Reduced Errors in position reports
- Surveillance in non-radar airspace
- Cost savings
- Higher degree of controller responsiveness to flight profile changes
- Conformance monitoring
- Improved emergency assistance

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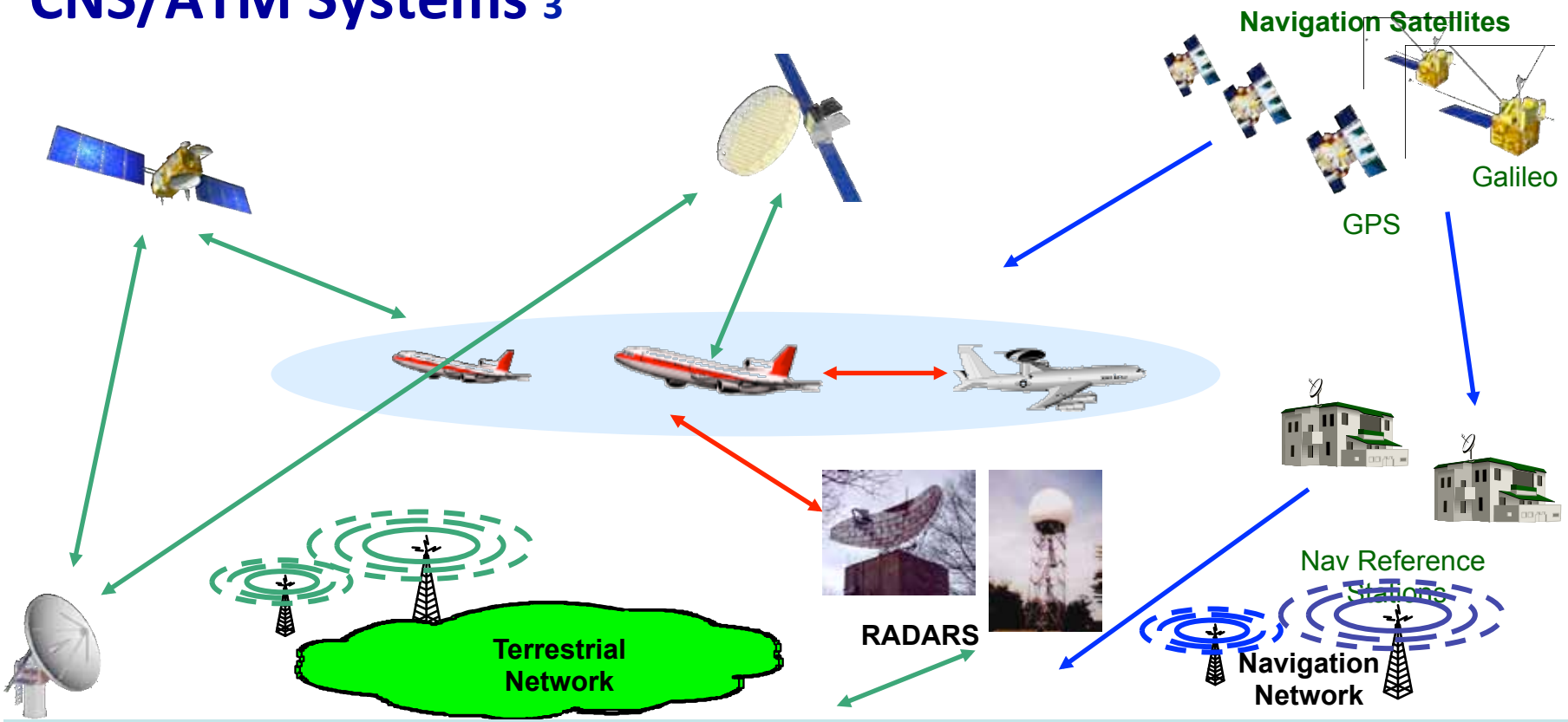
CNS/ATM Systems 3



Growing integration of communications, navigation and surveillance functions

SESAR

- The Single European Sky ATM Research (SESAR) program is building the future European Air Traffic Management System
- It is the technological and operational dimension of the Single European Sky (SES) initiative to meet future airspace capacity and safety needs
- The EU Single European Sky is an ambitious initiative launched by the European Commission in 2004 to reform the architecture of European air traffic management. It proposes a legislative approach to meet future capacity and safety needs at a European rather than a local level. The Single European Sky is the only way to provide a uniform and high level of safety and efficiency over Europe's skies.
- SESAR Joint Undertaking (SESAR JU) is an international public-private partnership, founded by European Community and EUROCONTROL (the European Organisation for the Safety of Air Navigation) to organize and coordinate the SESAR development activities; it unites 16 members representing the whole aviation community
- As a co-founding member of the SESAR Joint Undertaking together with the European Commission, EUROCONTROL plays a key role in all SESAR work packages.

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Aeronautical Communications 1

What makes supporting aviation safety communications "special"?

- Based on agreed international standards
- Operates in privileged radio bands
- Safety requirements drive the design process in ground and aircraft systems (e.g. avionics have appropriate level of 'certification')
- Agreed level of service from providers.

Two Categories of Communications

- Safety related:
  - Air Traffic Services (**ATS**)
  - Airline Operational Communications (**AOC**)
- Non Safety related:
  - Airline Administrative Communications (**AAC**) and
  - Air Passenger Communications (**APC**)

Technical Requirements for Safety

- Specified by International Civil Aviation Organisation (ICAO) Standards and Recommended Practices (SARPs).

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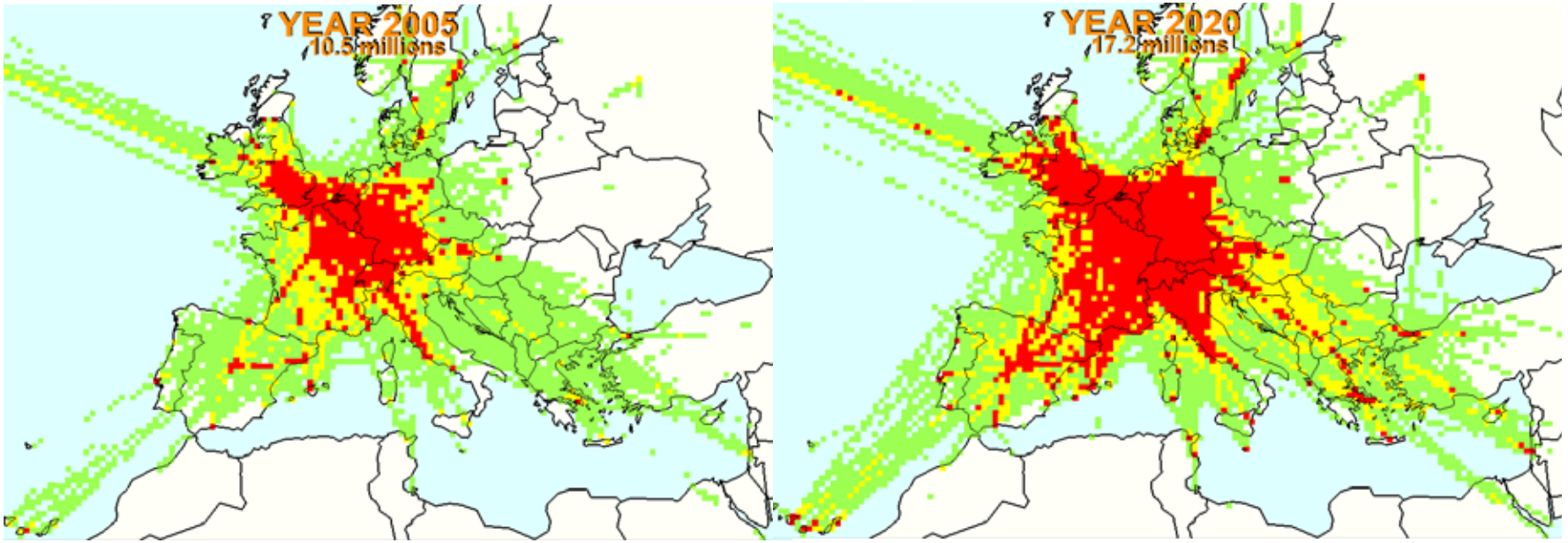
Aeronautical Communications 2

- **Terrestrial "HF":** low capacity, slow response but worldwide coverage
  - analogue voice and data services
  - Services operated on 3 kHz wide channels (dedicated frequency bands between 2.85 MHz and 22 MHz)
- **Terrestrial "VHF":** (118 - 137 MHz, 8.33 kHz wide channels. The same frequency can be reassigned many times provided that there are no interference problems): generally available in continental airspace
  - VHF Double Side Band Amplitude Modulation (DSB-AM) analog voice
  - VHF data links
- **Terrestrial "UHF"** [Operating frequencies: 1,030 MHz (ground to air) and 1,090 MHz (air to ground)]
- **Aeronautical Mobile Satellite Service** (AMSS): costly and not deployed on all aircrafts. Digital voice and data services via geo satellites in the mobile satellite service bands: 1,545 MHz - 1,555 MHz and 1,646.5 - 1,656.5 MHz.

Aeronautical Communications 3

- VHF is starting to suffer greater congestion of the aviation frequency band and the use of other frequencies to reduce this load is becoming increasingly urgent. The VHF Aero Band is nearing saturation and the introduction of data services will increase spectrum demand
- The communication exchanges will drastically evolve to enable the SESAR Capability levels. These exchanges will require implementation of new communication systems [(notably an AeroWiMAX system for short range airport ATC communications, LDACS (L-band Digital Aeronautical Communication System) radios to progressively replace the VHF datalink systems, and a new satellite system)].
- Satcom offers a potential alternative, but the associated infrastructure costs (avionics, satellites and ground stations) are more expensive than those for line-of-sight systems. At present, airlines revert to using VHF communications wherever possible and only use Satcom where there is no alternative.
- Current indications are that some of the availability requirements being identified for future datalink services cannot be met by a single air-ground link. It may therefore be necessary to have two different air-ground links available at all times between an aircraft and ATC (redundancy in case of failures).

Aeronautical Communications



Aeronautical Communications: Satellites opportunities

- In the near term, the possibility of rapidly deploying additional capacity over vast areas as soon as the satellite is operative; growth flexibility.
- The possibility of seamless integration of communications between continental and ocean or polar routes where satellite telecommunications are the only solution available.
- Easy provision of data links over such areas, thereby allowing for aircraft tracking and navigation when coupled with positioning systems; possibility of using synergies between data communication and navigation equipment for future avionics, in particular regarding the possibilities offered by software radio systems.
- The opportunity of driving standardization of equipment, applications and protocols, thus enabling a reduction in infrastructure costs as well as homogeneity of *modus operandi* among European Air Navigation Service Providers.
- The possibility of providing secure data links and automatic data logging for security and other potential services.

ICAO announced (in May 2011) that the use of SATCOM is no longer restricted to "emergencies and non-routine situations" (i.e. loss of voice radio).

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Aeronautical Communications: Required COM performance

Essential requirement in European Aviation Safety Agency (EASA) Basic Regulation EC 1108/2009

Communication services shall achieve and maintain sufficient performance with regard to their **availability, integrity, continuity and timeliness**. They shall be expeditious and **protected from corruption**

Iris Program: Satellite communications for ATM 1

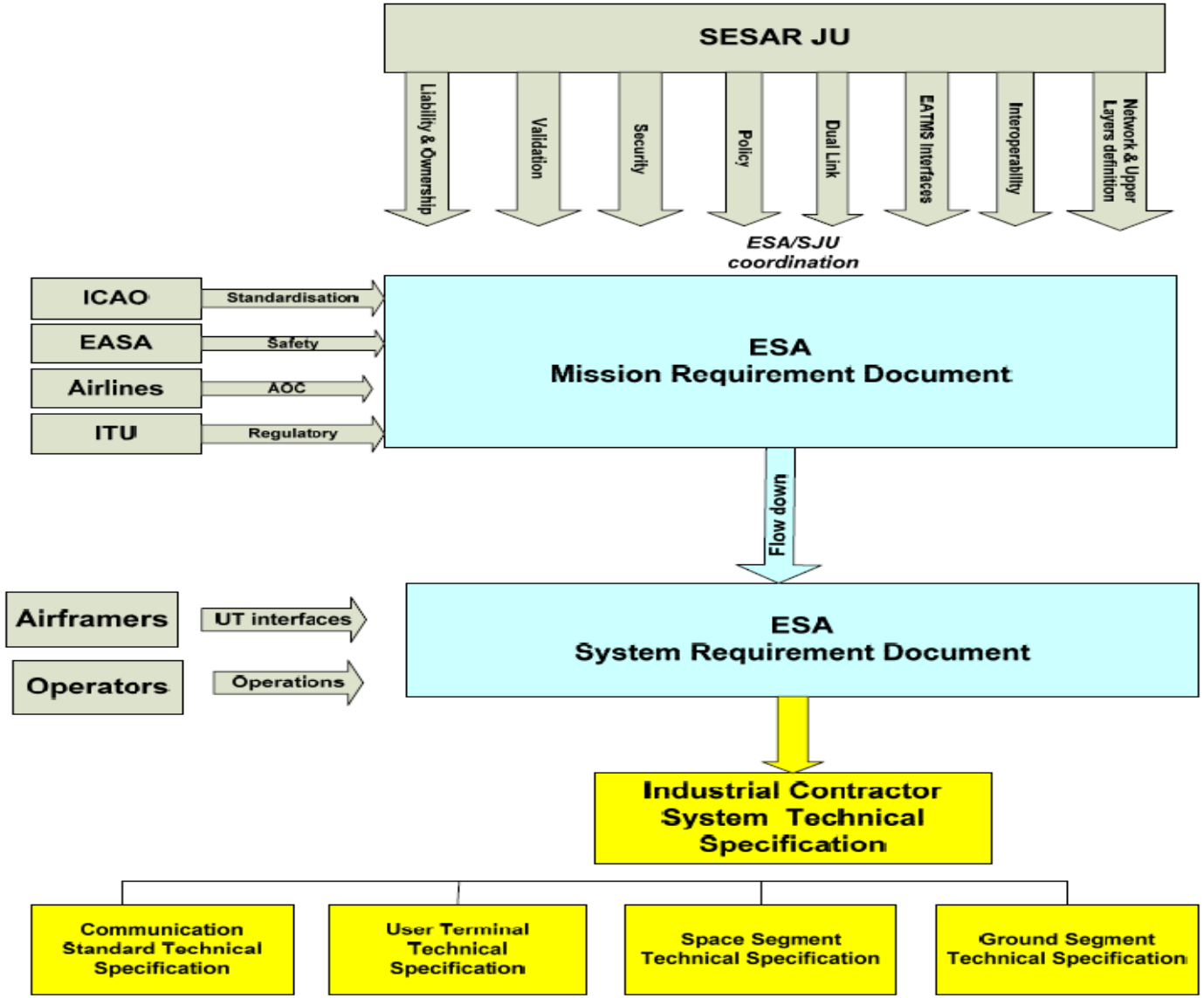
"**Iris**": dedicated **ESA** program to support **SESAR**, under the umbrella of the "Advanced Research in Telecommunication Systems" (ARTES) program, has the objective to design, develop, validate and standardize a satellite-based communication system for the provisioning of ATM safety communications, in accordance with the future ATM concept on the basis of the SESAR requirements.

In Greek mythology, **Iris** is the personification of the rainbow and the messenger of the gods: **Iris** links the Sky to the Earth.

Iris Program: Satellite communications for ATM 2

EUROCAE: European Organisation for Civil Aviation Equipment

Iris Program: Satellite communications for ATM 3



Iris Program: Satellite communications for ATM 4

- **Iris** aims to develop a new communication system for ATM
- **Iris** proposes a satellite-based solution to support the evolution from "voice based" communications toward digital data links in continental and oceanic airspace.
- The future European ATM System is currently being defined by SESAR program (Project 15.2.6: develop the requirements for the future satellite communication system) that supplies the requirements to Iris program and will perform the complementary activities of validation and support to the standardization). According to SESAR definition phase results, there is the need to evolve from voice based communications to digital data links between the aircraft flight management system and the ground Air Traffic Control (ATC) and Airline Operations Centre (AOC) systems.
- This has driven the requirement for a dual link solution to guarantee the necessary availability, especially over dense traffic areas. The dual link is expected to include a terrestrial and a satellite-based component.

Iris Program: Basic Assumptions on Future Systems

- Future (2020+) system needs to support **Air Traffic Services** and **Airline Operational Communications** including air/ground and air/air communications
- In future operating concept **data** becomes the primary mode of communications
- In case of failure of data comms, **voice** is unlikely to be able to sustain operations at the same capacity level. Therefore different data links may be needed to maintain capacity of operations. In the future concept **voice** will remain available for emergency communications
- No single technology meets all requirements across all operational flight domains
- Future system will be a system of systems integrating existing communication systems (voice, VHF Data Link) as well as new communications systems to meet the operational requirements
- Future system should support digital voice in the long term, however in the short term the emphasis is to support data communications
- Appropriate spectrum allocations

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Iris Program: Assumptions on comm. technologies available

Airspaces	SATCOM	LDACS	AeroMACS
ORP (Oceanic, Remote and Polar airspace domain)	P	N/A	N/A
ENR (En-route airspace domain)	P	P	N/A
TMA (Terminal Manoeuvring Area airspace domain)	P	P	N/A
APT (Airport airspace domain) **surface**	F	B (when available)	P
APT surface (AeroMACS not available)	F	P	N/A
APT surface (AeroMACS and LDACS not available)	P	N/A	N/A

***P**: Primary, **F**: Fallback, **B**: Back-up, **N/A**: Not Applicable*

- **AeroMACS:** Aeronautical Mobile Airport Communications System (airport communications system operating in C-band, 5,091 - 5,150 MHz based on WiMax technology) currently under definition by SESAR JU and standardisation procedure
- **LDACS:** L-Band Datalink Air-Ground Communications System, currently under definition by SESAR JU, and to be used by aviation post-2020 as data communication network composing the dual link in high-density continental airspace

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Iris Program: Class of Services for Data Messages

CoS	ET (s)	TD95 (s)	Integrity	Continuity	Ap	Au	Service Type
DG-A	rsvd	9.8	5.00E-08	N.A	rsvd	rsvd	NET
DG-B	1.6	0.74	5.00E-10	0.99999992	0.99999999995	0.99999995	ATS
DG-C	5	1.4	5.00E-08	0.9996	0.999995	0.9995	
DG-D	7.8	2.4	5.00E-08	0.9996	0.999995	0.9995	
DG-E	8	3.8	5.00E-06	0.996	0.9995	0.9965	
DG-F	12	4.7	5.00E-08	0.996	0.9995	0.9965	
DG-G	24	9.2	5.00E-06	0.996	0.9995	0.9965	
DG-H	32	13.6	5.00E-06	0.996	0.9995	0.9965	
DG-I	57	26.5	5.00E-06	0.996	0.9995	0.9965	
DG-J	N.A.	13.6	5.00E-08	N.A	0.9995	0.995	AOC
DG-K	N.A.	26.5	5.00E-10	N.A	0.9995	0.995	
DG-L	N.A.	51.7	5.00E-10	N.A	0.9995	0.995	

Class of services definition

- ET is the Expiration Time, i.e. the maximum time between updates beyond which a service interruption is declared.
- TD95 is the Transit Delay one-way latency requirement specified in terms of a probability, e.g., a 95% percentile delay.
- Ap is the Availability of Provision: The required service availability to make the service usable - The safety effect when unable to communicate to all aircraft
- Au is the Availability of Use: The required availability when using the service to make the service usable - The safety effect when unable to communicate with one aircraft

Iris Program: Capacity Requirements and Communication traffic profile per aircraft

- Total of 48 Applications (considered in terms of required performances: latency, expiration time, CoS, Size for Forward and Return Links)
  - 25 ATS Applications
  - 21 AOC Applications
  - 2 Network Management Applications
- *Aircrafts in terms of PIAC (*Peak Instantaneous Aircraft Count*)*

2015	500
2017	4,000
2020	7,000
2025	9,000
2030	11,500

- Various message sizes (From **77** to **21,077** bytes long)
- Short messages with stringent latency requirements
- Receive and transmit is infrequent and not predictable (Ad-hoc reservation of capacity required)
- Average throughput per aircraft is a few bps (low volume of information per aircraft)
- overall capacity of 5.08 Mbps (TBC, forward link) and 1.4 Mbps (TBC return link)
- Three possible additional Scenarios (Low, Medium and Large) for sat capacity
  - overall capacity of 1.05 Mbps (forward link) and 0.85 Mbps (return link)
  - overall capacity of 4.2 Mbps (forward link) and 1 Mbps (return link)
  - overall capacity of 8.7 Mbps (forward link) and 2.1 Mbps (return link)

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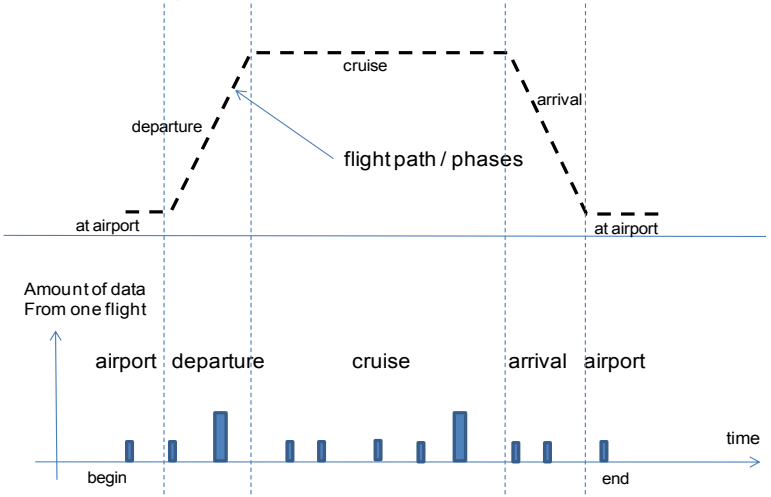
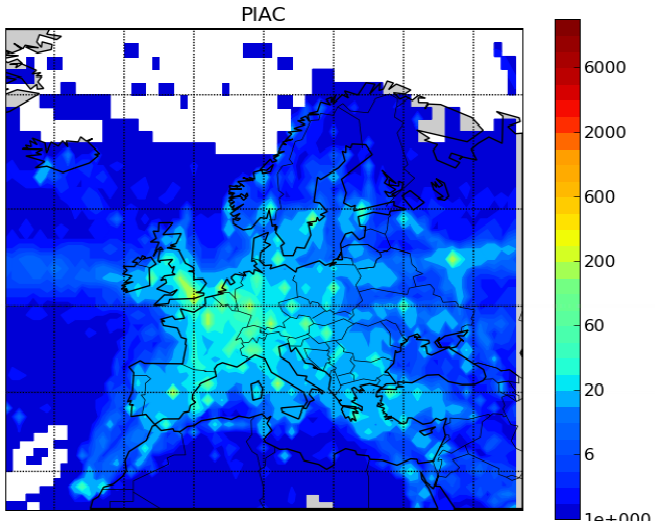
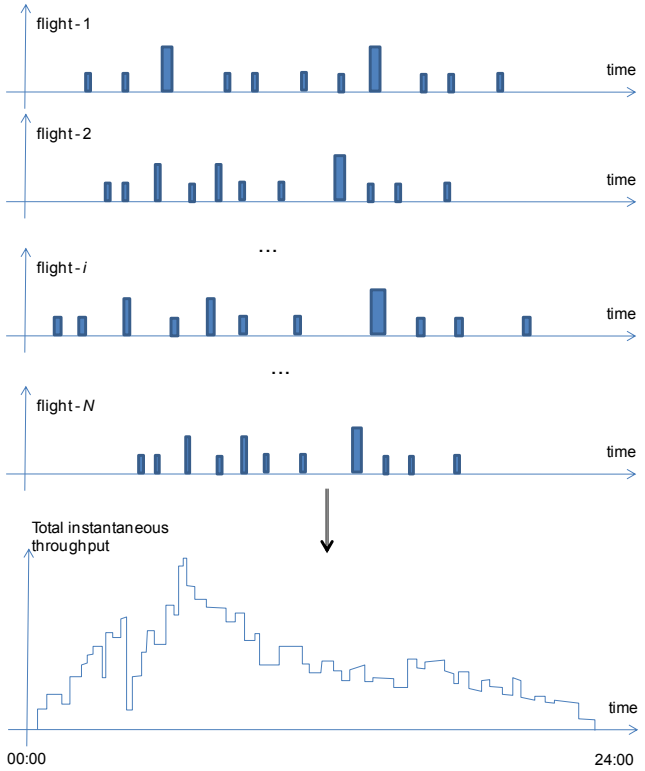
Iris Program: Capacity Requ. (ATS & AOC applic.) x air traffic growth



Communication pattern of one aircraft (cf. COCR)



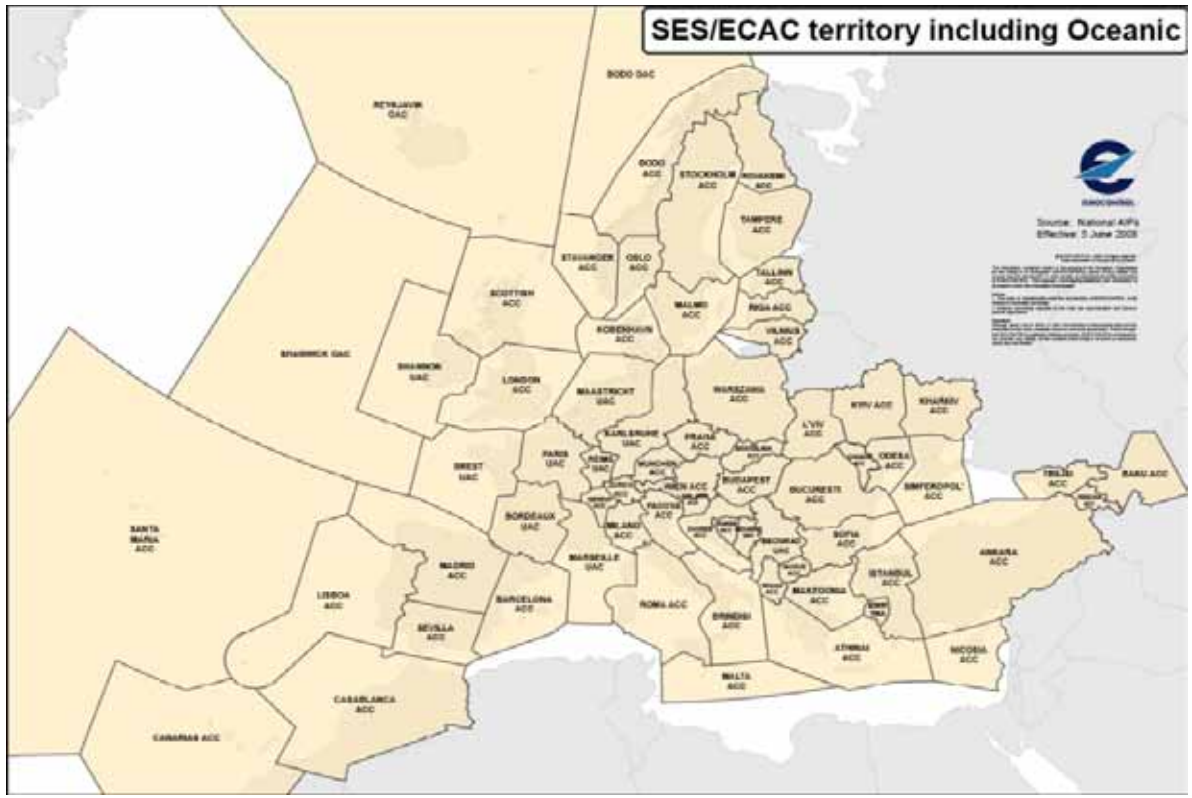
Traffic density in 2025 (cf.Eurocontrol Long Term Forecast)



Traffic Model: calculation of the information throughput for all aircraft flying simultaneously over a given area during the busiest day of the year

Iris Program: geographical area of Service Provision

Iris focus on SES/ECAC (European Civil Aviation Conference) service area but the communication system designed is foreseen to become a worldwide standard (ICAO standardisation) so that other world regions could implement compatible systems using the very same terminals on-board aircraft



Possible extensions of coverage considered in Iris studies:

- Visible Earth from GEO orbit
- Northern areas by agreement with other countries operating ATM Satcom services on HEO satellite systems

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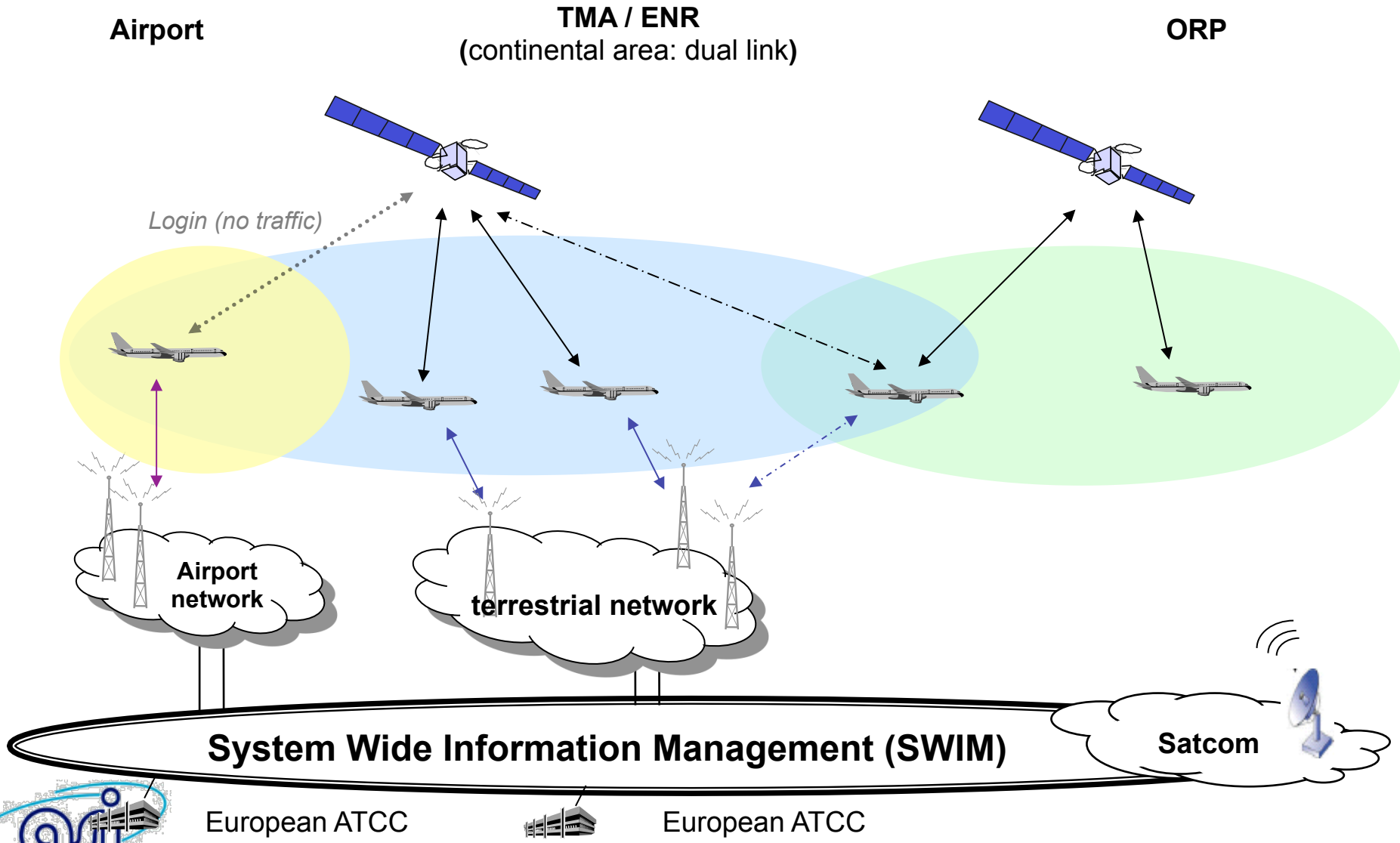
Iris Program : Satellite System Architecture



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Iris Program : Two possible different solutions

Two possible solutions under technology investigations:

- Evolution of INMARSAT SBB (**T**ailored and **H**armonised satcom for **A**TM **U**ses, **M**aximising re-use of **A**ero **S**wiftbroadband: **THAUMAS**)
- New SATCOM system (**A**ero**N**au**T**ic**A**l **RE**sources **S**atellite based: **ANTARES**)

SBB: SwiftBroadband

IP-based packet-switched service that provides a symmetric 'always-on' data connection of up to 432 kbps per channel

THAUMAS: SwiftBroadband Features

- SwiftBroadband is an IP-based packet-switched service that provides a symmetric 'always-on' data connection of up to 432 kbps per channel.
- Standard IP data – currently up to two channels per aircraft:
  - Up to 432 kbps per channel over a high-gain antenna
  - Up to 332 kbps over an intermediate-gain antenna
- IP data streaming on demand at 32, 64,128kbps – can be combined for higher rates
- high-quality voice channel with the full functionality of land-based fixed phone services and a generic SMS service
- Simultaneous voice and high-speed data:
  - Packet data (TCP/IP) and ISDN
  - Circuit-switched voice and VoIP
- GPRS and UMTS compatible
- Support for high-assurance applications

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THAUMAS: SwiftBroadband Applications

SwiftBroadband supports applications for crew and passengers:

Crew

- Safety services – Automatic Dependent Surveillance (ADS), Controller/ Pilot Datalink Communications (CPDLC)
- Voice communications
- Electronic Flight Bag (EFB), flight plan, weather and chart updates
- Engine performance monitoring and fault reporting for major systems
- General operational planning
- Crew reporting and general administration

Passengers

- Telephony: in-seat, mobile, VoIP and text messaging
- Email, intranet, internet and instant messaging
- Secure VPN access
- Large file transfer – presentations, graphics, video
- Videoconferencing
- In-flight news updates

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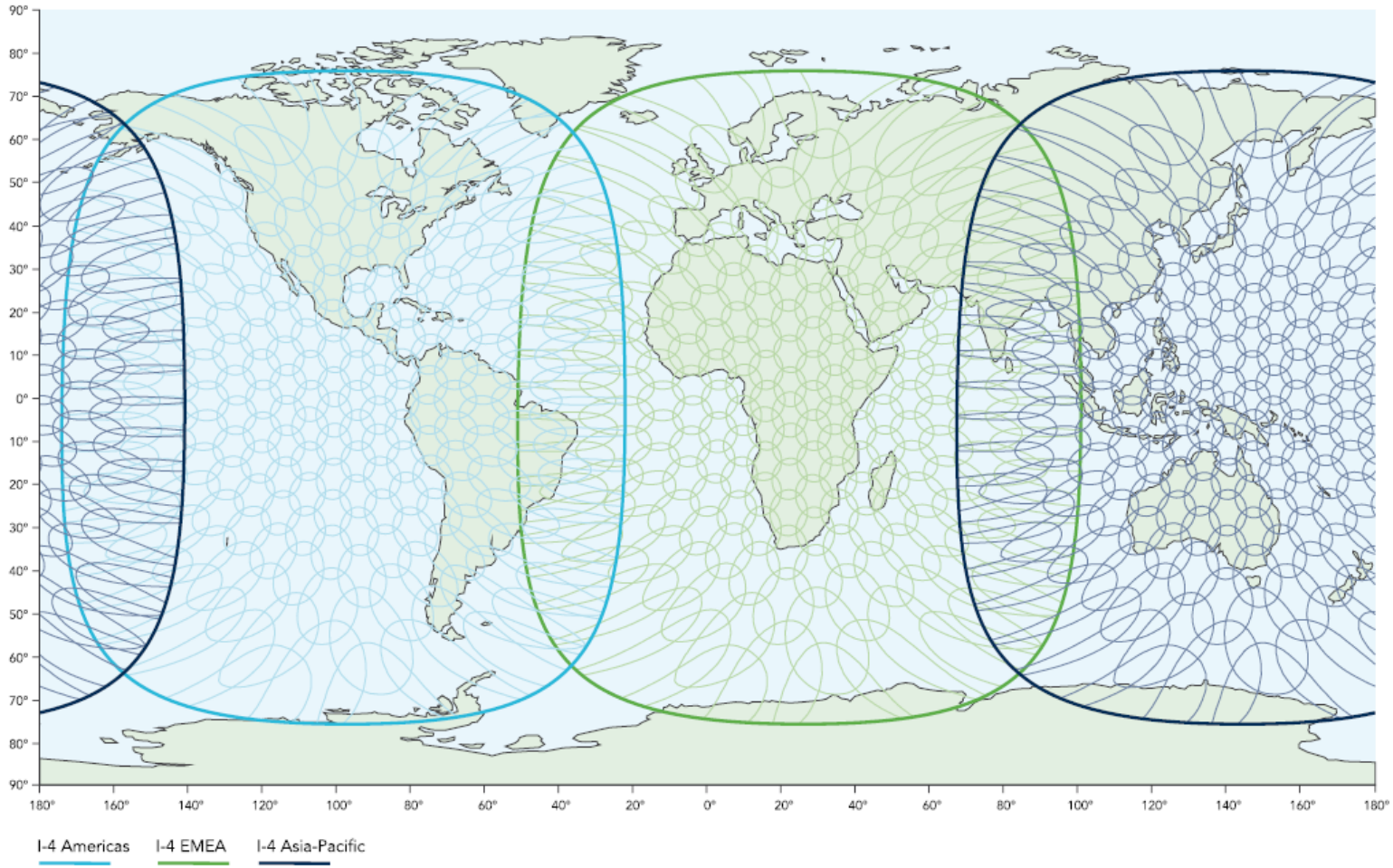
THAUMAS: SwiftBroadband Coverage



SwiftBroadband coverage (expectations of coverage, not guarantee of service).

SwiftBroadband uses the narrow spot beams of the Inmarsat-4 (I-4) satellites. Currently accessible over the Indian and Atlantic Ocean regions, it will be available globally, except the extreme polar regions, following the repositioning of the I-4 satellites.

THAUMAS: Issues

- Not fully compliant to Safety Requirements
- Final cost to deploy the operational service unknown
- Possibly large impact of SW Assurance Level requirement
- Risk of monopoly of a private operator who owns the infrastructure and has other markets as commercial priority