Space for safe skies

ESA's Iris Programme of satellite communication for ATM

EIWAC, 19 February 2013 – Nathalie.Ricard@esa.int

What is the European Space Agency?

Purpose of ESA: "To provide for and promote, for exclusively peaceful purposes, cooperation among European states in space research and technology and their space applications."

- **Intergovernmental organisation with 20 Member States**: 18 EU states (Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Poland (since Sep. 2012), Portugal, Romania, Spain, Sweden and the United Kingdom) plus Norway and Switzerland

- **Canada** takes part in some programmes under a cooperation agreement.

- **7 other EU states have Cooperation Agreements** (Estonia, Slovenia, Hungary, Cyprus, Latvia, Lithuania and the Slovak Republic) while **2 are negotiating Cooperation Agreements** (Bulgaria and Malta).

Addressing aviation's requirements

ESA develops space-based solutions to address aviation's needs in an evolving environment:

- Need to modernise air traffic management (SESAR Programme) due to **foreseen limitation of existing CNS/ATM systems**. Supporting air traffic growth requires **new systems that can be space-based**:

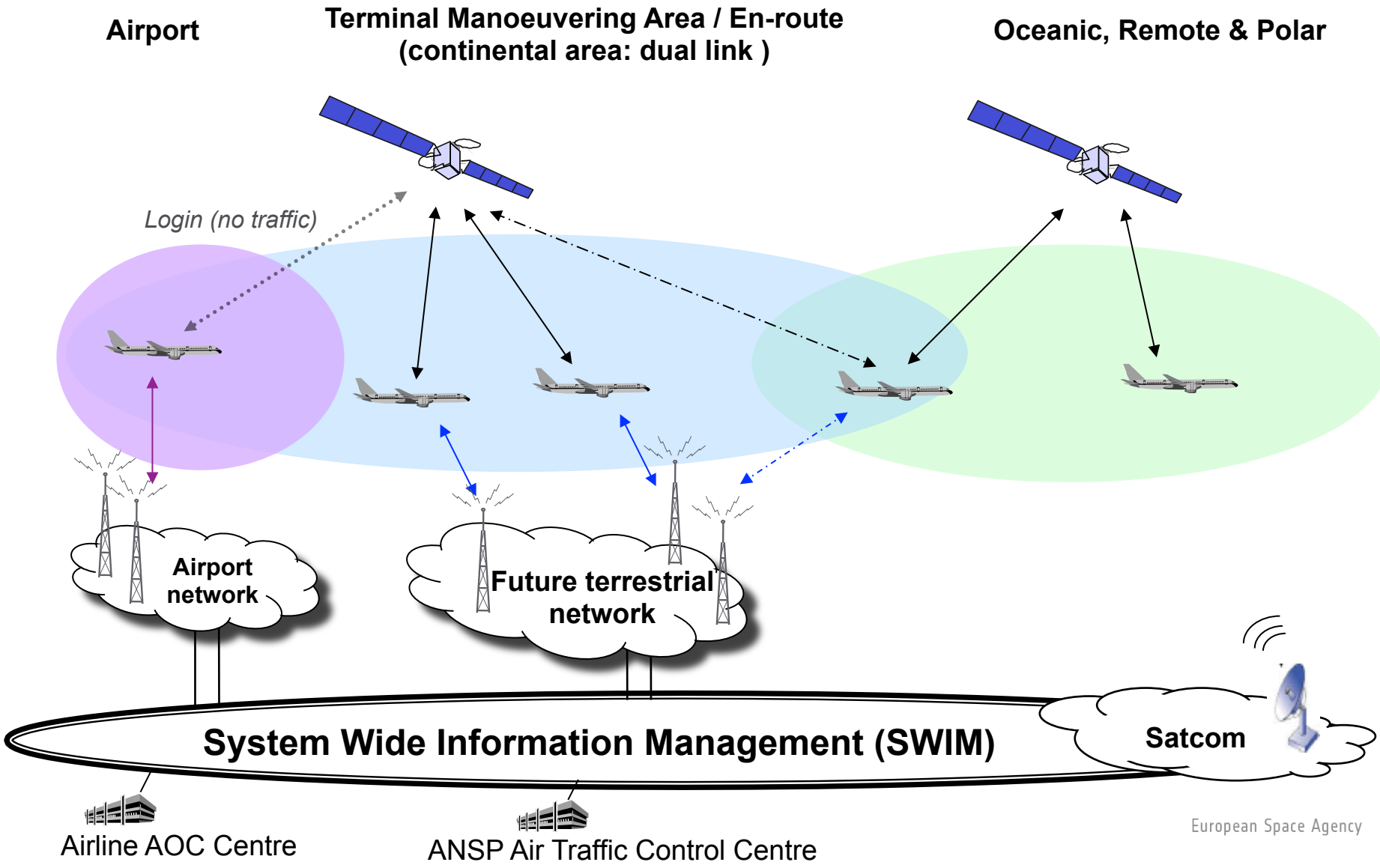
  => Iris Programme to develop the satellite **communication** system defined in SESAR for safety communications

  => GNSS (EGNOS & Galileo) for satellite **navigation (SBAS)**

  => demonstration of new capabilities for air traffic **surveillance** (space-based ADS-B with in-orbit receivers, and ADS-C via satcom e.g. Iris)

- New **application solutions** developed within the Integrated Applications Promotion Programme, which address a variety of users needs, using existing space technologies

New air-ground safety coms systems for 2020+
cf ICAO Global Air Navigation Plan



Iris: Advantages of satellite communications to support air traffic growth

1. Ubiquitous coverage: available both in continental airspace and oceanic/ remote airspace, with the same high performance level
2. Immediate deployment at the level of a world region (i.e. no delay versus roll-out of a terrestrial network); could be deployed as soon as 2018 whenever and wherever aviation needs new datalinks
3. Affordable for any aircraft type: designed to allow small low-cost user terminals + cheaper service wrt today's satcom services (sustainable service provision in Europe for a communication flat fee of EUR 5 per flight)
4. Can be adopted by any world region: **open standard** with available specifications (ICAO) to allow a modular regional system deployment and aircraft fitted with a single user terminal can use any **interoperable** network in other world regions; competition between satcom service providers is also possible (several providers with interoperable networks)
5. Spectrum available, with no interference from commercial systems (frequency band for safety services)

Iris Programme objectives

Iris is implemented in close collaboration with the Single European Sky ATM Research programme (SESAR) and is driven by its schedule & requirements.

Iris objective: supply a validated satellite-based communication solution for the European Air Traffic Management System

- Develop a new **communication system** & validate end-to-end performance
- Subject to agreement with SESAR/European Commission and a future Operating Entity, **develop the validation infrastructure**

NEW additional objective: develop also the Iris **Precursor service** for the shorter-term (2017), based on Inmarsat's SwiftBroadband, to contribute to the longer-term objectives of SESAR

Iris Programme external interfaces

13 Participating States

Funding (provided ca.EUR 55m since 2008)

SESAR JOINT UNDERTAKING

ESA-SJU and ESA-EC relations

Main source of technical requirements

SESAR deployment scheme pending…

Aeronautical stakeholders

incl. ANSPs, Airspace Users, Eurocontrol, EASA, ICAO, EUROCAE…

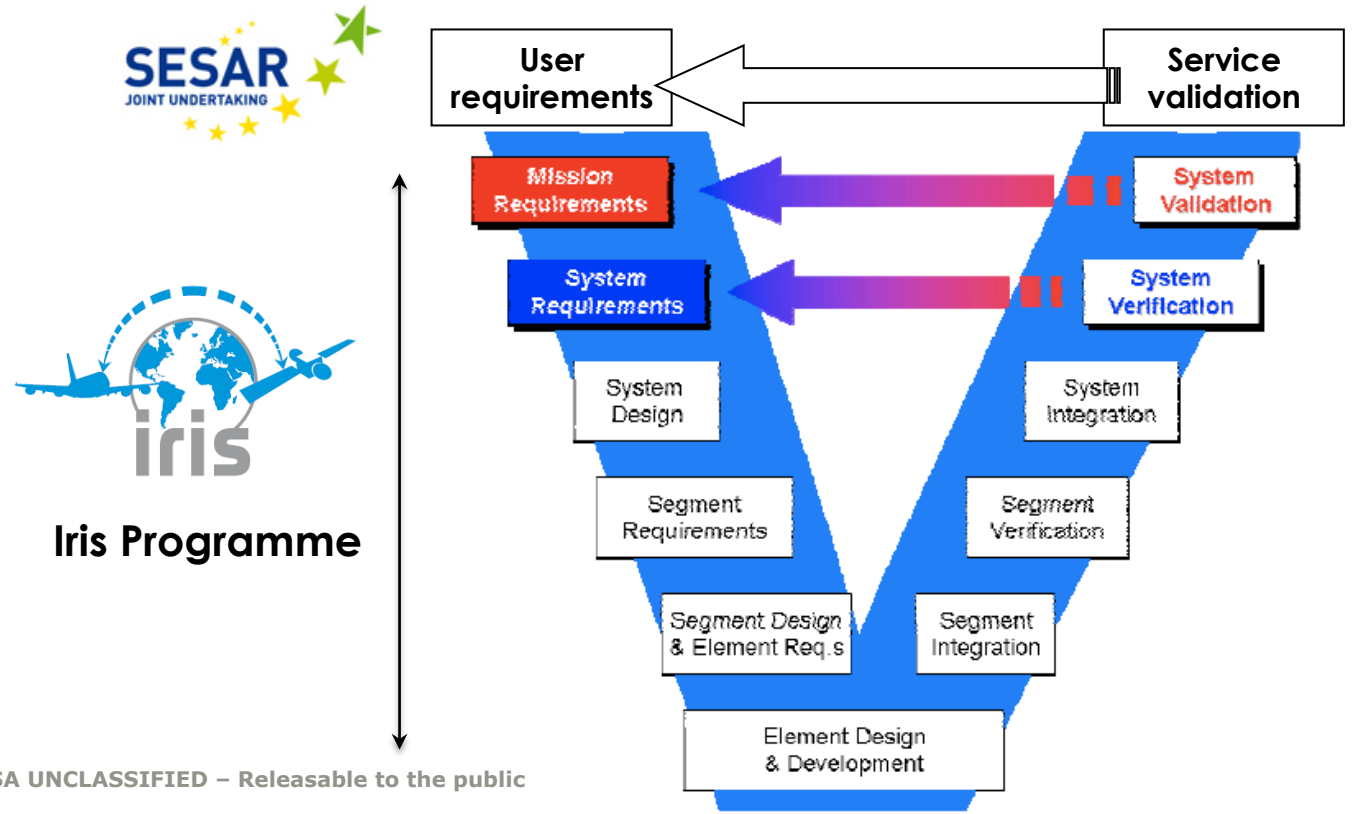
Other sources of requirements

Iris programme contractors

European industry	Non-commercial
Aerospace, Telecom	Aerospace & Telecom R&D institutes

Technical interface with SESAR JU

- User requirements are being defined by SESAR JU (esp. Project 15.2.6)
- ESA translates them into system requirements, carries out design, development and verification (i.e. under ESA's own funding)
- SESAR will carry out the service validation end-to-end



Iris, EASA and EUROCONTROL

Safety Board chaired by the European Aviation Safety Agency (EASA)

- EASA's competence in Single European Sky legislation for regulation/ certification of pan-European provision of services
- Iris Safety Board gathers several civil aviation authorities, SJU and Eurocontrol to anticipate and facilitate preparation of the safety case for the satellite communication system

Memorandum of cooperation ESA-EUROCONTROL (since 2002):

- Exchange of technical expertise
- Contributions to the NEXUS sub-group to facilitate adoption of a new global satellite communication standard at ICAO
- Coordinate actions regarding regulatory efforts (AMS(R)S spectrum)

Iris: Technical design & business case activities

Long-term Iris solution: Purpose-built system and open service model

ANTARES System Design study

(Prime: Thales Alenia Space & 20+ contractors)

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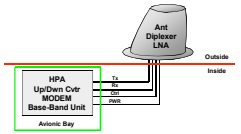
System

Preliminary Design Specifications



Aircraft terminal Preliminary Design

Satellite System

Preliminary Design Specifications

Develop Aircraft terminals (with industry)

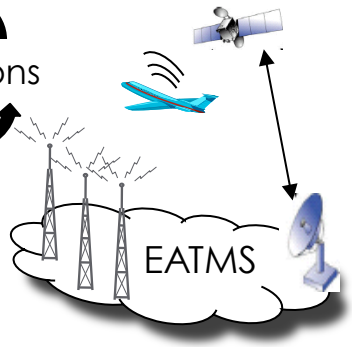
Satellite system:

- validation infrastructure (Iris Phase 2.2)
- operational system

ICAO Standardisation (by SJU/EC)

Interactions

Satellite System Operations studies

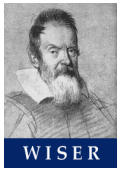


Service provision + Business case model

3 studies with Sat. Operators during 2010/12

Need public support for validation, then sustainable service for EUR 5/flight (flat fee)

Iris : ANTARES study team

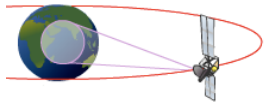


Iris : Satellite System architecture

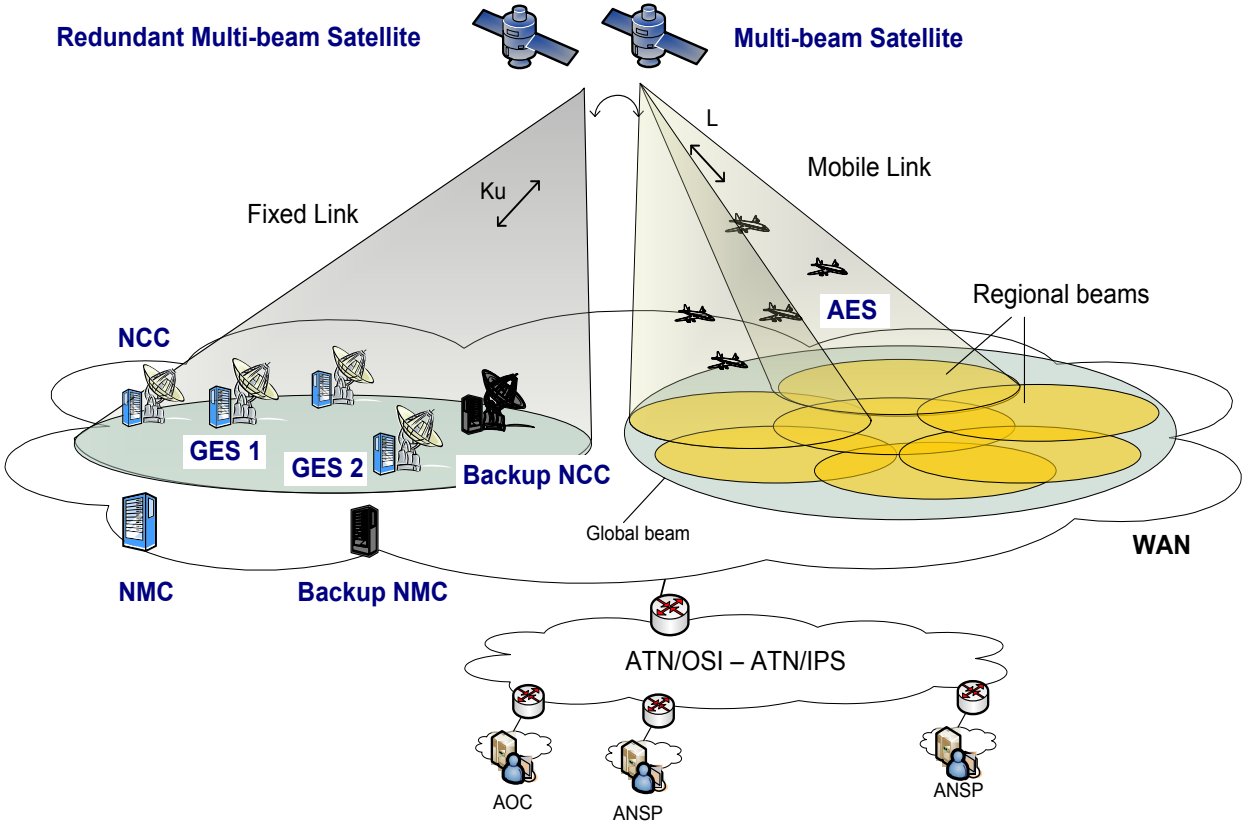
SESAR JOINT UNDERTAKING

User requirements

Iris baseline



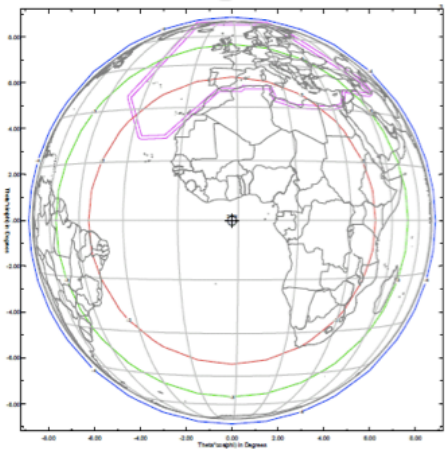
GEO to cover core European airspace



- 1 GEO satellite (+redundancies)
- Redundant Ground Segment
- Interface to ground-ground ATM System

Service Provision requirements: geographical area

The satellite system focuses on the European (SES/ECAC) service area but the design is modular so that other world regions could implement their own compatible systems, following their own calendar of deployment.



Possible extensions of coverage of the European system:

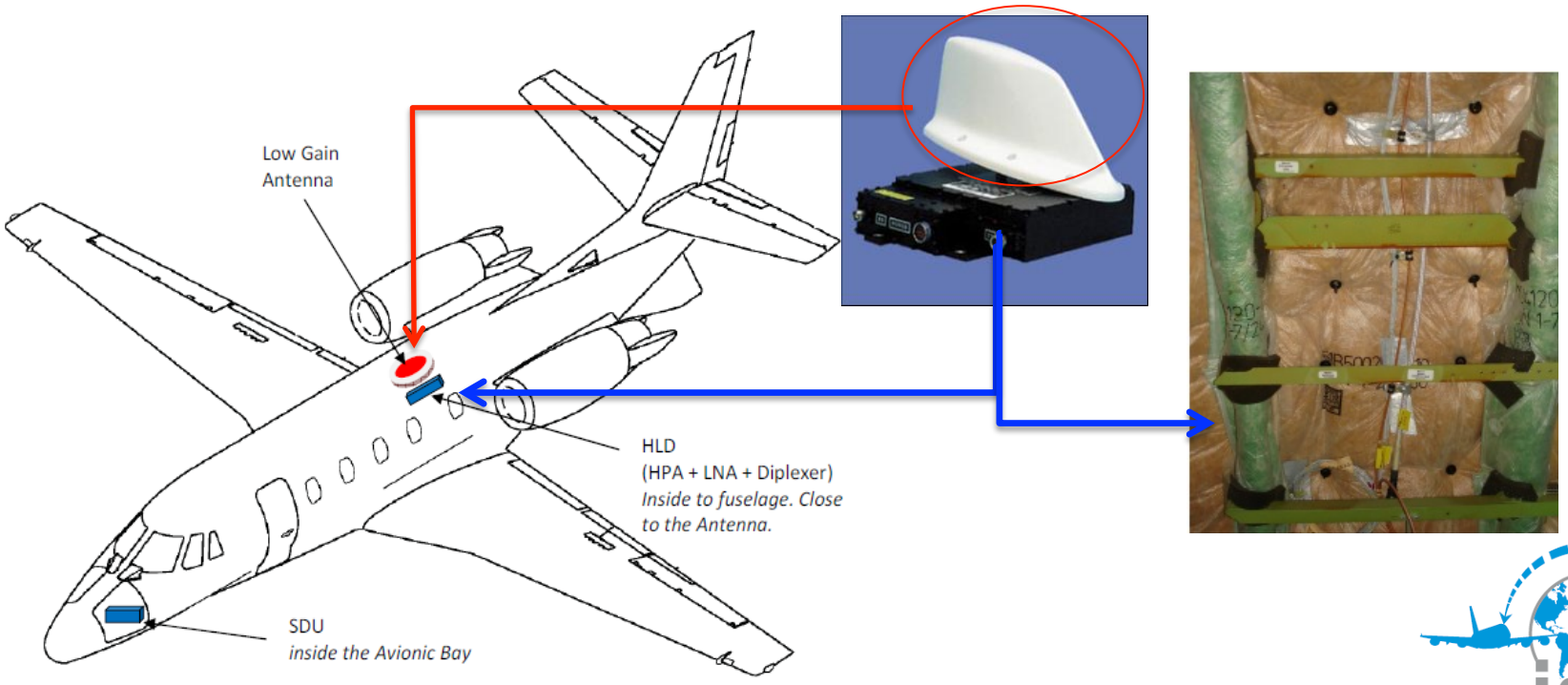
- Visible Earth from GEO orbit

- Northern latitudes areas by agreement with other countries operating HEO satellite systems

Aircraft equipment

Terminals need to be low cost and highly reliable

- Use small antennas (Low power consumption, highly reliable, low drag)
- Use terminals able to operate without forced air cooling, and developed for airliners but also for General Aviation (i.e. business jets, rotorcraft, etc)
- Software certification of the data unit drives the cost



Iris new Satellite Communications Standard

Designed for full 4D trajectory management in continental airspace, based on COCR document, with extra design drivers:

- Cost of equipage and cost of use to be kept low
- Meet capacity needs for 2030+
- Flexible and scalable architecture

Similar to AMSS

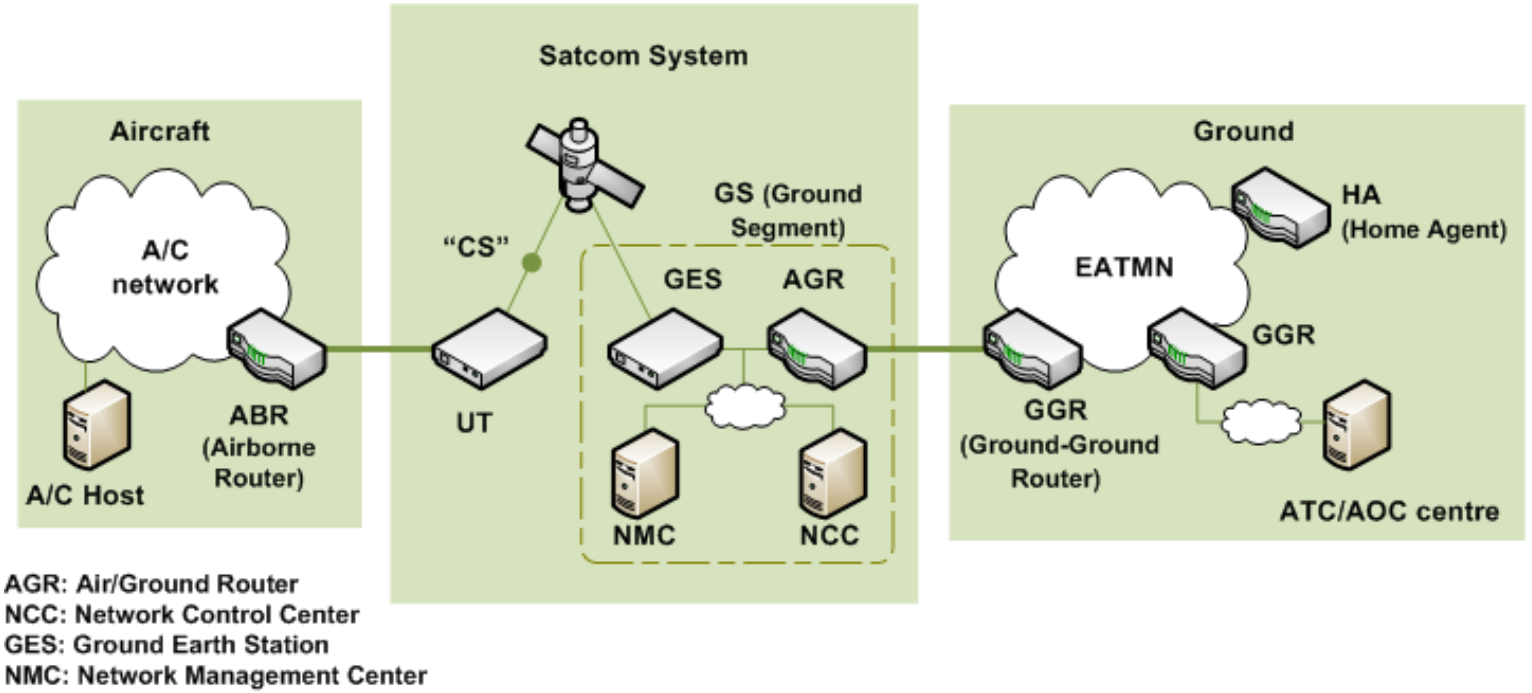
- Interoperable standard supporting multiple Service Providers
- Use protected radio-spectrum in L-band (AMS(R)S band: 1,545-1,555 MHz and 1,646.5 – 1,656.5 MHz)
- Support voice and data

NEW

- System specifically designed for aeronautical Air/Ground safety (ATS and AOC, not passenger coms)
- Quality of Service management
- Light terminals, low power, small antenna, highly reliable
- Improved spectrum efficiency
- Can be used by any type of satellite (GEO, MEO, HEO…)

Iris new Satellite Communications Standard

The standard specifies the air interface of the satellite network.
It covers up to the network layer.
It supports two network layer stacks: ATN/OSI (=legacy) and ATN/IPS.



Iris new Satellite Communications Standard (1/3) Forward link

- Based on **MF-TDMA** technique
- **Forward link synchronization** mechanism to assure that all the forward link carriers are received synchronously by the user terminals
- Baud rate = 160 kbauds, BW = **200 kHz**, L band spectrum resources

- **Robust** and **flexible coding** (IRA LDPC) and modulation schemes (MPSK)
- Support of **Adaptive Coding & Modulation** (ACM) to adapt the coding and modulation to the channel propagation conditions.
- **Intra-burst interleaver** to spread the channel errors produced by the aeronautical mobile channel.

- **Forward link resources** allocation providing flexibility to adapt to different GS architectures with different number of GS elements.

Iris new Satellite Communications Standard (2/3) Return link

- Random Access scheme based on **Asynchronous Code Division Multiple Access** (A-CDMA)
  - **Enhanced Spread Spectrum ALOHA** (E-SSA) combination of Spread Spectrum ALOHA (SSA) with **Successive Interference Cancellation** (SIC).

- **Burst formats** adapted to the different application messages sizes and latency requirements
  - Chip rate of **160 kchips/s**, bandwidth **200 kHz,** spreading factors 4 & 16 (flexibility to support higher chip rates).
  - **Powerful FEC** scheme based on Turbo code 1/3, block lengths from 288 to 2048 bits.

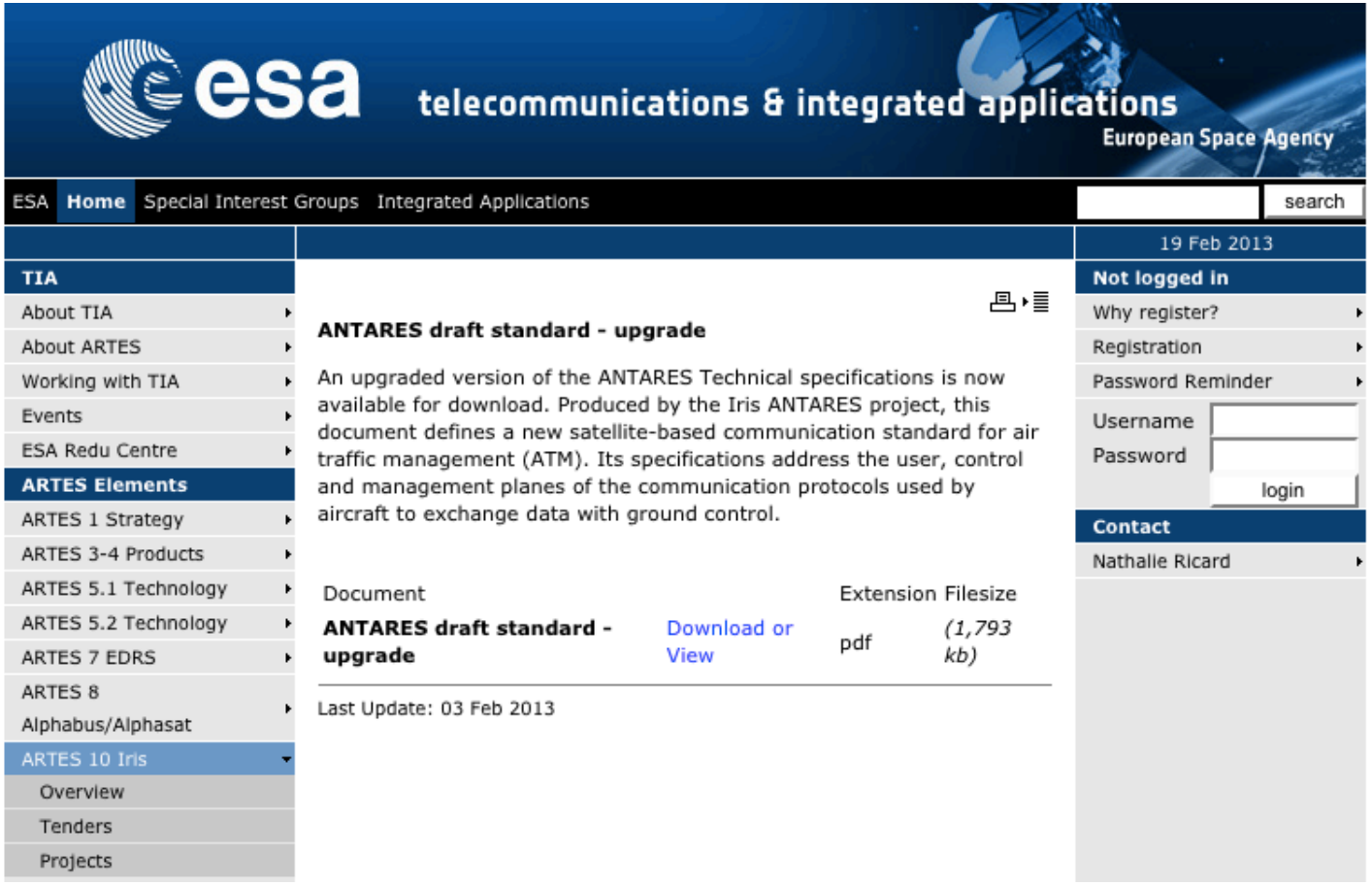
- **Congestion Control**: mechanism based on the measurement of the channel load conditions by the Ground Segment

Iris new Satellite Communications Standard (3/3)

- **MAC / LL Layer**
  - **CoS oriented** taking into account packet priority depending on stringent delay requirements
  - **ARQ** mechanisms based on positive ACK
  - Optimized state of the art **encapsulation scheme** (GSE-like) providing an efficient encapsulation of L2 Data Units over variable-length L1 Data units.

- **Control functions**
  - **Flexible control** procedures to support **different GS architectures**.
  - **Log on** procedure which establishes associations between UT and GS elements.
  - **Seamless handovers** between GES, between mobile link beams and between different satellite.
  - Handover relies on **signal quality measurements** (based on ACM) to detect a need for handover.
  - **Broadcast of system tables** including Forward and Return carriers parameters and system information.

Iris new Satellite Communications Standard



Document accessible via http://telecom.esa.int/iris

Iris activities during 2013

Iris solution

1. Final Standard specifications issued once completed by the ANTARES study
   - Ready to initiate standardisation at EUROCAE and ICAO (via SESAR)
   - Seek partners in other world regions to initiate joint activities (esp. develop testbeds to validate performances)

2. Development of the emulators i.e. the communication protocols will have been implemented and their performance verified
3. Breadboarding of user terminals and design of space+ground segments at the level required for the system's Preliminary Design Review

Technical support studies

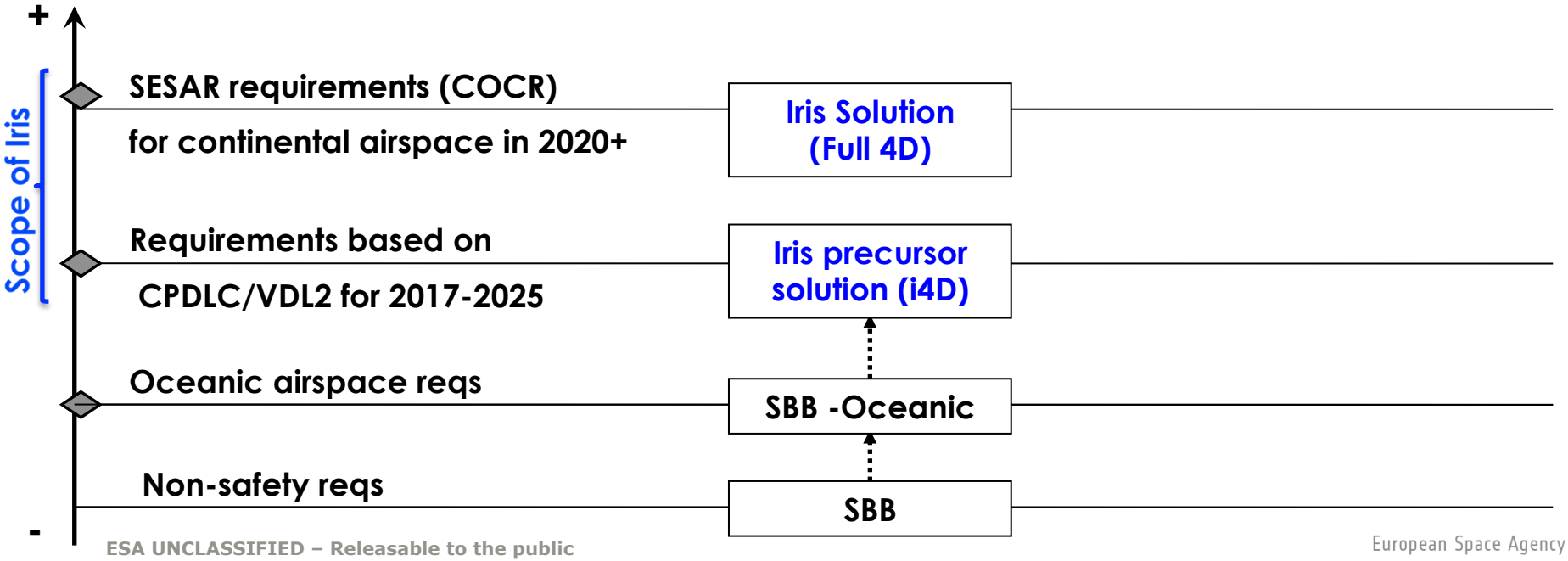
Continuation of on-going activities with EASA (Safety Board), Airbus, etc…

Definition of the Iris Precursor service

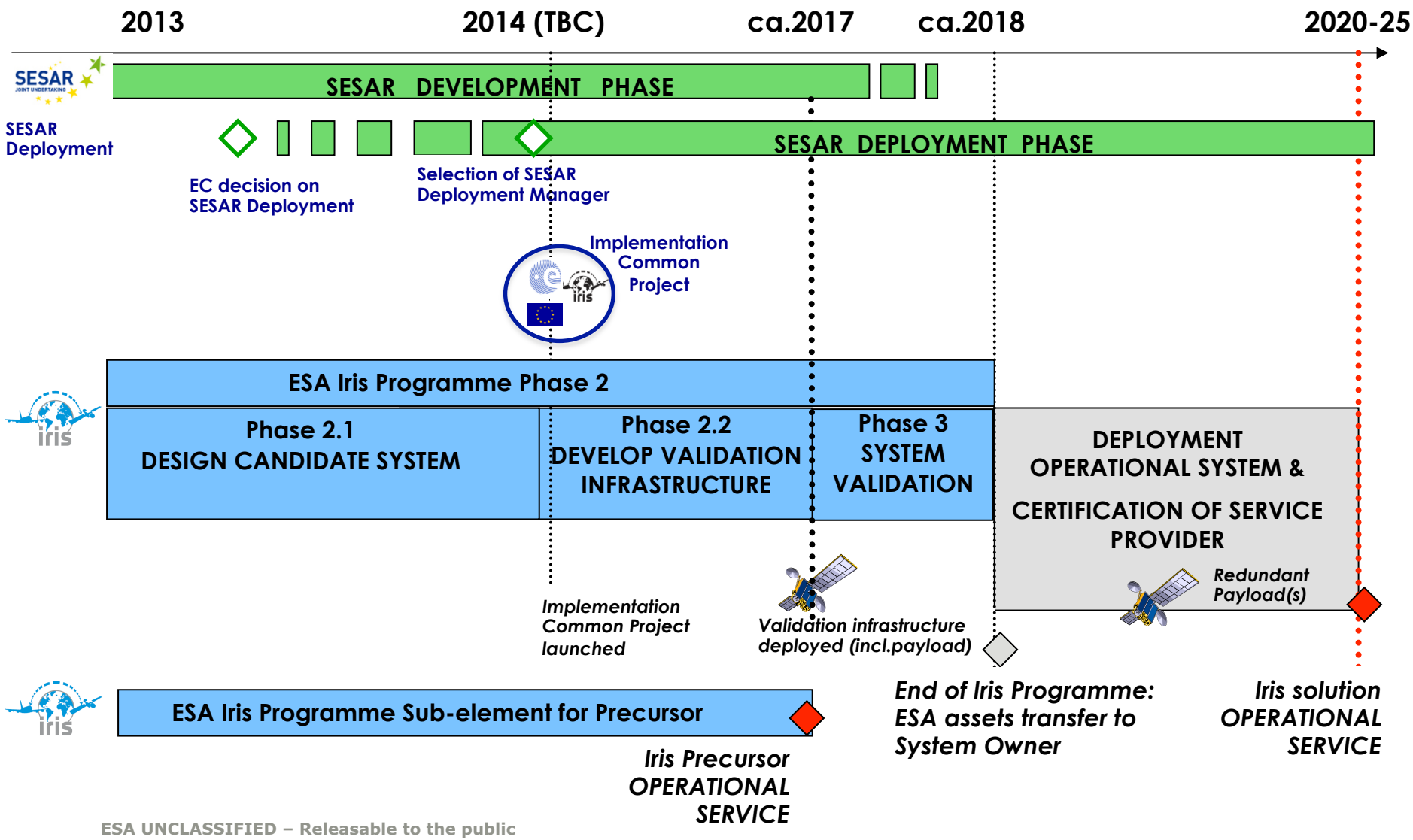
Implementation on a hardware testbed + system simulator.

Iris now includes 2 requirements levels: Precursor for i4D and solution for Full 4D services

- Slow evolution towards datalink services in Europe led to reconsider the level of performance for a concept based on Inmarsat's SwiftBroadband => **Precursor** service to Iris, at horizon 2017
  - Level of performance lower than COCR, rather for "initial 4D"
  - Service based on Inmarsat SBB system (with additions)
  - Service provider to be certified by EASA



Iris Programme Timeline



Iris - Contact Points

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- Recent Public Event held in Salzburg, Austria (4-5 February)

Documentation available via http://telecom.esa.int/irisevent2013