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ESA ARTES Integrated Applications Promotions:

Future Downstream Services: Digital Sky and Beyond

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Thales Alenia Space Deutschland
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ESTEC 18. May 2018

Background: ESA ARTES-20 ADS-B Services

ESA ARTES Integrated Applications Promotions:

Exploring the viability of integrated applications based on Automatic Dependent Surveillance Broadcast (ADS-B)

Purpose:

- Propose new / advanced services around ADS-B, especially around space-based ADS-B
- Go beyond the „obvious“ global surveillance
- Combine ADS-B with other „assets“ to derive new services
- Analyse technical and economic viability of these services

Study team:

- TAS-D as prime
- EGIS (F), Helios (UK), Atmosphere (D, F), DLR/GSOC (D), SAP (D), Thales ATM (D)

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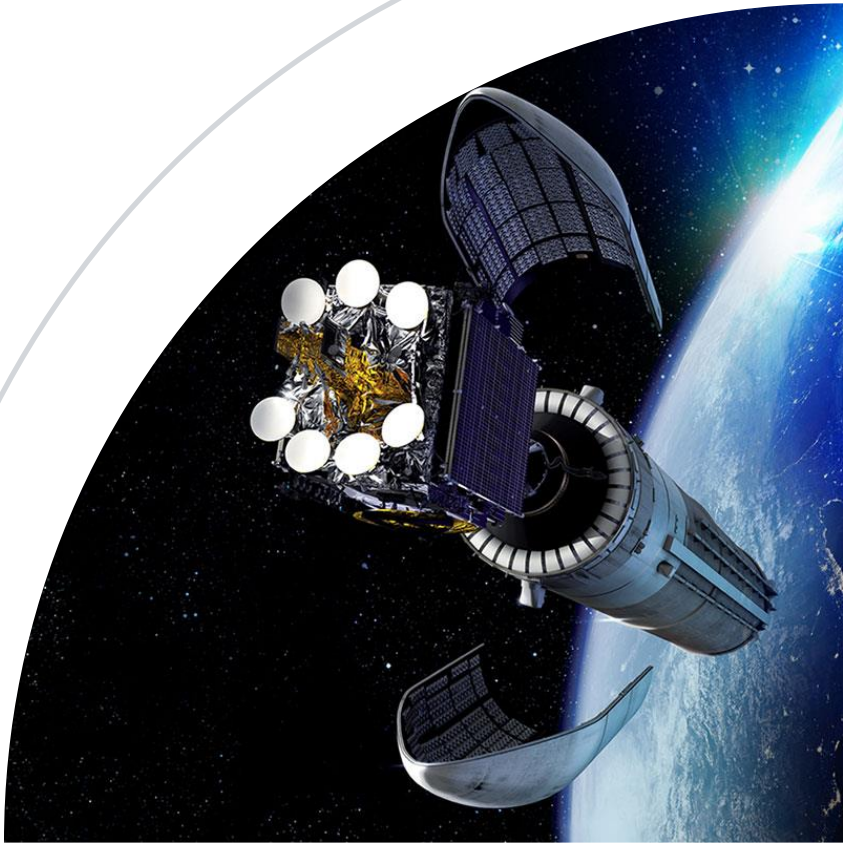
Overview (Services and Team)

- Proposed Services and Consortum Allocation

  - **AEREAS**
    Airspace Sharing between UAV and manned traffic
    Consortium: TAS-D, Egis (F)

  - **OpenADSB**
    Make ADS-B data openly available to everyone
    Consortium: TAS-D, Atmosphere (D, F), SAP (D), DLR (D)

  - **SATVAS**
    Create satellite based airband VHF COM overlay
    Consortium: TAS-D, Helios (UK), Thales [ATM] (D)



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AEREAS: *What do we want to do?*

- **Allow coexistence of UAV and manned air traffic in airspaces class E, G, VLL**
  - Auto-avoidance of UAV towards ADS-B out equipped manned aircraft
  - UAV shall transmit ADS-B like signals on dedicated frequency (L-Band or MLS band)
  - UAV/UAV shall handle mutual avoidance

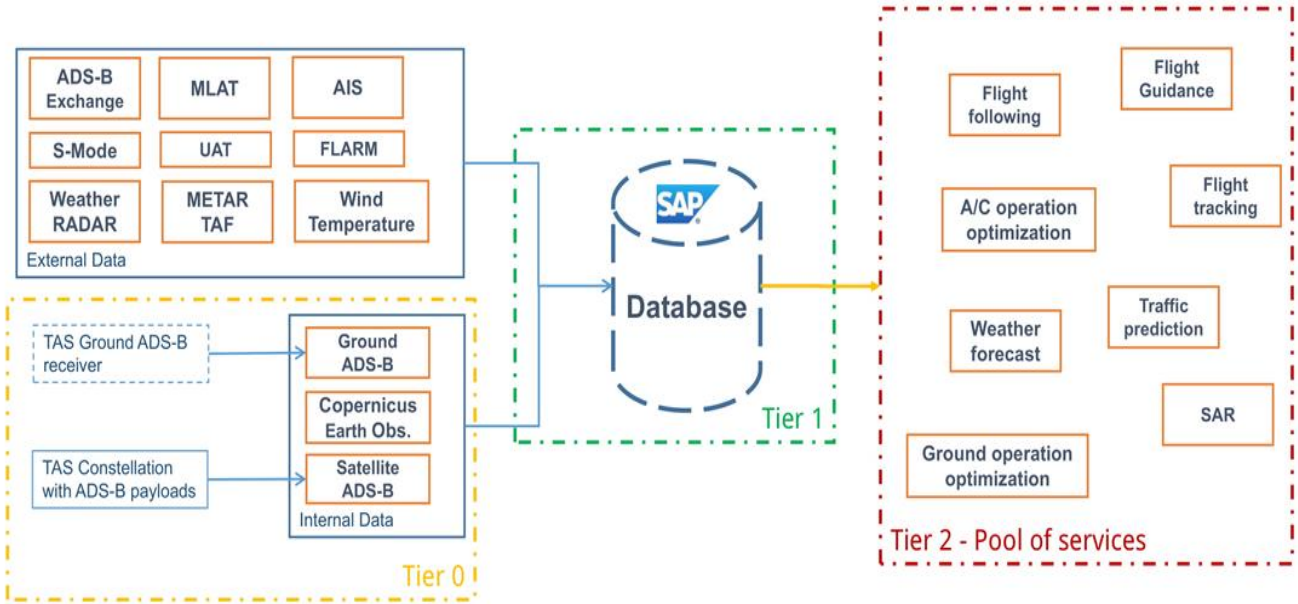
Note: Separate data streams from UAV:
- **Position / Intent Reporting (AEREAS)**
- **Command & Control (not covered here)**
- **Mission / Payload data (not covered here)**

- **Simple and global system**
  - Does not require terrestrial infrastructure to function
  - Uses aviation protected spectrum (not regionally fragmented ISM)
  - Do not depend on telecom business models (data plans, SIM, access etc.)
  - Inexpensive for the user (target: every drone, even > 1..5 kg is equipped, < 100$ equipment costs)

- **New Geo-fencing concept**
  - Use ground based ADS-B NTD transmitter to broadcast forbidden / restricted area
  - Can be activated immediately (theoretically: no preceding NOTAM required!)
  - Does not require any database update by the user – and works worldwide in real time
    → compliance by design!

OpenADSB: *What do we want to do?*

- Provide a global platform for ADS-B data use and exchange – easy to access, outside the ATM world
  - Preprocess / store data (Tier 1 layer)
  - Establish harmonized interfaces (for everything !)
  - Enable plug-in apps (Tier 2 layer); layer is open to everybody; especially small companies. They can produce powerful apps without needing the considerable upfront invest for the global infrastructure. Attracts innovative solutions! (similar to SAP COPERNICUS EO platform)
- Investigating BigData structures for data storage (e.g. SAP HANA)
- Aggregate with MET / EO data (COPERNICUS)
- Shape OpenADSB like „Google“ of ATM/EO data



Note: Data privacy regulations Now in force in the EU !! How does this apply to ADS-B traffic data (realtime / aggregated)

OpenADSB: *Examples for „Enriched“ ADS-B data*

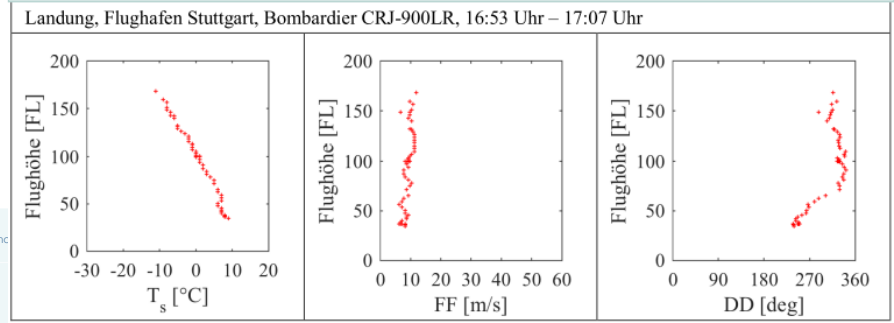
Directly ATM related – outside „bare“ tracking:

- Capacity analysis and forecasts; better flow forecasts; real-time delay modelling
- In radar airspace: monitor performance of ADS-B against radar (especially G/A) to characterize and finally allow „lower grade“ certified equipment

Not directly ATM related:

- Extract METEO data from Mode-S squitters (later – DO260C – this will be present in ADS_B out) [data is broadcast for free, not like AMDAR or ADS-C]
- Produce trajectory analysis / aggregation
  - Real time → Distress detection (→ GADSS) combine with near-time EO (MET, optical, SAR)
  - Aggregated → Traffic / traffic density monitoring, environmental compliance, air routes
  - Against geofencing → asset control (aircraft leasing)

METEO: Landing at EDDS airport with temperature and wind profiles extracted from BDS0x44/0x45 data (will become part of ADS-B as per DO-260C)



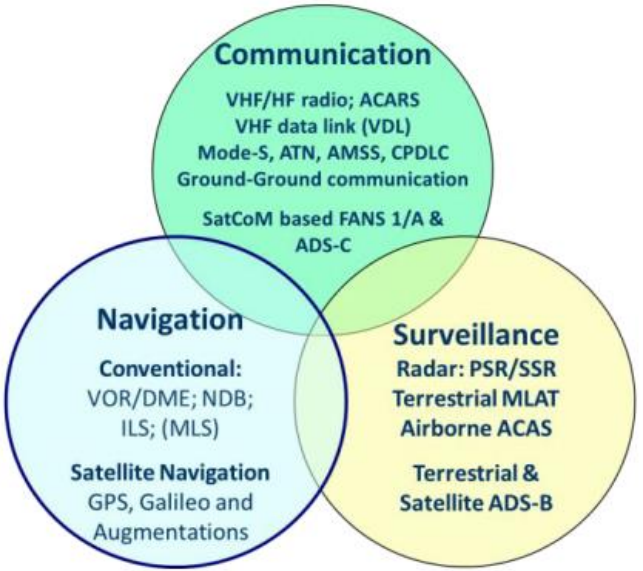
SATVAS: *What do we want to do?*

- Enhance global surveillance → provide VHF communication via satellite („tower in the sky“)
  - Focus on remote areas (oceanic, polar, remote continental)
    for ECAC / CONUS: only some spots of interest, but could provide services for developing countries
  - Check feasibility to provide digital VHF services as well in these areas (combined with ground network)!

- Platform is preferably LEO satellite (LEO constellation)
  - Low latency compared to GEO
  - Real-time COM required (ISL or G/S network)

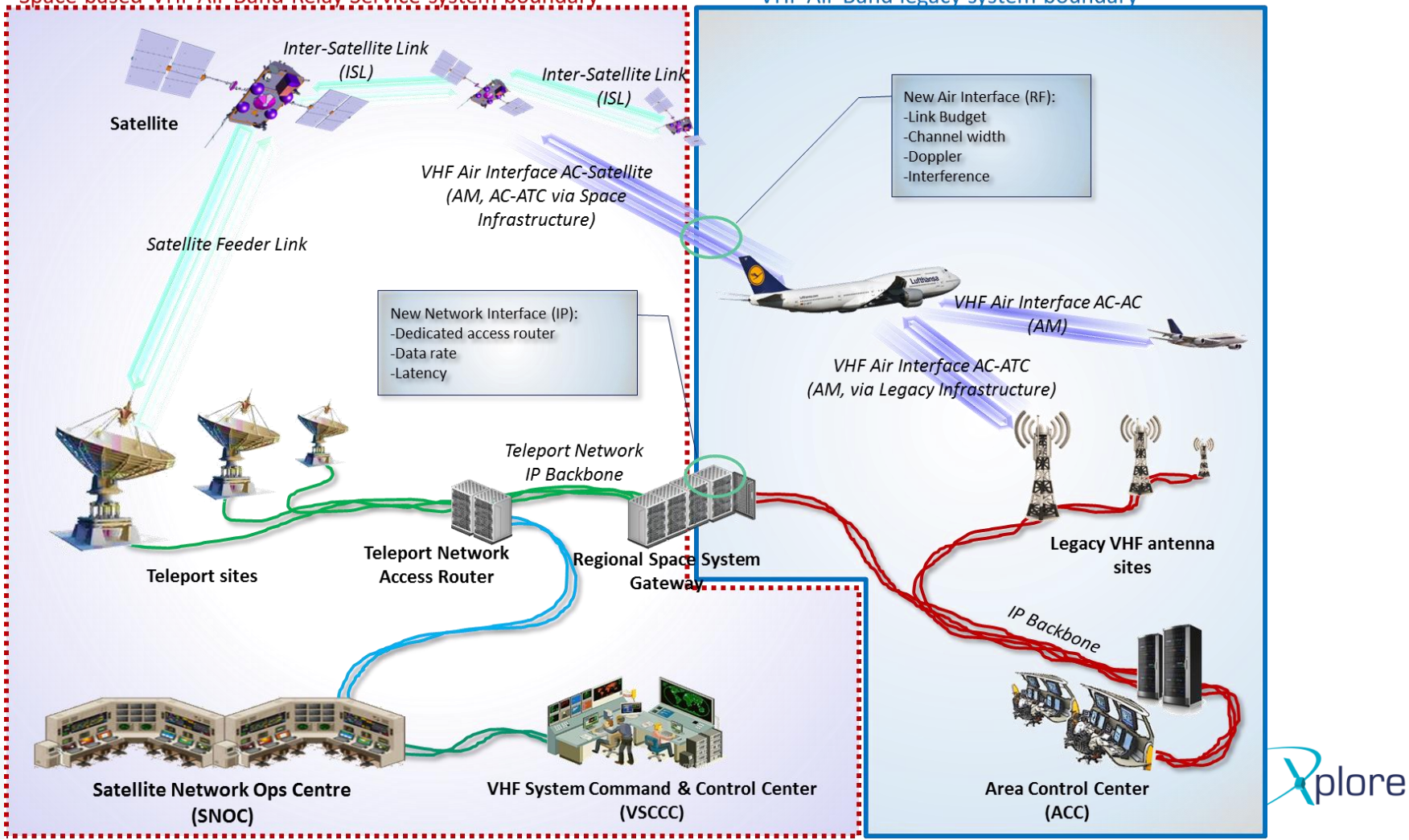
- Some initial thought already presented to ICAO
  - CAAS Singapore in 2016

- Cave! VHF frequencies are not formally authorized fo
  - Satellite Rx (more a formal issue – protection etc.)
  - Satellite Tx (this will be mandatory for the service)



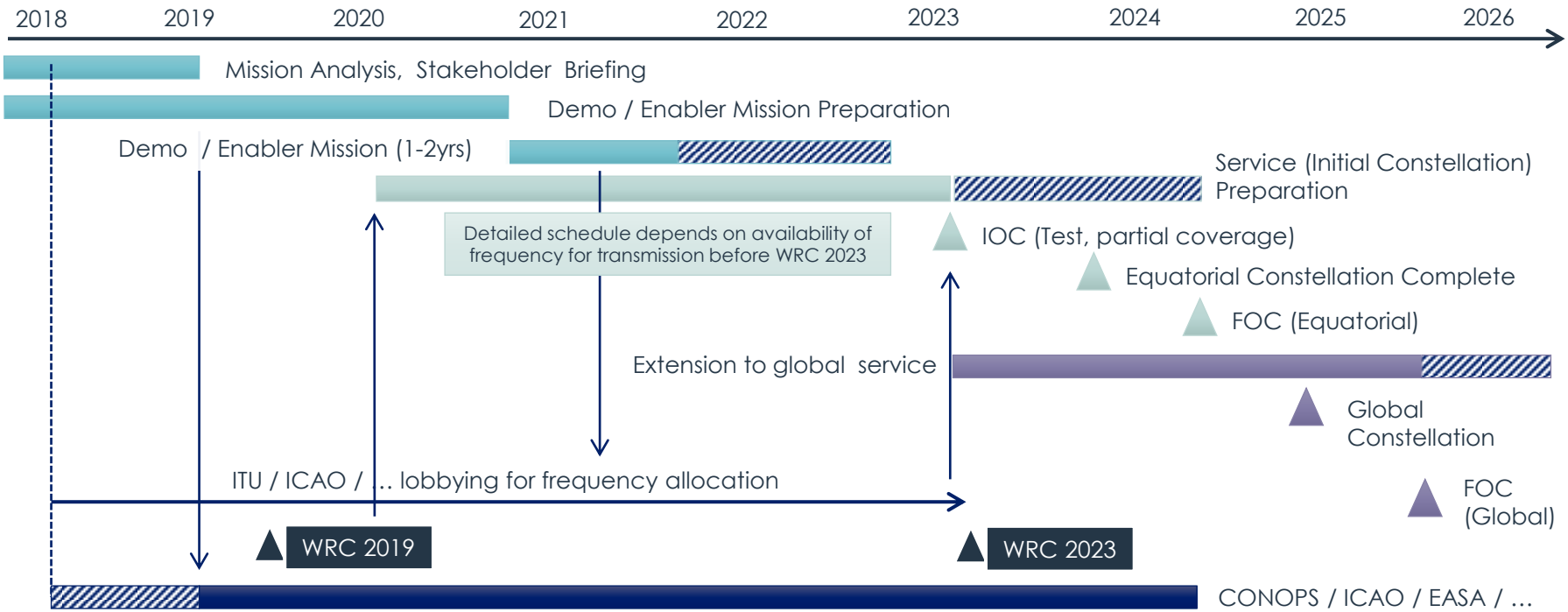
SATVAS: *Benefits for the users*

- No equipage costs for users: Almost 100% of all existing aircraft have a VHF radio – no retrofit
  Equipage of VHF radio exceeds even equipage rates for transponders, especially in G/A
- G/A and small aircraft will not have Satcom equipment within the next decades.
- Well-known operation procedures (same CONOPS) for users – no training
- Sat VHF network serves different purposes:
  - Overlay / backup for existing systems in Australia, South America, Oceania, parts of Africa
  - Initial communication infrastructure, where no terrestrial system is available,
    e.g. parts of Africa, Oceanic, Polar, Siberia
  - Provide low-level COM gap-filler even in „well developed“ areas,
    e.g. low level flights in Scandinavia, to North See oil rigs
  - Provide simple service to large FIR (only one satellite instead of complex CLIMAX network)
- Sat VHF enables …
  - Infrastructure boost for less developed countries (e.g. Africa)
  - Exploit benefits of ADS-B and allow together with global surveillance improved routing, less emissions
  - Assist in GADSS / distress: can monitor 121.5 MHz all over the world (and can transmit also!)


Space-based VHF Air-Band Relay Service system boundary
VHF Air-Band legacy system boundary
Inter-Satellite Link (ISL)
Inter-Satellite Link (ISL)
Satellite
New Air Interface (RF):
-Link Budget
-Channel width
-Doppler
-Interference
VHF Air Interface AC-Satellite (AM, AC-ATC via Space Infrastructure)
Satellite Feeder Link
New Network Interface (IP):
-Dedicated access router
-Data rate
-Latency
VHF Air Interface AC-AC (AM)
VHF Air Interface AC-ATC (AM, via Legacy Infrastructure)
Teleport Network IP Backbone
Teleport sites
Teleport Network Access Router
Regional Space System Gateway
Legacy VHF antenna sites
IP Backbone
Satellite Network Ops Centre (SNOC)
VHF System Command & Control Center (VSCCC)
Area Control Center (ACC)

Way Forward - Timeline

Three Steps towards Global VHF: Demo/Enabler → Euqtorial Belt (Africa) → Global Coverage



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Stepwise Approach

Three Phases

- **Step 0:** Enabling Phase (frequency allocation!)
  - Verify assumptions regarding airborne equipment (receiver sensitivity, operations)
  - Demonstrate capabilities (technical, operational)
  - Spectrum measurements (interference measurement, spectrum analysis)
  - Demonstrate satellite (antenna concept) and payload (transceiver concept)

- **Step 1:** Equatorial Belt (± 25 degrees latitude), initial operational service
  - Focus on developing countries (Africa, Equatorial Asia, Equatorial Pacific, Central America, …)
  - Full service demonstration (real-time, integration into surveillance [space-based ADS-B])
  - Integration into GADSS

- **Step 2:** Full Constellation, global service
  - Global, worldwide coverage including ECAC, CONUS, polar area
  - Providing service even in ECAC, CONUS (large pan-EU transit FIR)
  - Global Integration into GADSS and surveillance systems

Preparatory activities:

- Field trial to characterize airframe equipment (e.g. using HAPS)
- Approach users for demonstration mission (ASECNA, ASA, DSNA, ICAO)
- Follow-up GADSS use
- Prepare frequency usage topic for WRC 2019 agenda
- Prepare initial CONOPS aspects

Any secondary payloads?

- Opportunity for second ADS-B constellation
- Opportunity for airband spectrum monitoring

But: This should not prevent the primary mission (VHF) from progressing!

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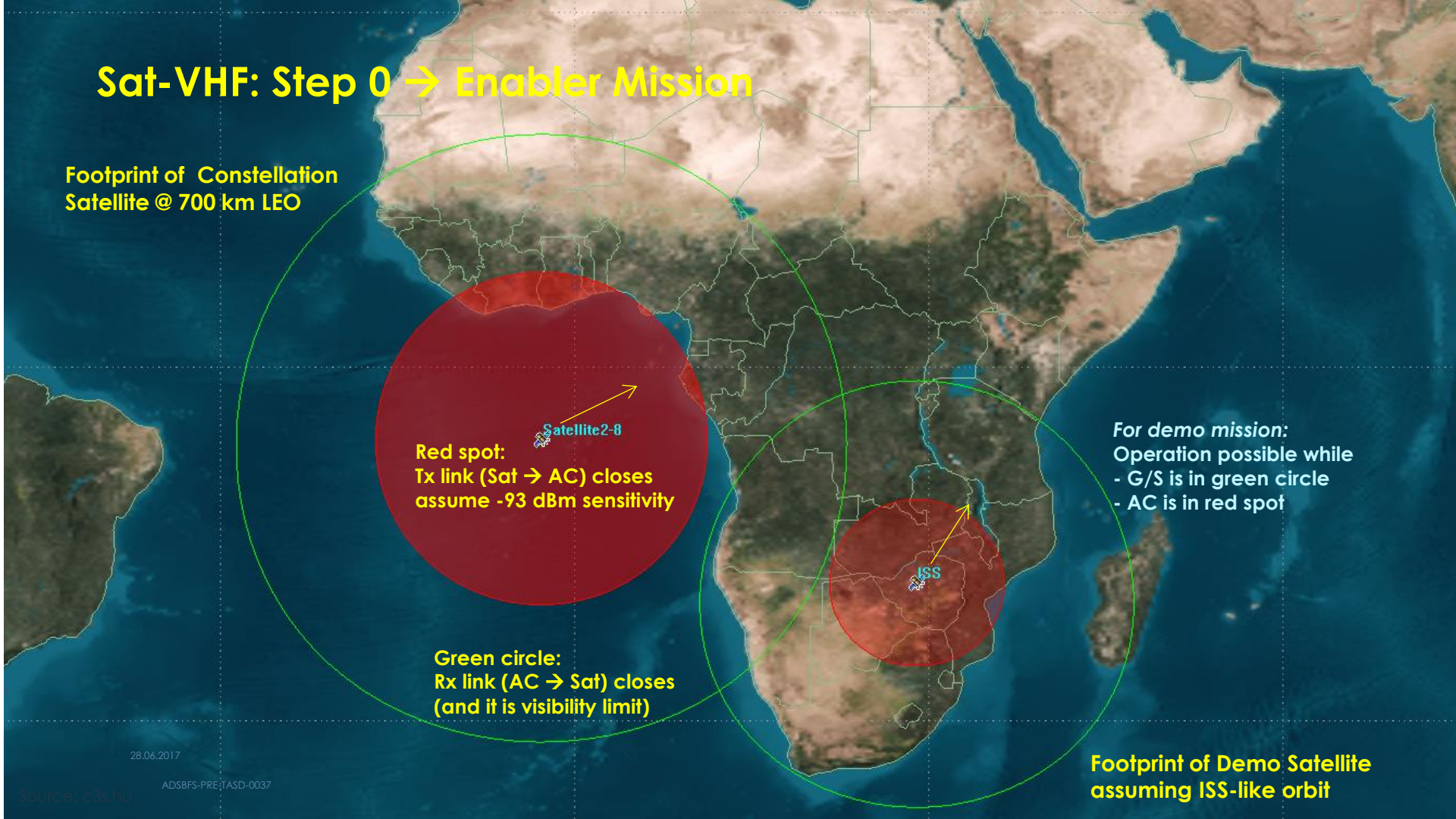
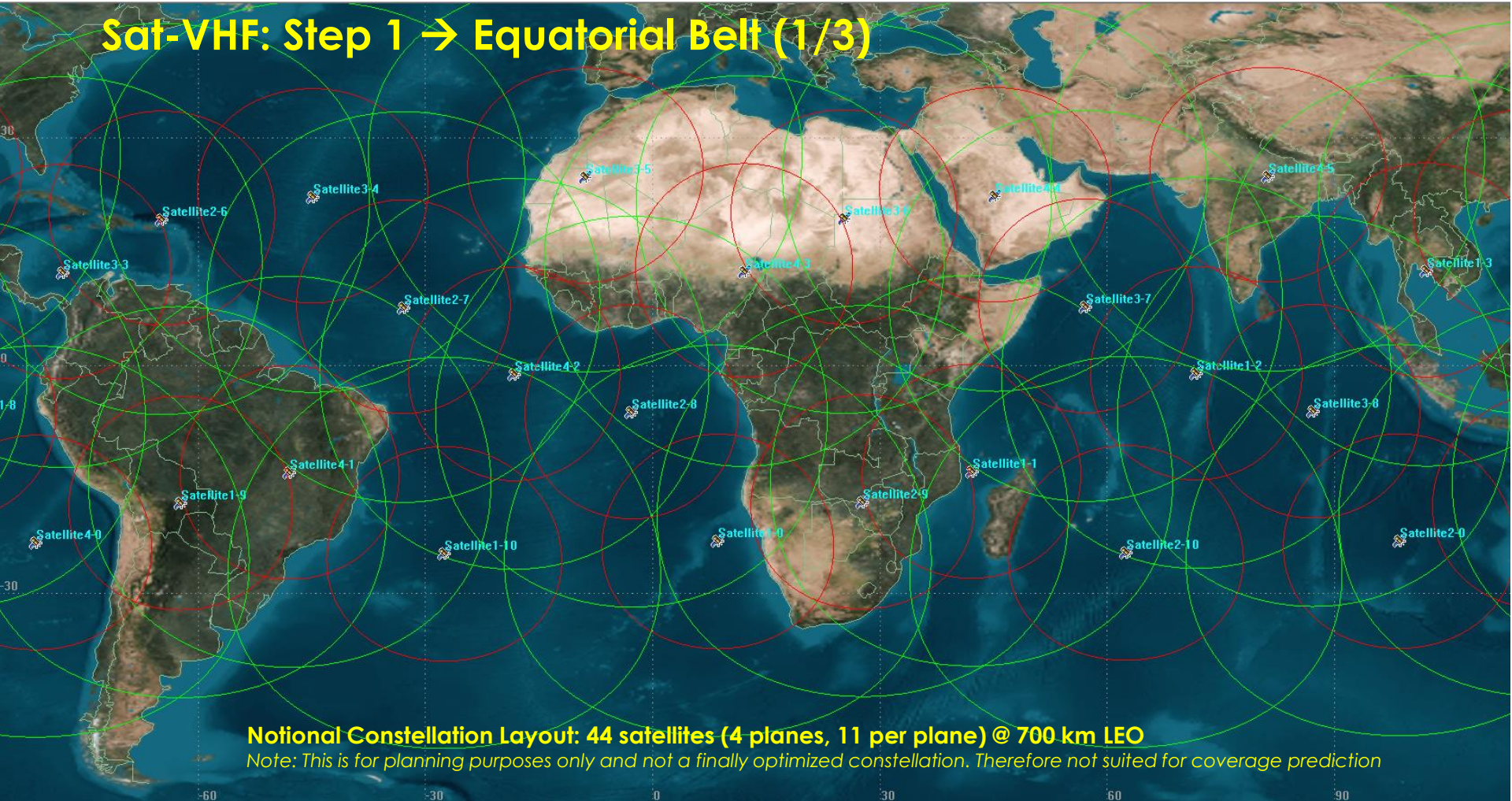

Sat-VHF: Step 0 → Enabler Mission
Footprint of Constellation Satellite @ 700 km LEO
Satellite2-8
Red spot:
Tx link (Sat → AC) closes
assume -93 dBm sensitivity
ISS
For demo mission:
Operation possible while
- G/S is in green circle
- AC is in red spot
Green circle:
Rx link (AC → Sat) closes
(and it is visibility limit)
28.06.2017
ADSBFS-PRE-TASD-0037
Source: c3s.hu
Footprint of Demo Satellite assuming ISS-like orbit

Sat-VHF: Step 1 → Equatorial Belt (1/3)



Notional Constellation Layout: 44 satellites (4 planes, 11 per plane) @ 700 km LEO

Note: This is for planning purposes only and not a finally optimized constellation. Therefore not suited for coverage prediction

Thank you!

Questions?

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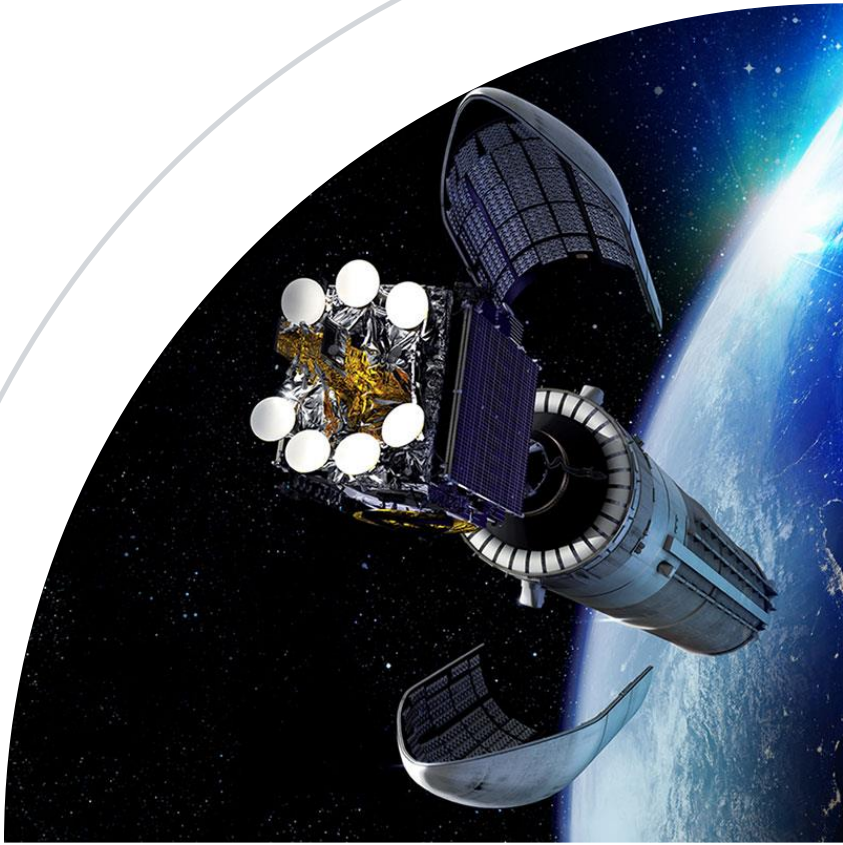

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