

Status of Standards and Requirements for Wireless Avionic Intra-aircraft Communication(WAIC) Systems for Commercial Aircraft

Passive Wireless Sensor Technology Workshop
WiSEE 2019 - 17 October 2019
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AIRBUS



Honeywell



THALES

Outline

- Why WAIC?
- What is WAIC?
- How did we get here?
- Where are we going?



WAIC and Aviation: An Acronym-rich Problem Space

- WAIC – Wireless Avionics Intra-Communication
- ICAO – International Civil Aviation Organization
- FSMP – Frequency Spectrum Management Panel (ICAO)
- FAA – Federal Aviation Administration
- EASA – European Aviation Safety Agency
- RTCA – Radio Technical Commission for Aeronautics
- EUROCAE – European Organization for Civil Aviation Equipment
- AVSI – Aerospace Vehicular Systems Institute (Texas A&M)
- ARINC – Aeronautical Radio, Inc.

- MASPS – Minimum Aviation System Performance Standard (RTCA/EUROCAE)
- MOPS – Minimum Operational Performance Standard (RTCA/EUROCAE)
- SARPS – Standards and Recommended Practices (ICAO)

The Problem

- A large commercial passenger aircraft has more than 100,000 wires with a total length of 470 km and weighing 5,700 kg
- There is about 30% of additional weight in harnessing and connectors
- About 30% of electrical wires are potential candidates for a wireless substitute!

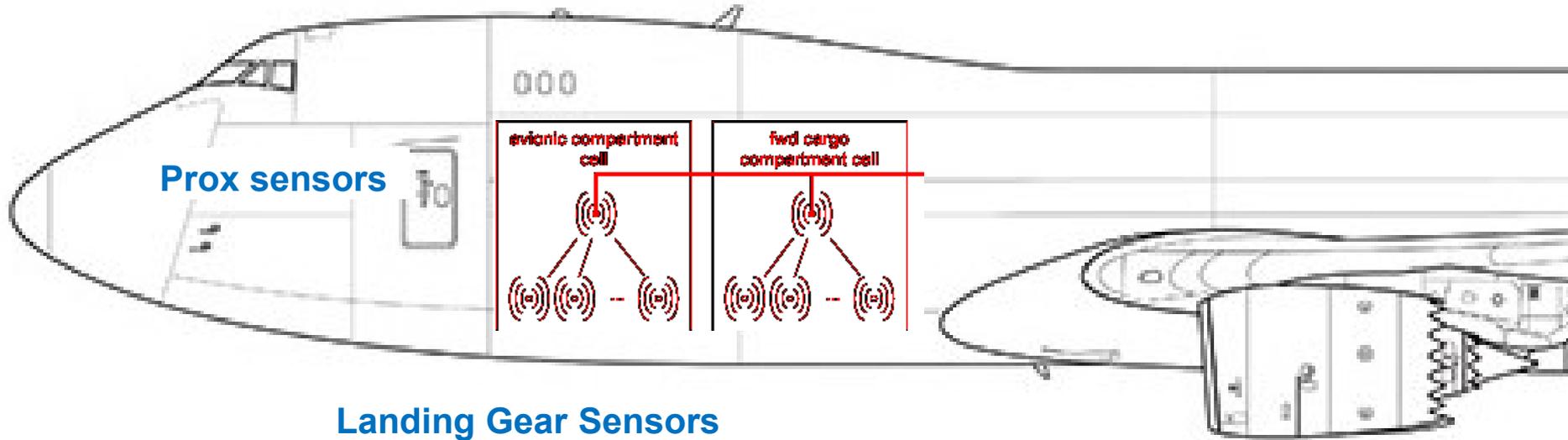
Importance of WAIC to Operators

- **Safety Improvements**
 - Dissimilar redundancy
 - Fewer wires means fewer failures
 - Mesh networking redundancy
- **Environmental Benefits**
 - Fewer wires = less weight = less fuel burn
- **Increased Reliability**
 - Reduce aging wire
 - Simplify and reduce life-cycle cost of airplane wiring
 - Enhance aircraft health monitoring
 - Add new sensors and controls without additional wire routing
- **Provide operational efficiencies and associated cost savings**
 - Reduced need to take aircraft out of service for inspection
 - Enhance configurability



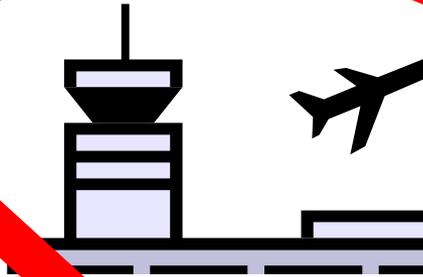
WHAT EXACTLY IS WAIC?

THIS



Engine sensors

NOT THIS



Communications
with Ground



Operational
Communications

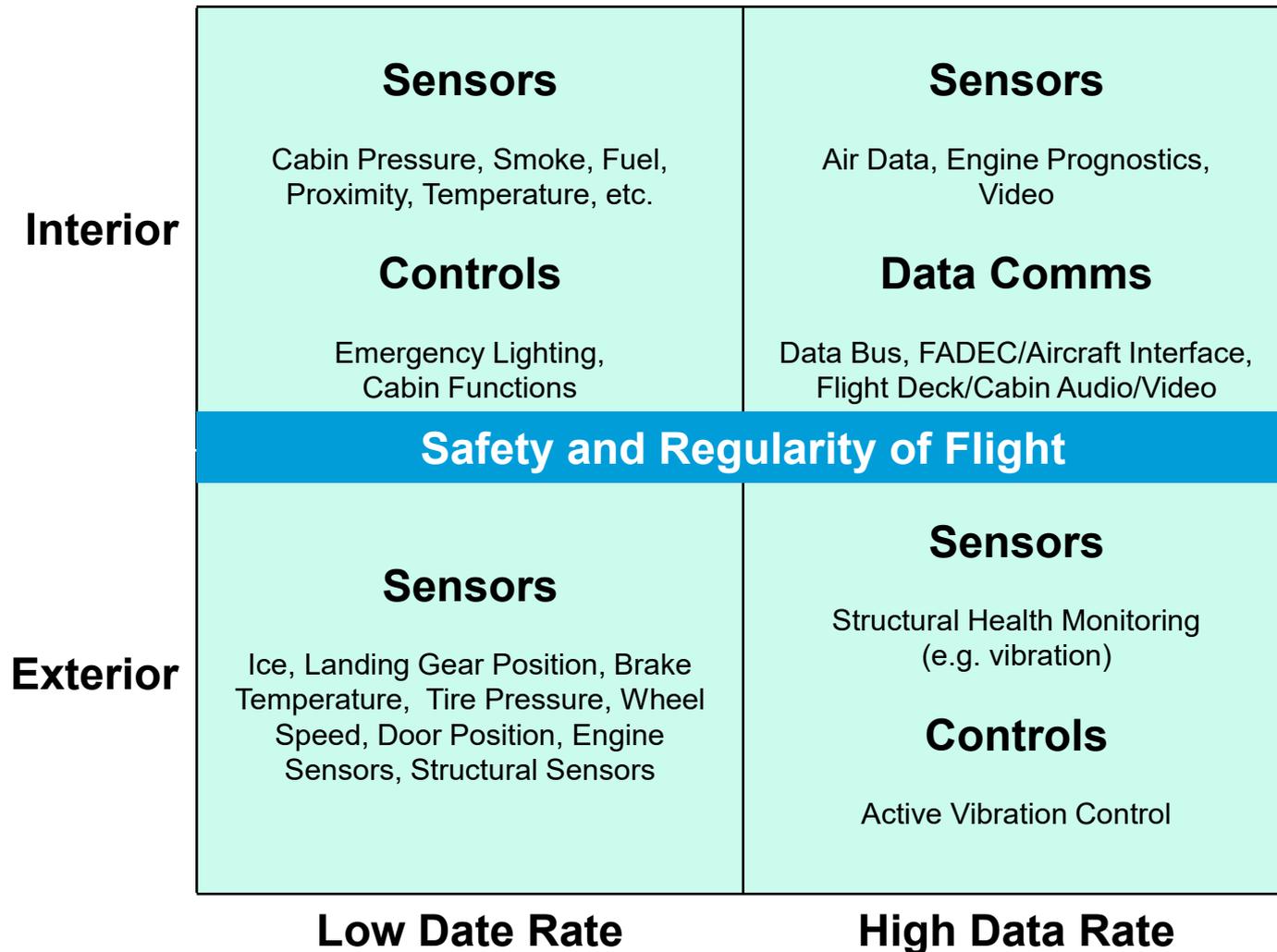


Internet
Connectivity

What is Wireless Avionics Intra-Communications (WAIC)?

- **WAIC is:**
 - Radiocommunication between two or more points on a single aircraft.
 - Integrated wireless and/or installed components to the aircraft.
 - Part of a closed, exclusive network required for operation of the aircraft.
 - Only for applications supporting safety or regularity of flight.
 - Low maximum transmitted power levels (≤ 6 mW/MHz)
- **WAIC is not:**
 - Off-board air-to-ground, air-to-satellite, or air-to-air service.
 - Communications for passengers or in-flight entertainment.

Bandwidth requirements were developed by considering potential WAIC applications



The Aerospace Vehicle Systems Institute

AVSI is an industry-centric applied research cooperative founded in 1998 at Texas A&M University that facilitates pre-competitive collaborative research projects (“AFE’s”).



AIRBUS



Collins Aerospace



EMBRAER



Honeywell



SAAB



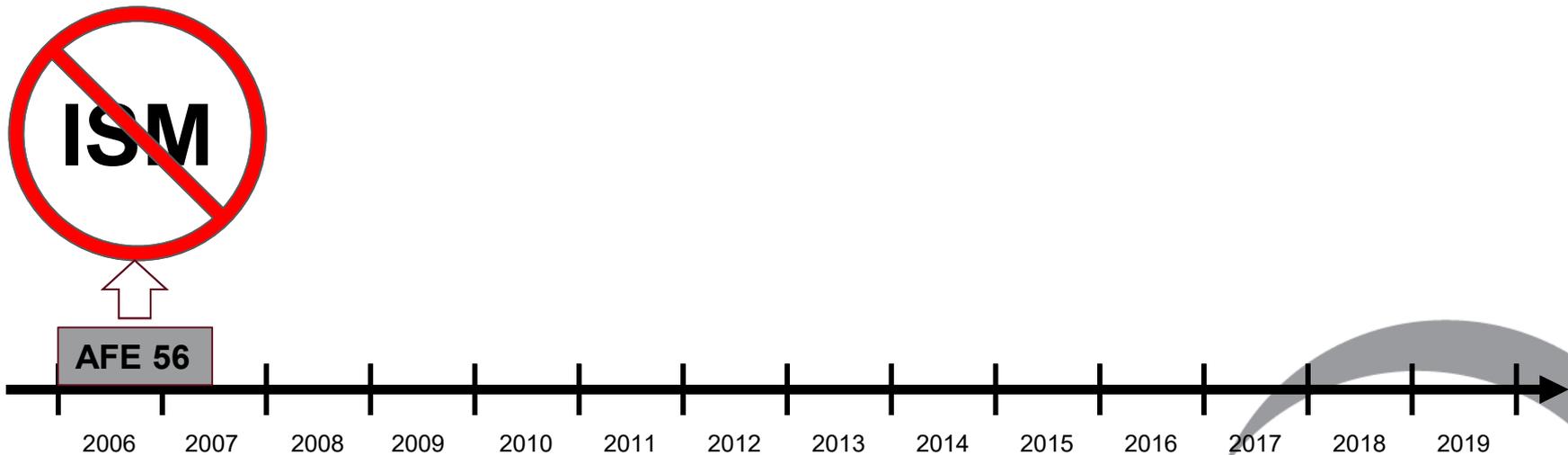
Software Engineering Institute

THALES

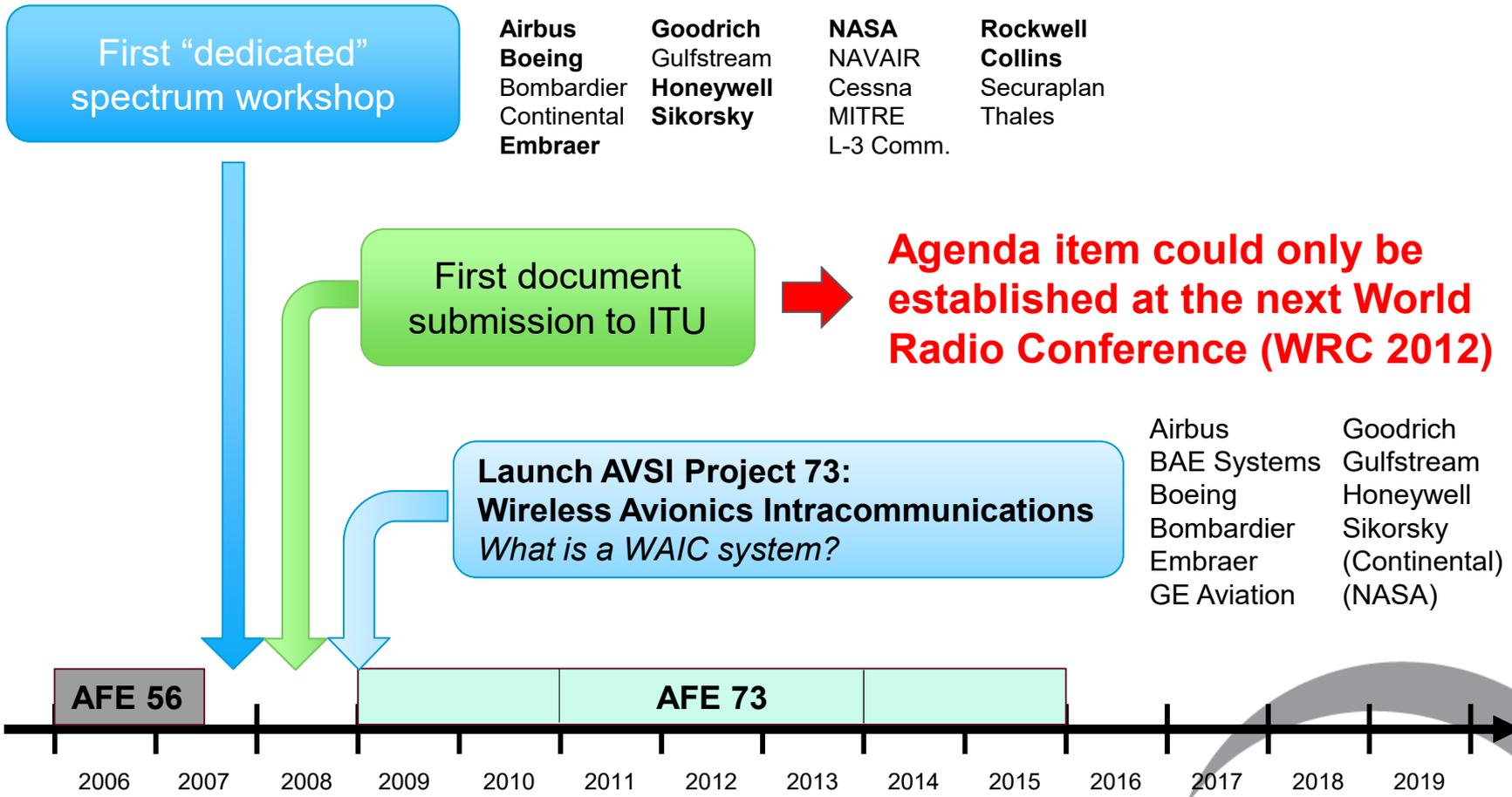
The WAIC Journey Begins: Feasibility Study

Main Findings:

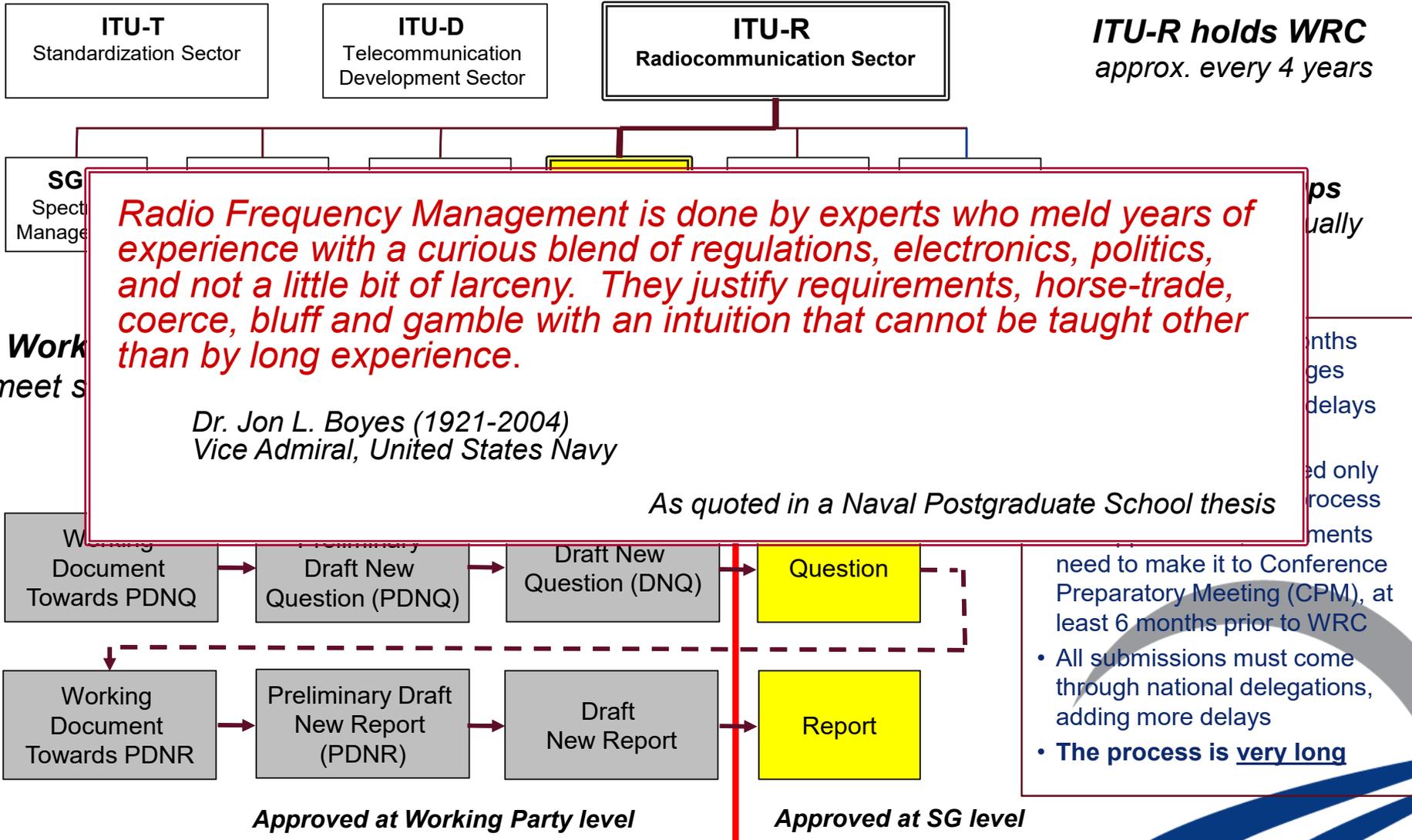
- “certification of intra-aircraft wireless sensors is possible within the existing certification framework”
- “use of the ISM bands for such sensors would be problematic”
- preference to use an already existing primary allocation to an Aeronautical Service



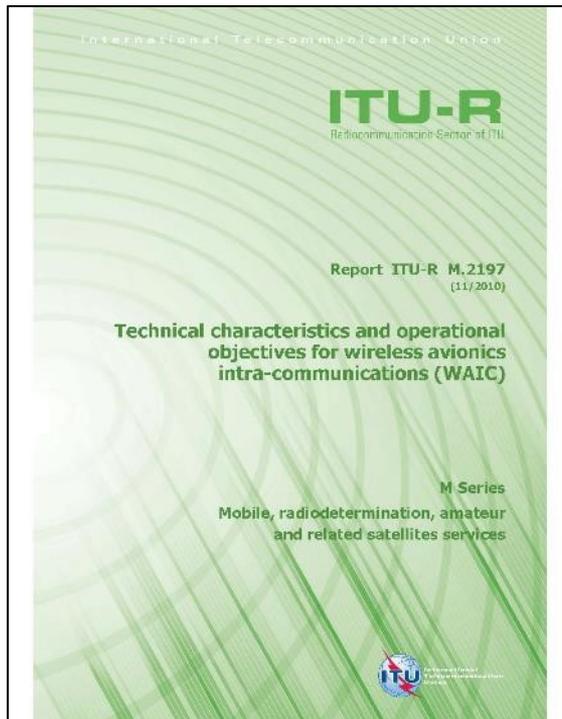
ITU-R: Seeking WAIC Spectrum



The Daunting ITU Process

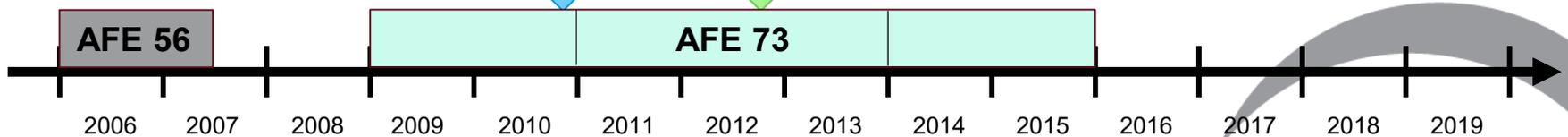


The WAIC Journey Continues: ITU-R



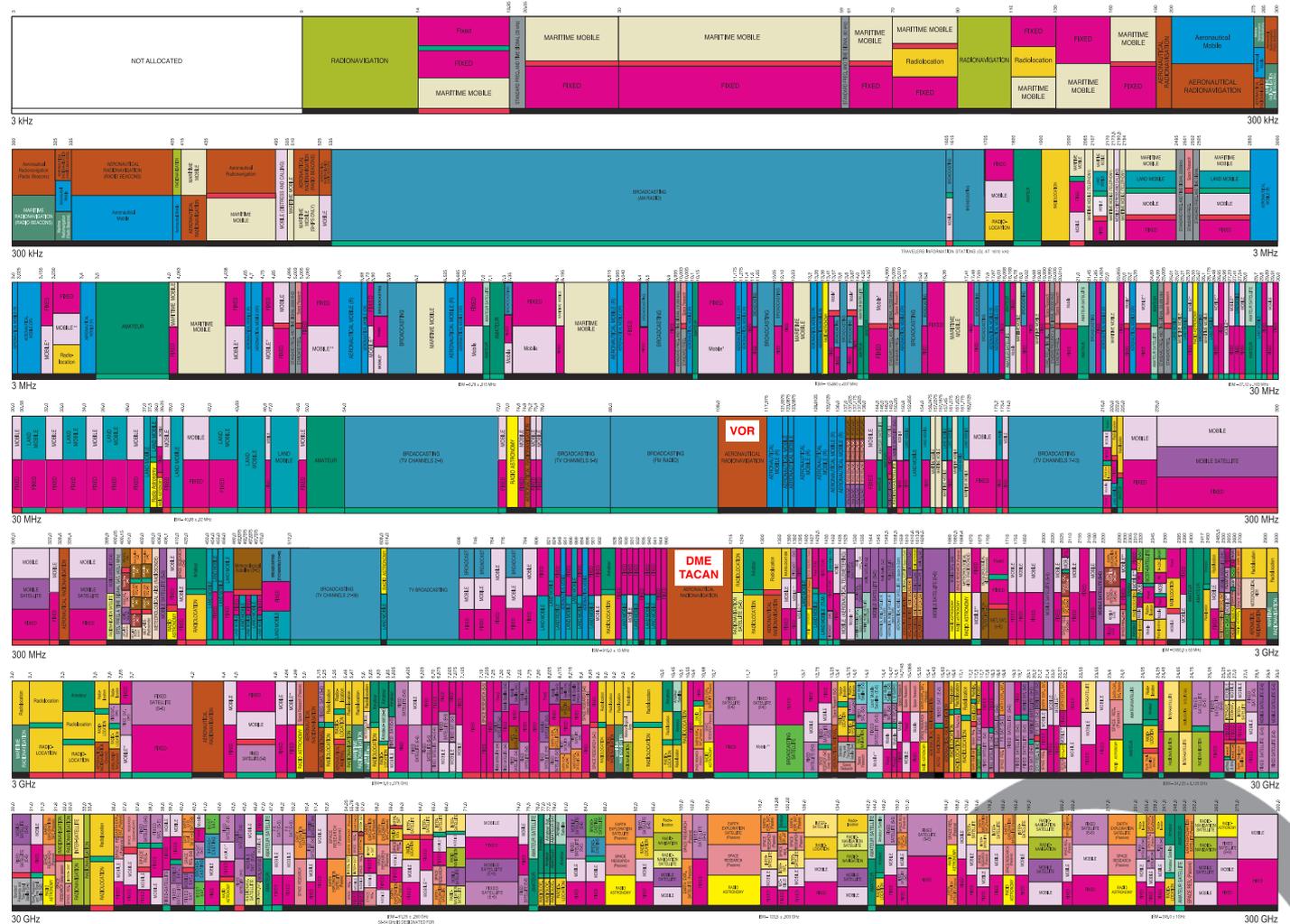
First ITU Report on WAIC

WRC '12:
Agenda Item
Authorized for WAIC



Where does WAIC fit best?

UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM



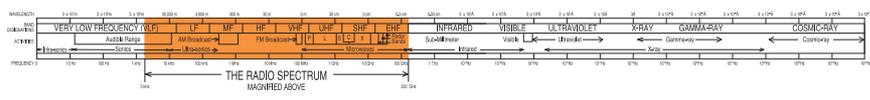
- RADIO SERVICES COLOR LEGEND**
- AERONAUTICAL MOBILE
 - AERONAUTICAL MOBILE SATELLITE
 - AERONAUTICAL RADIONAVIGATION
 - AMATEUR
 - AMATEUR SATELLITE
 - BROADCASTING SATELLITE
 - EARTH-EXPLORATION SATELLITE
 - FIXED
 - FIXED SATELLITE
 - INTER-SATELLITE
 - LAND MOBILE
 - LAND MOBILE SATELLITE
 - MARINE MOBILE
 - MARINE MOBILE SATELLITE
 - MARINE RADIONAVIGATION
 - MARINE RADIONAVIGATION SATELLITE
 - METEOROLOGICAL SATELLITE
 - METEOROLOGICAL SATELLITE
 - RADIO ASTRONOMY
 - RADIO DETERMINATION SATELLITE
 - RADIOLOGATION
 - RADIOLOGATION SATELLITE
 - RADIONAVIGATION
 - RADIONAVIGATION SATELLITE
 - SPACE OPERATION
 - SPACE RESEARCH
 - STANDARD-FREQUENCY AND TIME SIGNAL
 - MOBILE
 - MOBILE SATELLITE
 - STANDARD-FREQUENCY AND TIME SIGNAL SATELLITE

- ACTIVITY CODE**
- GOVERNMENT EXCLUSIVE
 - NON-GOVERNMENT EXCLUSIVE
 - GOVERNMENT/NON-GOVERNMENT SHARED

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	Mobile	1st Capital with Even case letters

This chart is a graphic representation prepared by the Table of Frequency Allocations staff of the FCC and is for informational purposes only. It does not constitute an allocation, a license, and does not constitute a guarantee of any kind. For more information, please refer to the Table of Frequency Allocations, Technical Information, and other documents available on the FCC website to determine the current status of U.S. allocations.



PLEASE NOTE THE SPACE ALLOCATED BETWEEN THE DOTS IS A GUIDELINE AND NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM AVAILABLE.

Proposed Allocation: Altimeter Band

200 MHz of RF between 4.2 and 4.4 GHz

Pros

- Aeronautical Radionavigation Service allocation used exclusively by Radio Altimeters
- Already aeronautical
- Potentially less non-aero opposition
- Band sharing could be easier to coordinate
- Improve efficient use of spectrum, which could help defend the band from non-aero interests

Cons

- Interference from altimeters potentially difficult to deal with
- Up to three independently operating altimeters per aircraft
- Spectrum effectively available at any given time is less than 200 MHz
- Much less bandwidth than initially contemplated in Report M.2197
- No officially recognized protection criteria existed for Radio Altimeter – difficult to demonstrate coexistence

Bottom line: only truly feasible choice

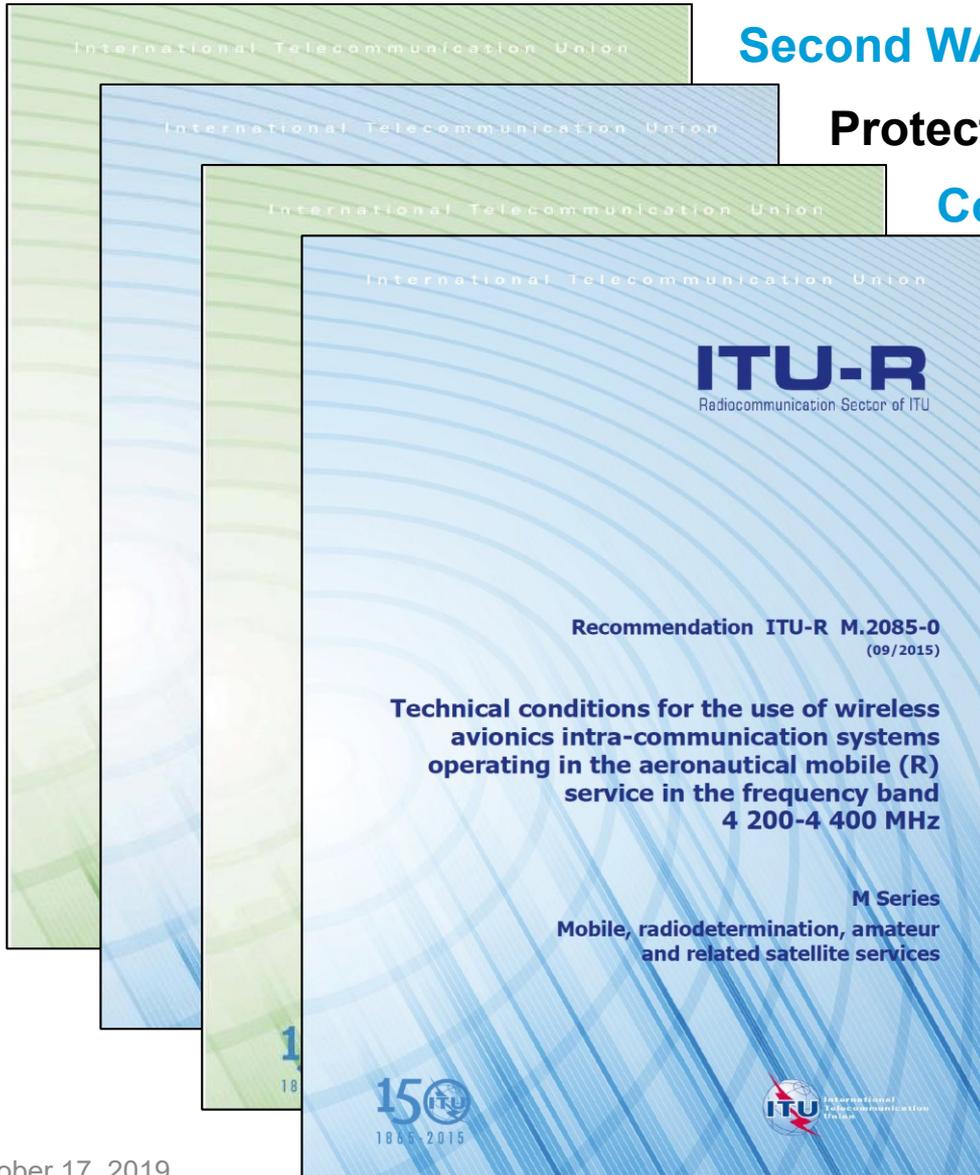
More Documents

Second WAIC Characteristics Report

Protection criteria for radio altimeters

**Compatibility study for WAIC
operating in 4.2-4.4 GHz**

Technical Conditions for WAIC



**M.2085:
Basis for
allocation
resolution**

WRC-15: New Allocation Approved

MOD

2 700-4 800 MHz

Allocation to services		
Region 1	Region 2	Region 3
4 200-4 400	AERONAUTICAL MOBILE (R) ADD 5.A117 AERONAUTICAL RADIONAVIGATION MOD 5.438 5.439 5.440 ADD 5.B117	

ADD

5.A117 Use of the frequency band 4 200-4 400 MHz by stations in the aeronautical mobile (R) service is reserved exclusively for wireless avionics intra-communication systems that operate in accordance with recognized international aeronautical standards. Such use shall be in accordance with Resolution **COM4/1 (WRC-15)**. (WRC-15)

Resolution COM4/1 (WRC-15)

RESOLUTION COM4/1 (WRC-15)

Use of Wireless Avionics Intra-Communications in the frequency band 4 200-4 400 MHz

The World Radiocommunication Conference (Geneva, 2015),

considering

- a) that aircraft are designed to enhance their efficiency, reliability and safety, as well as to be more environmentally friendly;
- b) that Wireless Avionics Intra-Communications (WAIC) systems provide radiocommunications between two or more aircraft stations integrated into or installed on a single aircraft, supporting the safe operation of the aircraft;
- c) that WAIC systems do not provide radiocommunications between an aircraft and the ground, another aircraft or a satellite;
- d) that WAIC systems operate in a manner that ensures the safe operation of an aircraft;
- e) that WAIC systems operate during all phases of flight, including on the ground;
- f) that aircraft equipped with WAIC systems operate globally;
- g) that WAIC systems operating inside an aircraft receive the benefits of fuselage attenuation to facilitate sharing with other services;
- h) that Recommendation ITU-R M.2067 provides technical characteristics and operational objectives for WAIC systems,

recognizing

that Annex 10 to the International Civil Aviation Organization (ICAO) Convention on International Civil Aviation contains Standards and Recommended Practices (SARPs) for safety aeronautical radionavigation and radiocommunication systems used by international civil aviation,

resolves

- 1 that WAIC is defined as radiocommunication between two or more aircraft stations located on board a single aircraft, supporting the safe operation of the aircraft;
- 2 that WAIC systems operating in the frequency band 4 200-4 400 MHz shall not cause harmful interference to, nor claim protection from, systems of the aeronautical radionavigation service operating in this frequency band;

3 that WAIC systems operating in the frequency band 4 200-4 400 MHz shall comply with the Standards and Recommended Practices published in Annex 10 to the Convention on International Civil Aviation;

4 that No. 43.1 shall not apply for WAIC systems,

instructs the Secretary-General

to bring this resolution to the attention of ICAO,

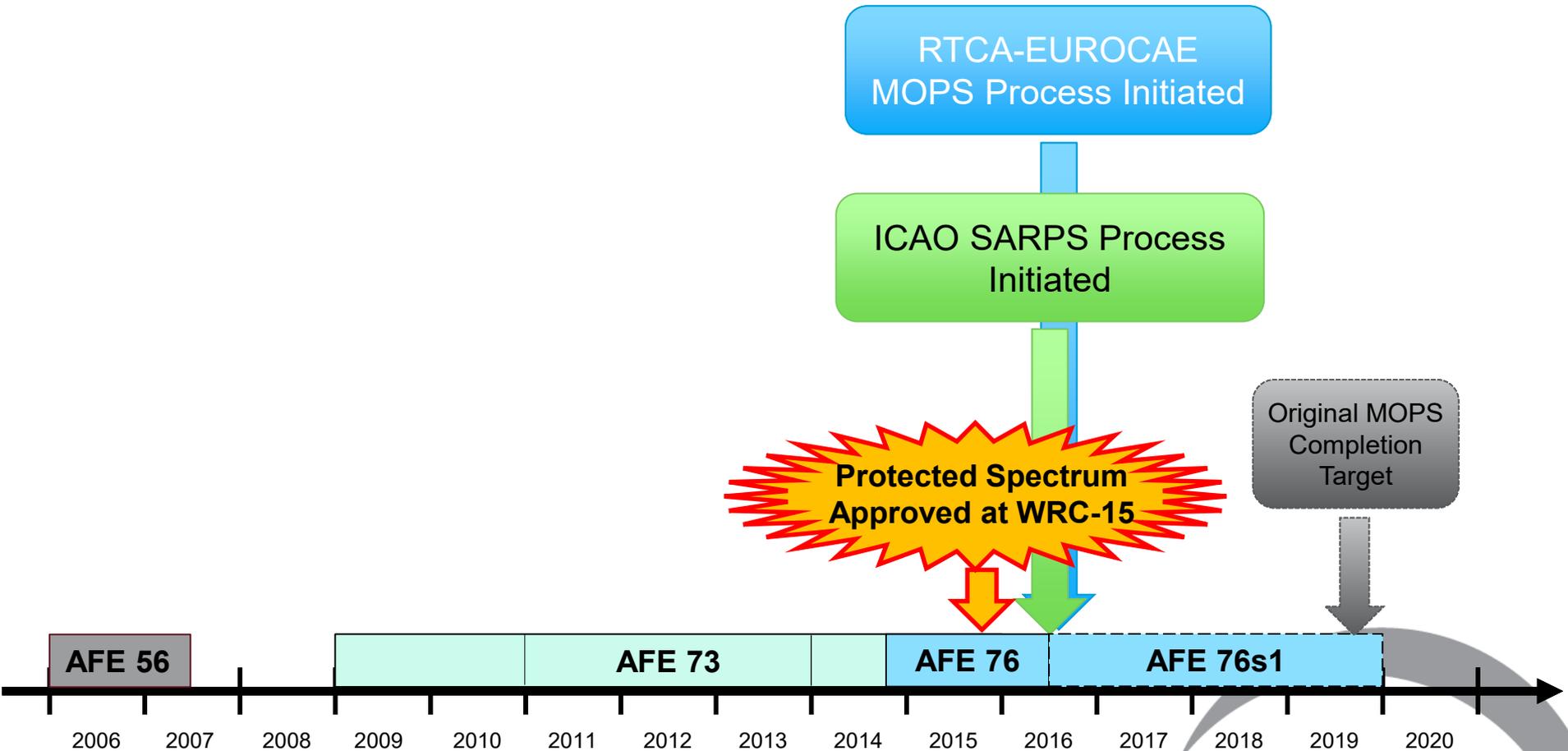
invites the International Civil Aviation Organization

to take into account Recommendation ITU-R M.2085 in the course of development of SARPs for WAIC systems.

Key points of the Resolution

1. WAIC is defined as stations on-board a single aircraft and supporting safe operation of aircraft
2. WAIC must give protection and precedence to radio altimeters
3. WAIC must comply with International Standards (SARPS)

Defining WAIC Specifications



WAIC Standardization Efforts

RTCA SC-236
EUROCAE WG-96
Joint Committee

WAIC MOPS
WAIC MASPS

ON Aircraft

ICAO FSMP

WAIC SARPS
(RadAlt SARPS)

BETWEEN Aircraft

ARINC CSS

Secure Media
Independent
Messaging
(SMIM)

*BETWEEN
WAIC
Equipment
(Interopera
bility)*

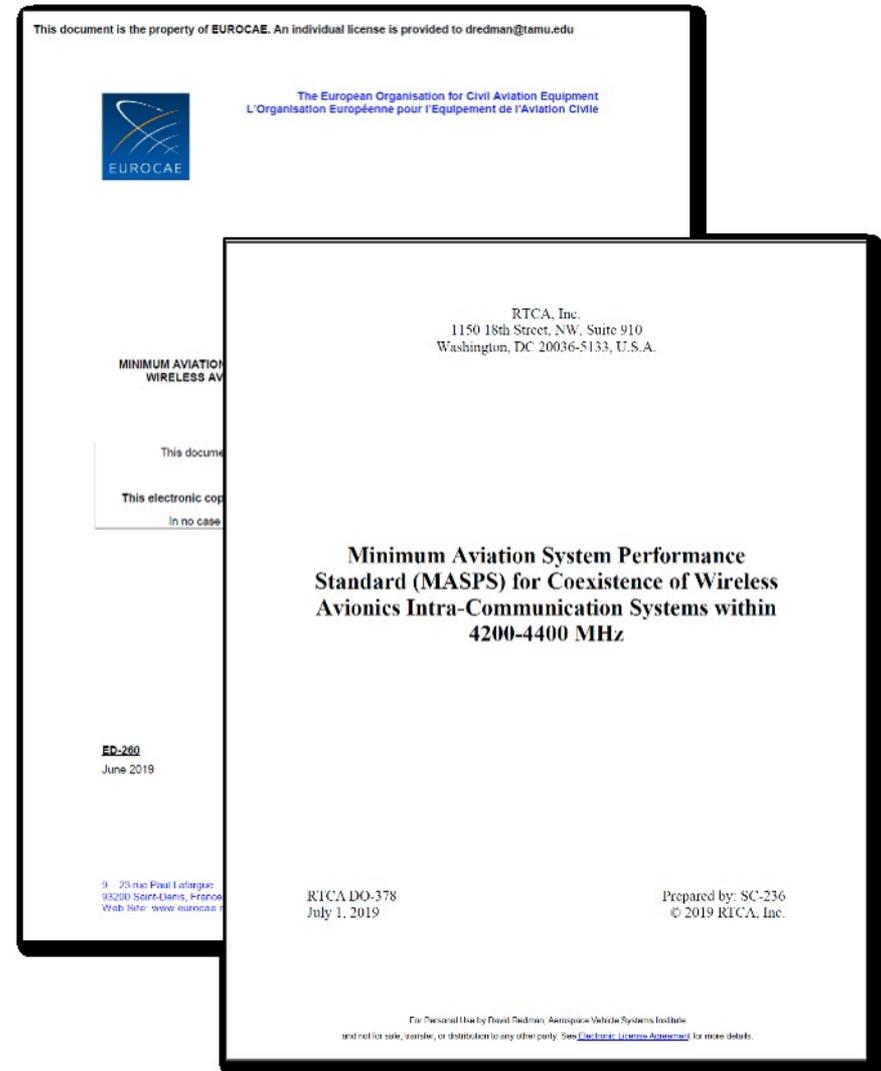
AVSI

Laboratory Testing
SARPS Development

RTCA + EUROCAE: WAIC MOPS

- RTCA SC-236 and EUROCAE WG-96 form joint committee to develop the **Minimum Operational Performance Standard (MOPS)** defines WAIC behavior **on a given aircraft**
- Requirements and Compliance Test Procedures that lead to Technical Standard Orders (TSO) & Advisory Circulars (AC)
- Ensure that
 - The safe operation of Radio Altimeters is not compromised; and
 - Allows the worst-case performance of a WAIC system to be pre-determined
 - The development of wireless applications takes into account the key issues of spectrum availability, electromagnetic compatibility, and aircraft protection
 - Ensure *compatibility*, **NOT interoperability**

- Recommendation from FSMP to have SARPs refer to RTCA standards for technical details
- Interdependency between documents and development schedules led to decision to issue a **Minimum Aviation System Performance Specification (MASPS)** through SC-236/WG-96 to provide technical details relevant to ensure coexistence *between aircraft* to support ICAO SARPS
- Led to publication of RTCA DO-296 / EUROCAE ED-260 in June 2019



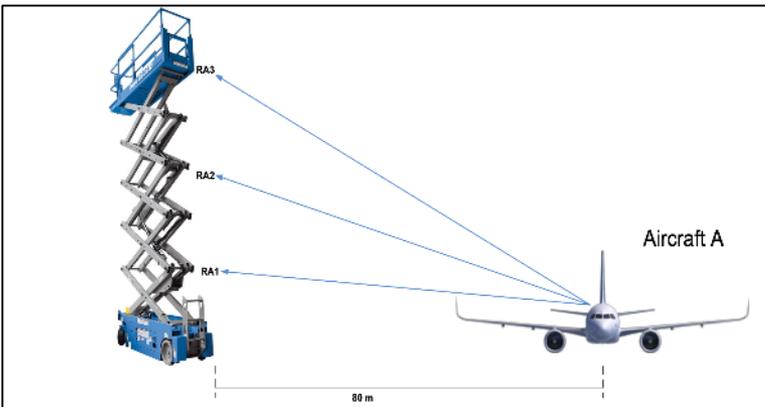
ICAO (FSMP): WAIC SARPS

- The International Civil Aviation Organization (ICAO) is a UN Special Agency that supports global uniformity on aircraft operations.
- Annex 10 to the International Civil Aviation Organization (ICAO) Convention on International Civil Aviation contains Standards and Recommended Practices (SARPs) for safety aeronautical radionavigation and radiocommunication systems used by international civil aviation
- ICAO allocated SARPs development to the Frequency Spectrum Management Panel (FSMP) [Job Card FSMP-07-01-WAIC]
- SARPs drafted by AVSI project members submitted to FSMP at multiple meetings for review and comment.
- “Final” draft submitted for FSMP approval in January 2019.
- Still requires final approval through the Air Navigation Commission (ANC) before it is incorporated in the Convention.

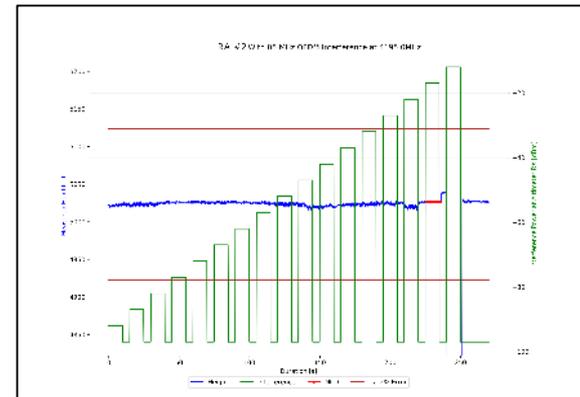
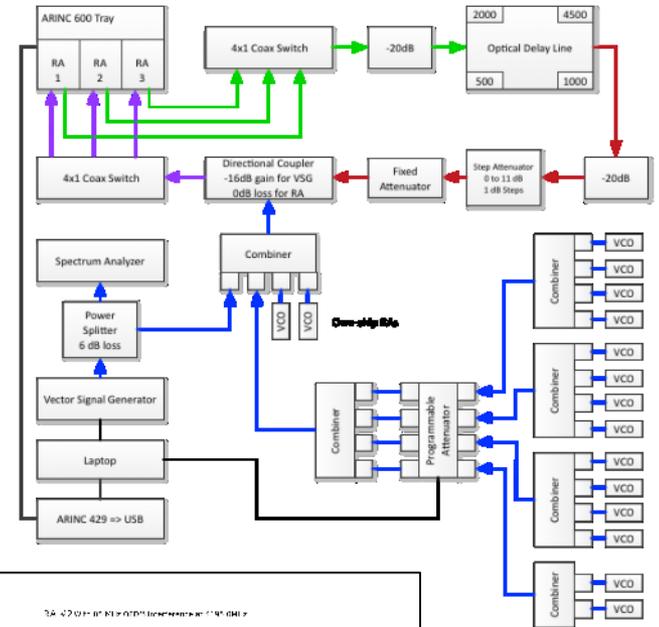
AVSI: WAIC + RA Testing



Internal Propagation Measurements



Path loss measurements



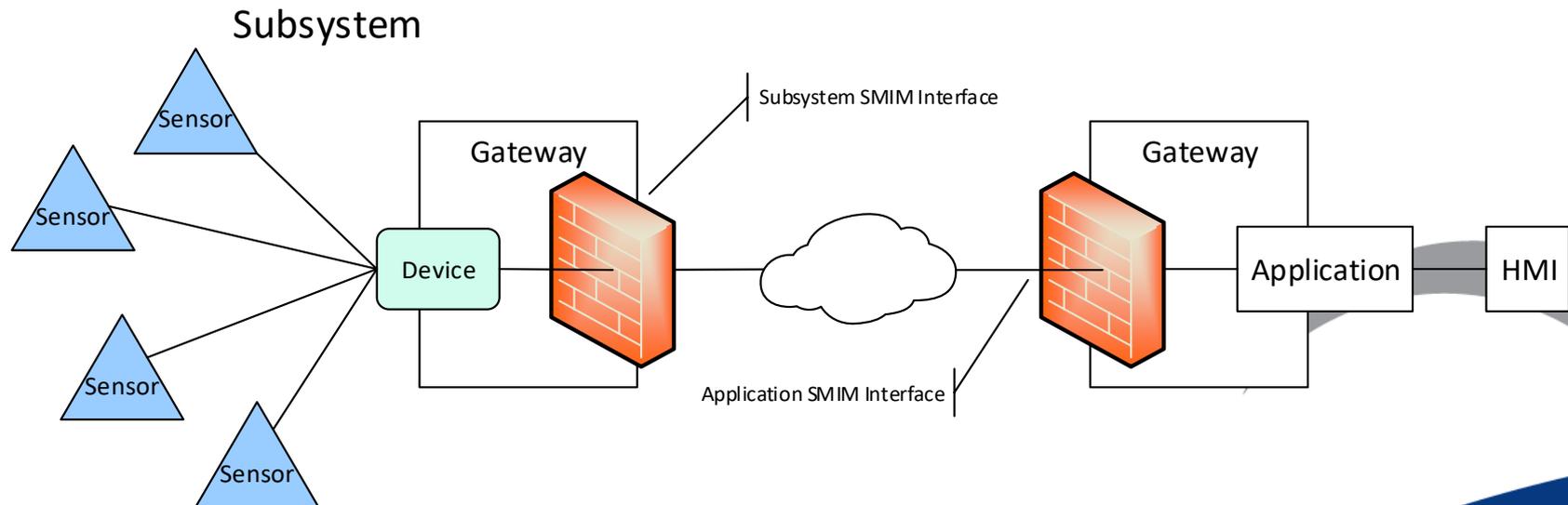
Laboratory interference testing

ARINC: Security & Interoperability

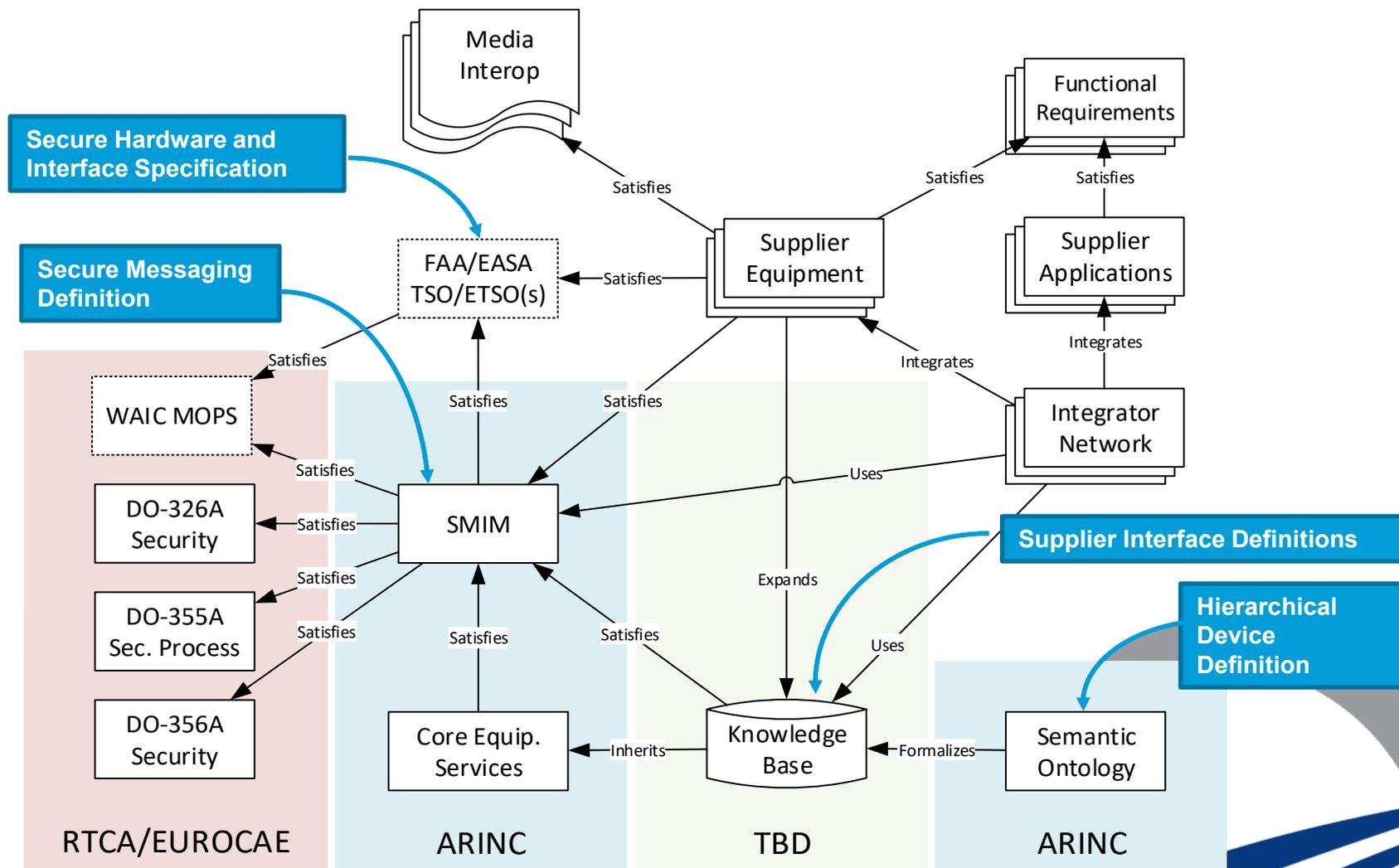
- SC-236/WG-96 defined WAIC requirements specifically to address security vulnerabilities introduced due to the use of wireless media for safety and regularity of flight applications.
- Security-related requirements derived by SC-236/WG-96 are not unique to WAIC.
- Planned FAA/EASA TSO/eTSO from WAIC MOPS will dictate hardware requirements and interface definition necessary to meet security requirements when using wireless communications for safety and regularity of flight applications.
- Wireless communications is the most vulnerable onboard communications media.
- Secure Media Independent Messaging (SMIM) applies the security requirements defined by SC-236/WG-96 for WAIC to all media types to establish a universal secure communications solution.

Hardware-based Security

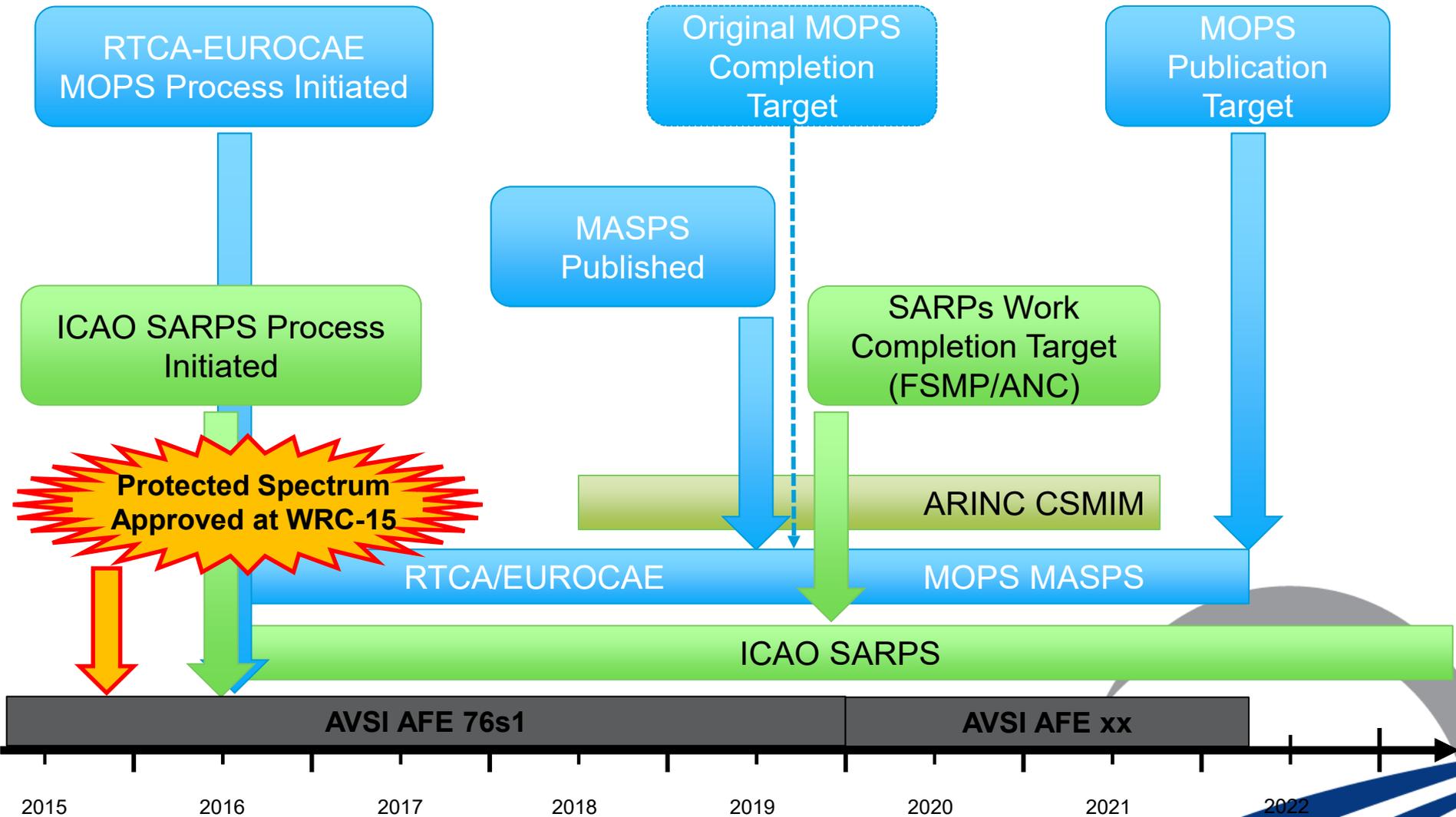
- As defined in WAIC MOPS, TSOed equipment and subsystems will be one of two basic types: Full Security Devices (FSD) and Minimum Security Devices (MSD).
- FSDs include a Trusted Execution Environment (TEE) and a gateway.
- Equipment and subsystems that are not FSDs must be isolated from other equipment and subsystems by an FSD to ensure that network security boundaries are maintained.



Industry Standard Ownership and Relationships



WAIC Development Status



Current Status

- ICAO
 - Draft WAIC SARPs submitted to *working group* in 1/2019
 - Late objections - sent back to drafting group
 - As of August 2019 – additional objections raised that are not resolved
 - ICAO Document approval process delays will slow formal adoption
- RTCA/EUROCAE
 - MASPS published June 2019
 - ToR extended to give time to complete MOPS – currently committee work completing January 2022 for March document publication date
- AVSI
 - WAIC on RA testing nearly complete (extending test based on FSMP feedback)
 - Additional altimeters will also be tested
 - Planning for RA on WAIC & WAIC on WAIC testing
- ARINC CSS Committee
 - Committee launched under ARINC in late 2018 – just getting started

Challenges

- Must not interfere with radio altimeters
- Constrained available radiated power
- External applications are severely limited
- Spectral efficiency and EM compatibility at low price and power per node
- Cyber secure implementations
- QoS and availability
- Interoperability
- Capability roll-out

Conclusion

- WAIC will happen!
- WAIC is strictly for ONBOARD connectivity
- Have come a long way
- Only current roadblocks are procedural

Thank You!

- Questions?
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- Steve Rines (SC-236)
 - Steven.Rines@zii.aero

WAIC
WIRELESS AVIONICS
INTRA-COMMUNICATIONS