

# 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

David Redman, Director AVSI



**AIRBUS**



**Honeywell**



**THALES**

# Outline

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

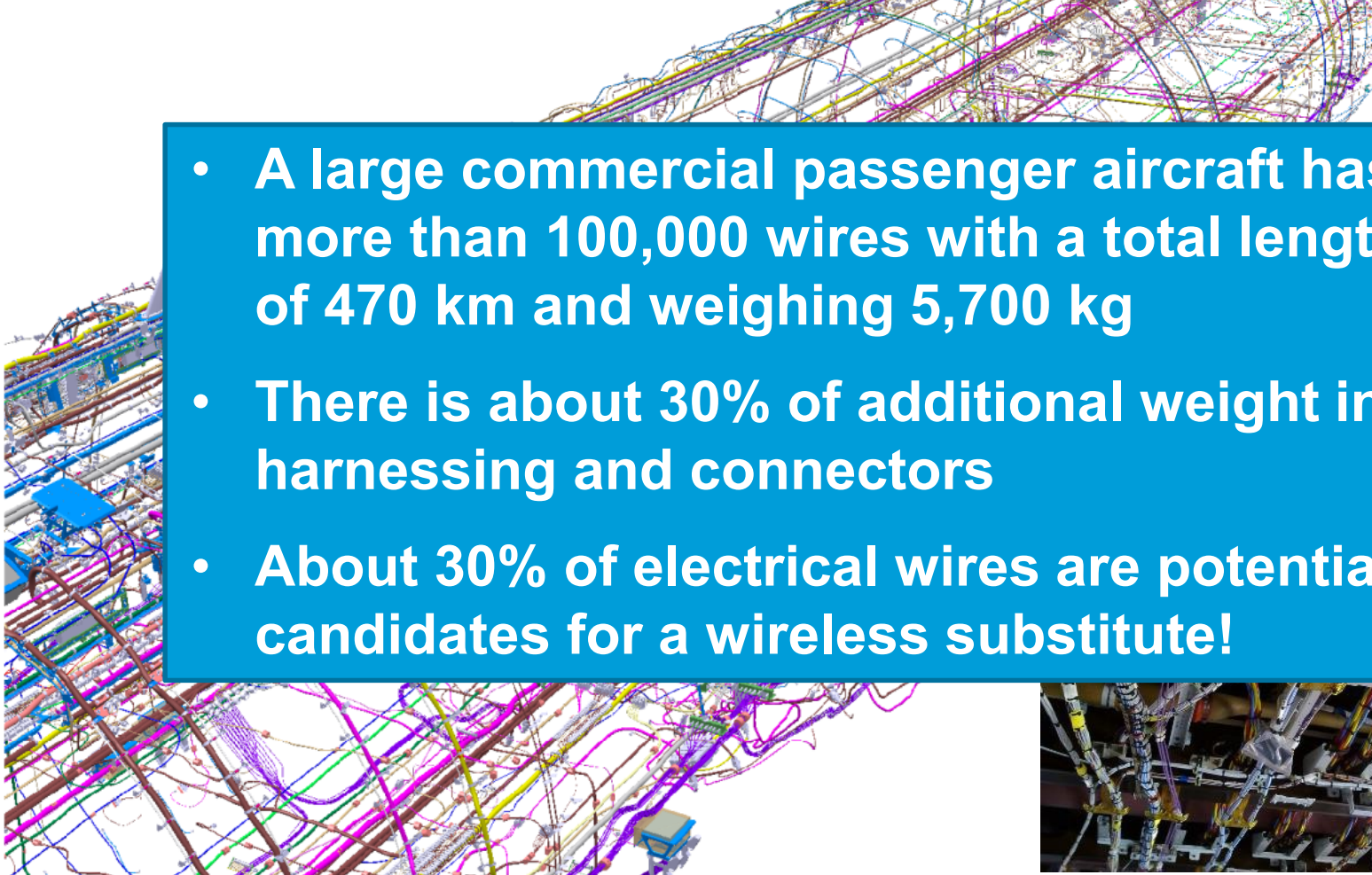



# WAIC and Aviation:

## 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!
- 

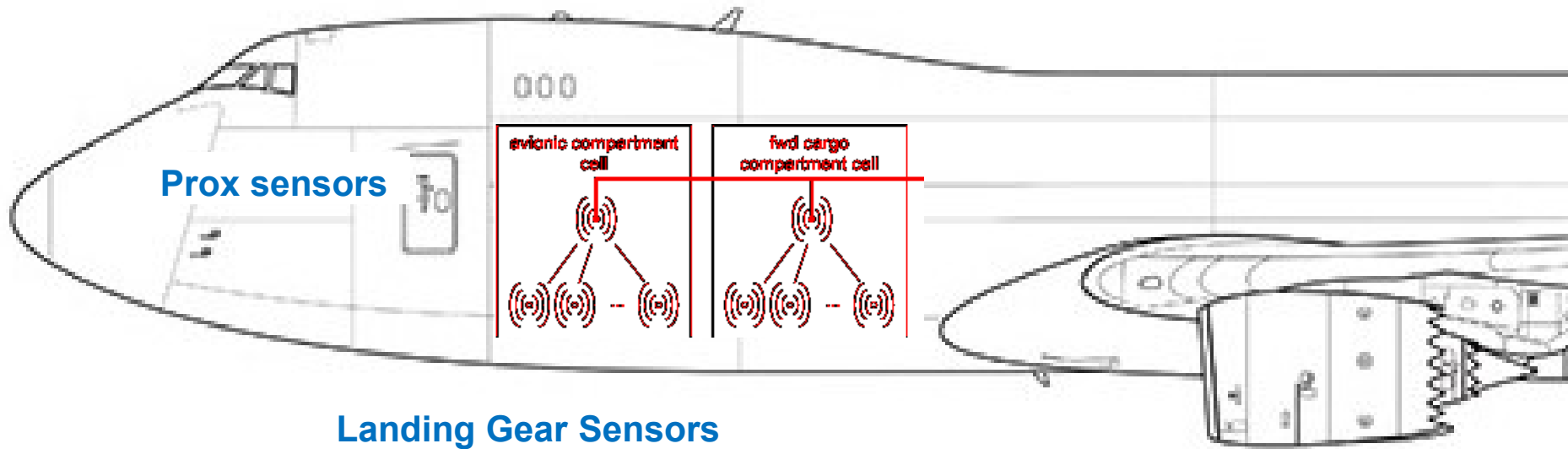
# Importance of WAIC to Operators

- **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

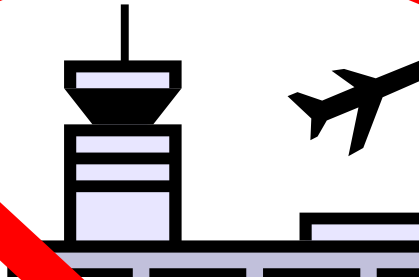


# WHAT EXACTLY IS WAIC?

# THIS



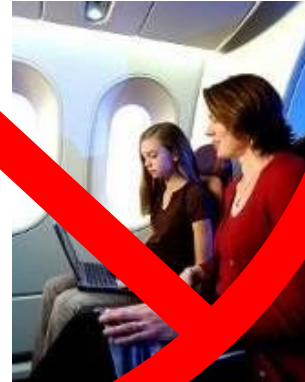
# NOT THIS



Communications  
with Ground



Operational  
Communications



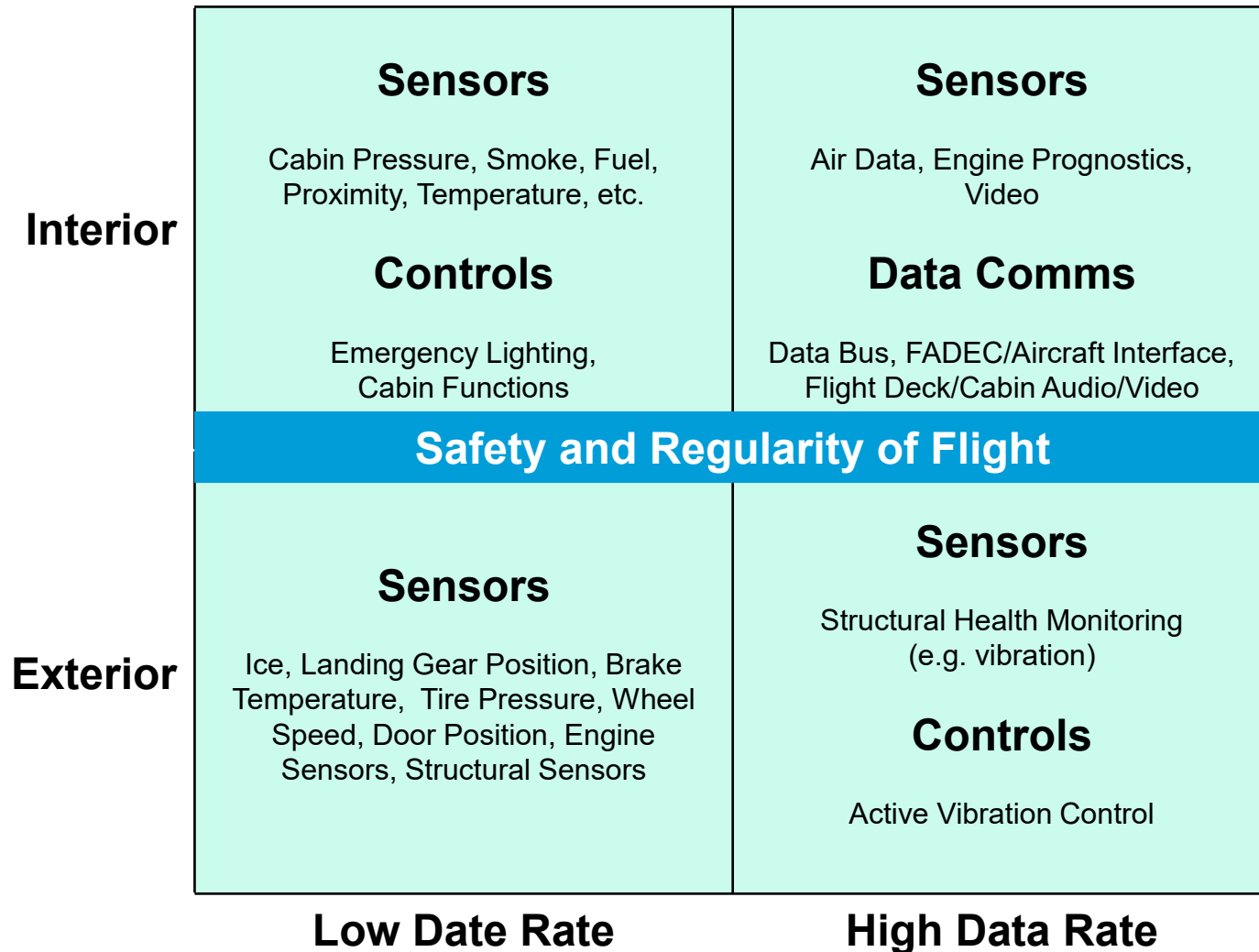
Internet  
Connectivity



# 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 ( $\leq 6$  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**



**Honeywell**



**SAAB**



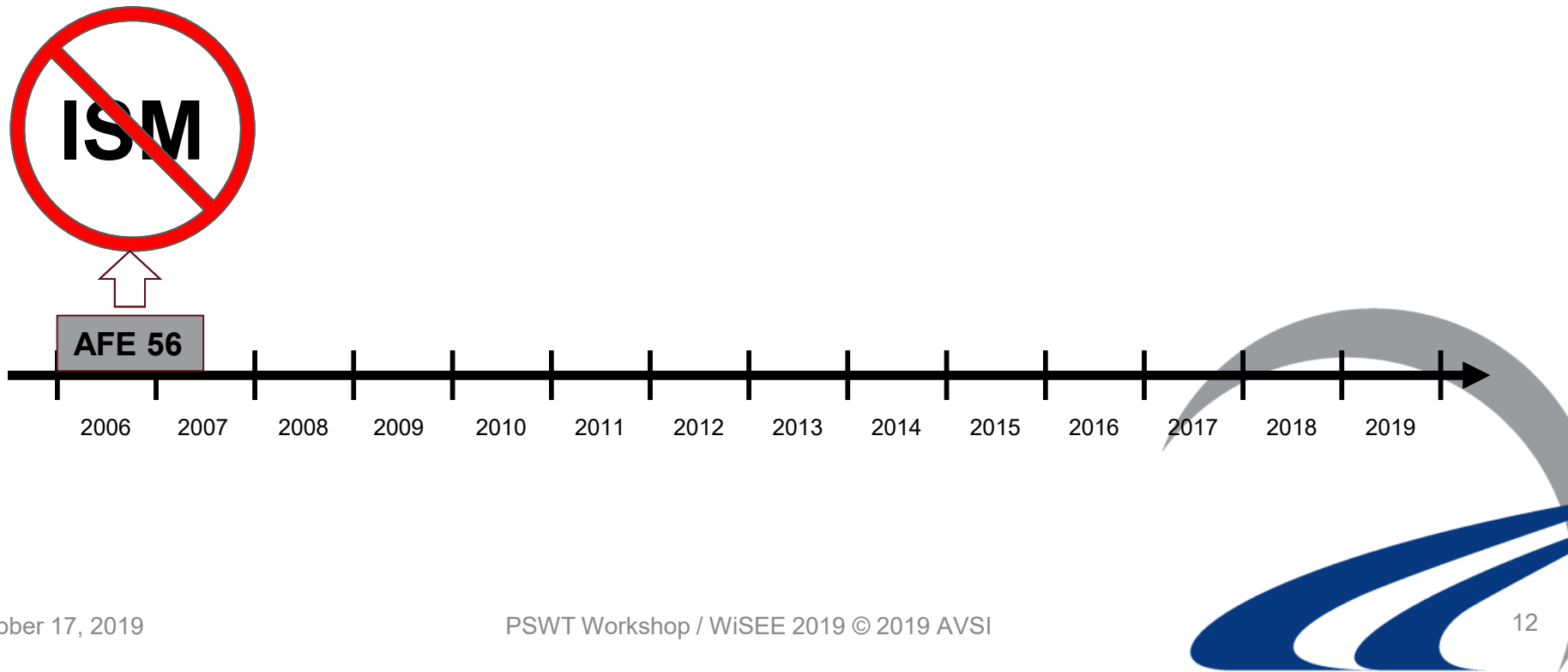
Software Engineering Institute

**THALES**

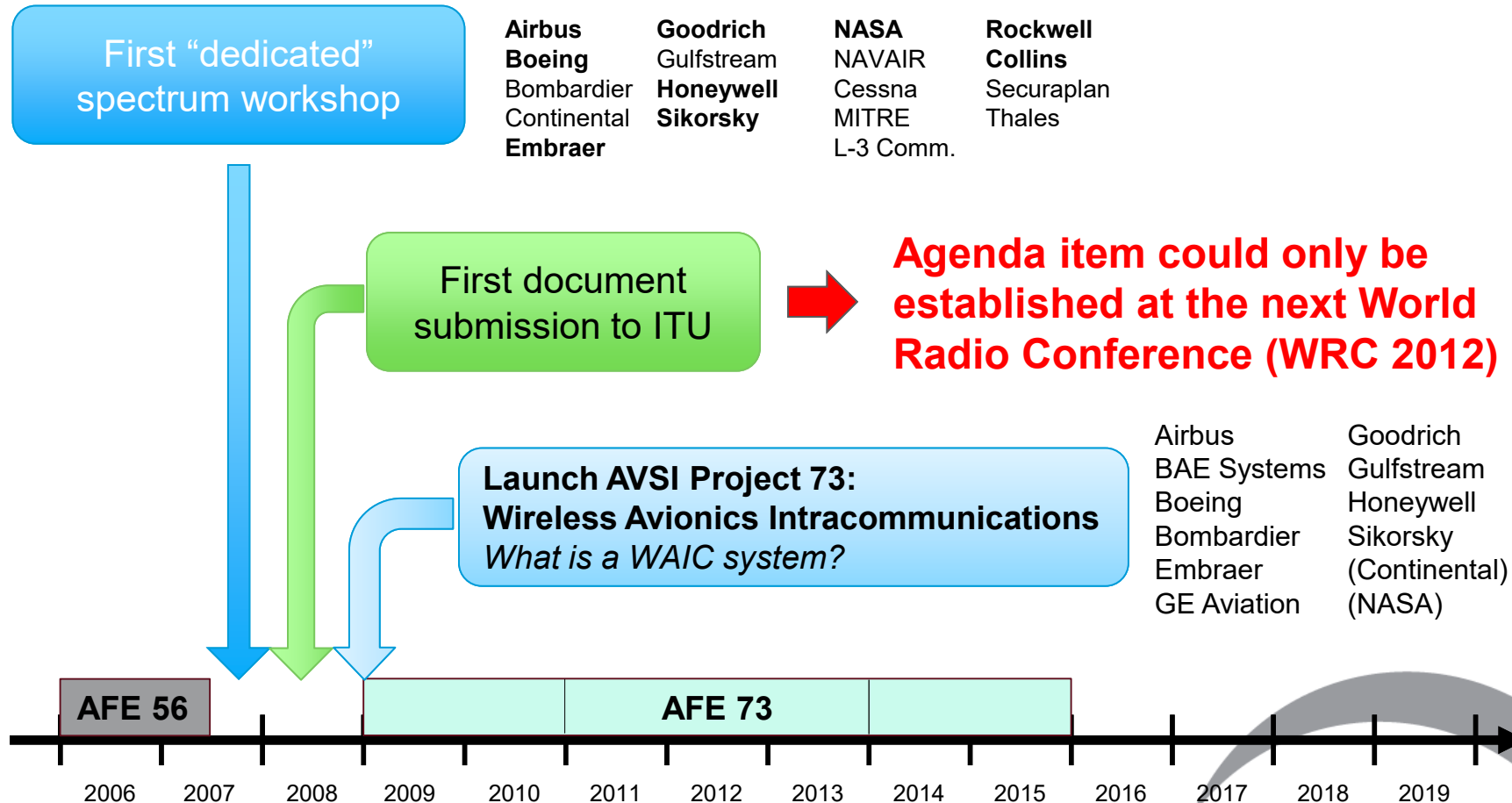
# The WAIC Journey Begins: Feasibility Study

## Main Findings:

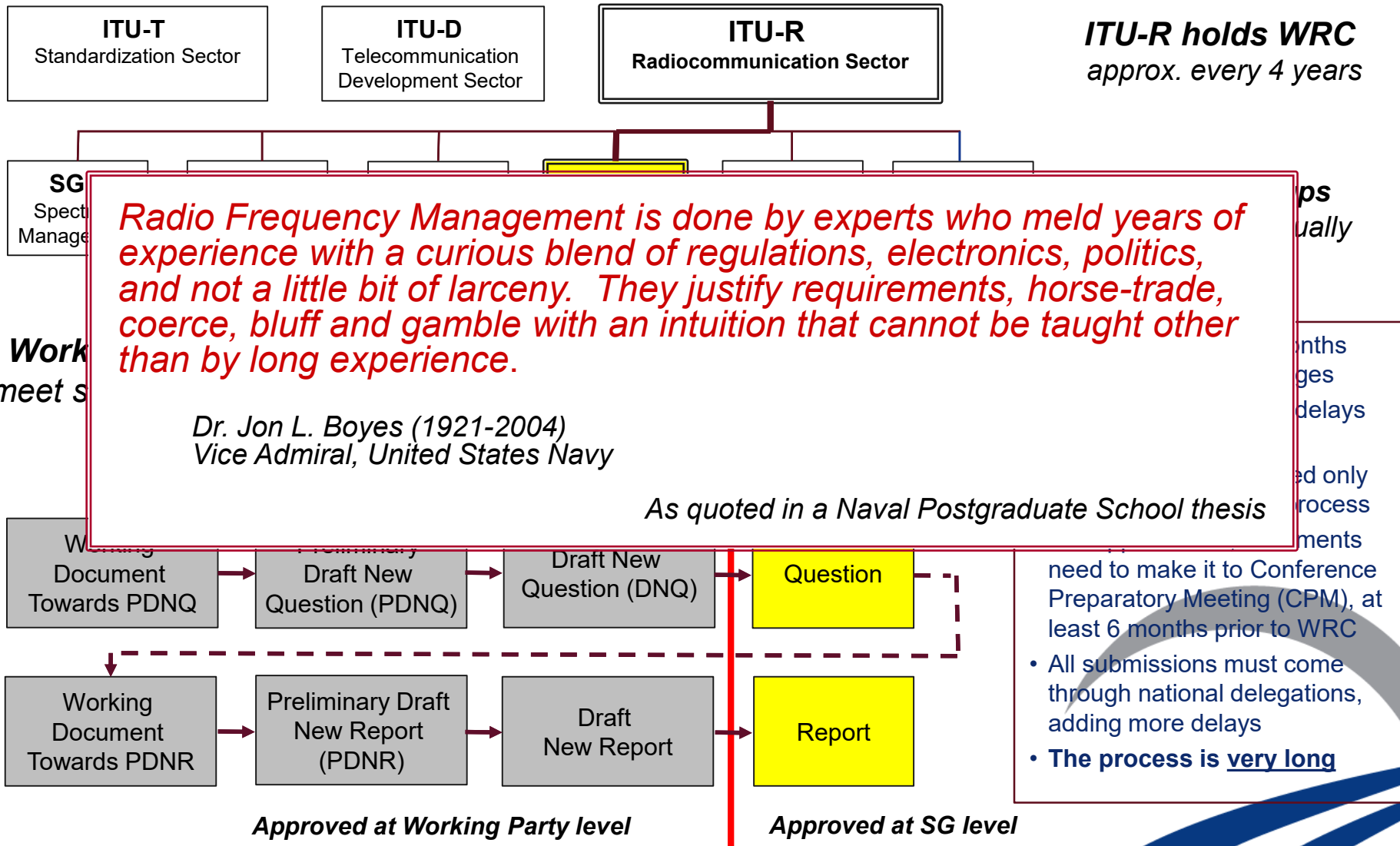
- “certification of intra-aircraft wireless sensors is possible within the existing certification framework”
- “use of the ISM bands for such sensors would be problematic”
- preference to use an already existing primary allocation to an Aeronautical Service



# ITU-R: Seeking WAIC Spectrum



# The Daunting ITU Process

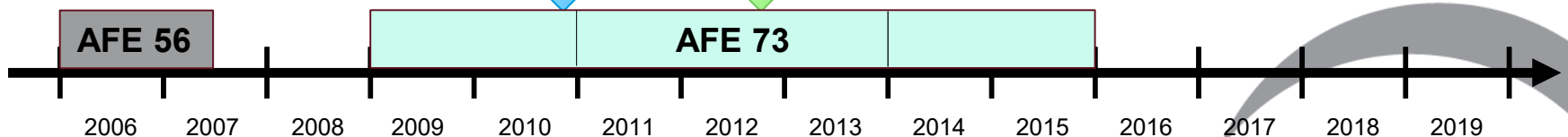


# The WAIC Journey Continues: ITU-R



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

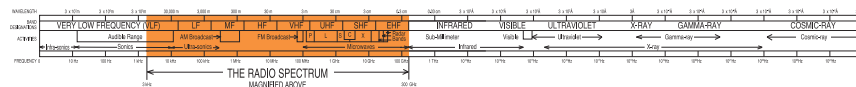
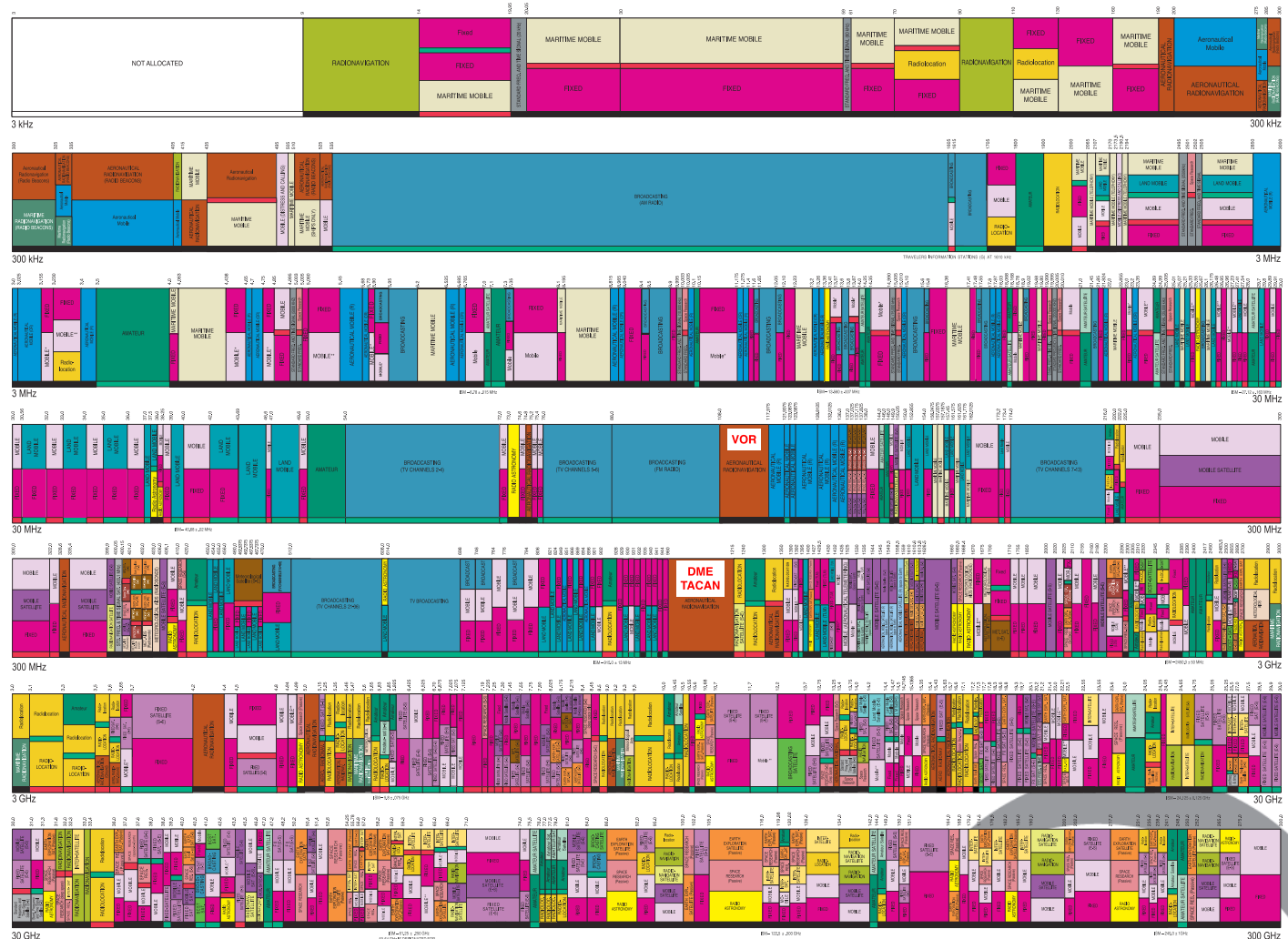

### ACTIVITY CODE


### ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	MOBILE	1st Capital with lower case letters

This chart is a graphic representation of the Table of Frequency Allocations used by the FCC and ICAO. As such, it does not constitute an official FCC or ICAO document. It is intended to provide a visual summary of the Table of Frequency Allocations. For complete information, users should consult the Table to determine the current status of U.S. allocations.

U.S. DEPARTMENT OF COMMERCE  
National Telecommunications and Information Administration  
Office of Spectrum Management  
October 2003



PLEASE NOTE: THE SPATIAL ALLOCATION OF THE SPECTRA IS A GUIDELINE ONLY AND DOES NOT REPRESENT THE ACTUAL ALLOCATION OF SPECTRA TO SERVICES.



# 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**

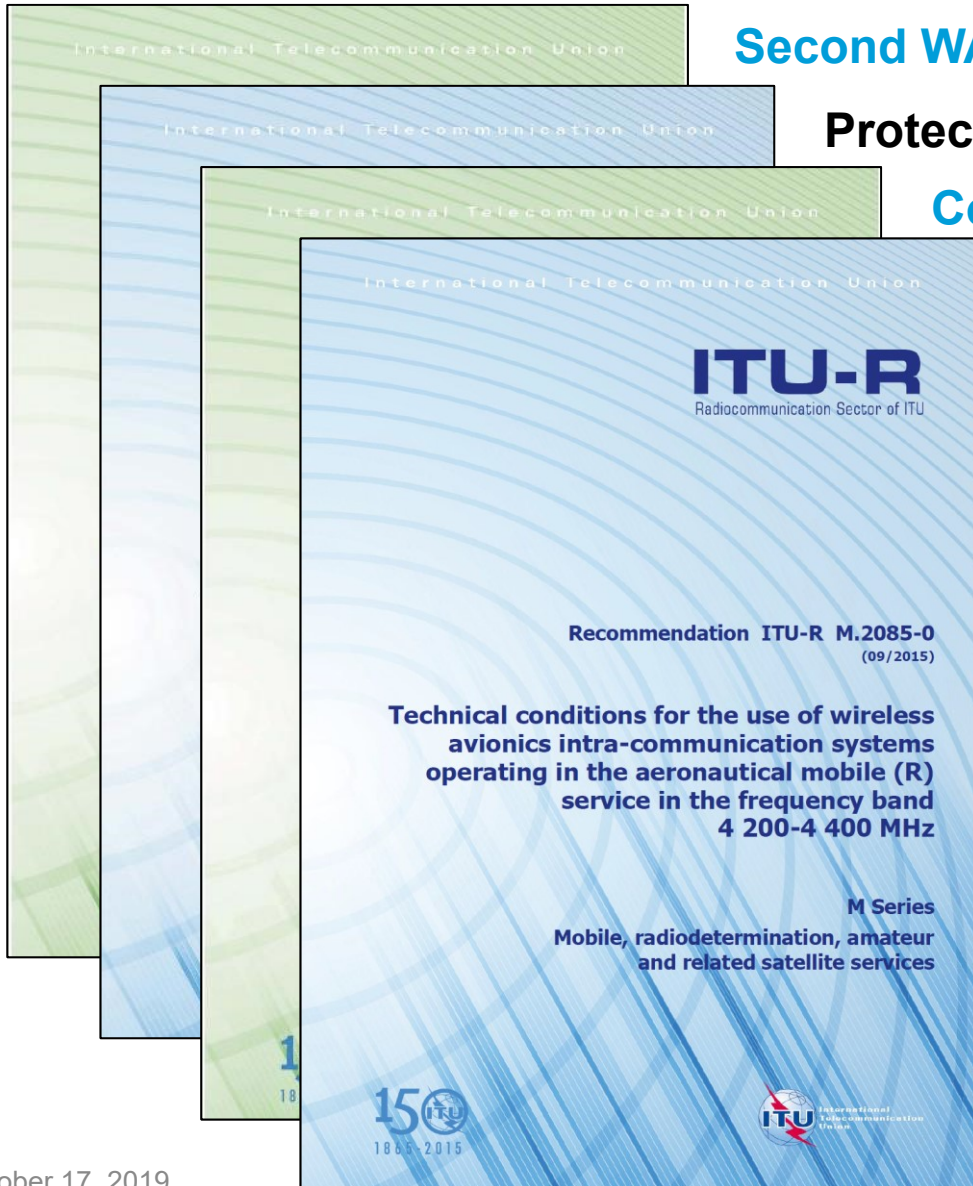
# More Documents

## 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.

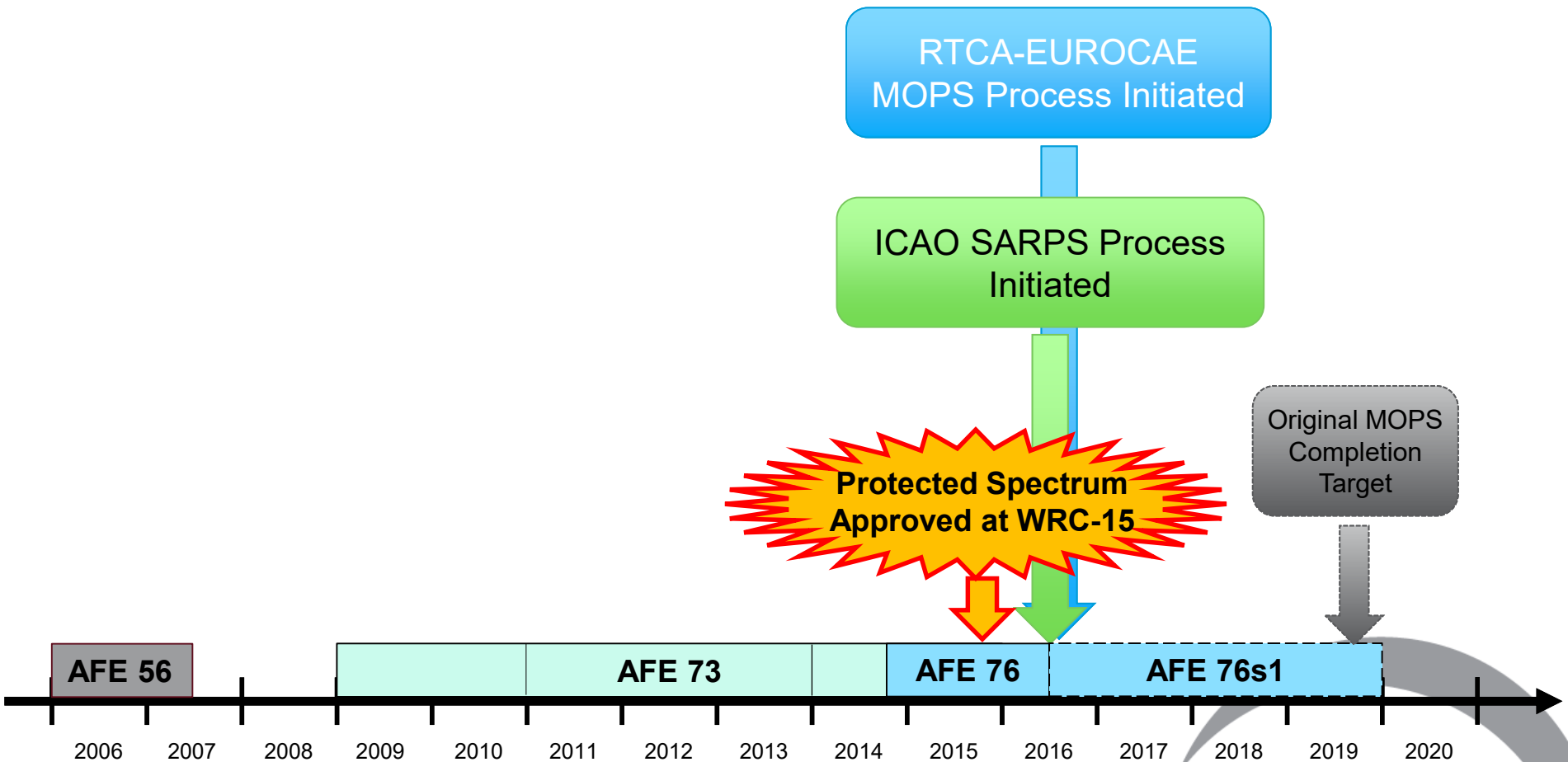
## Key points of the Resolution

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**

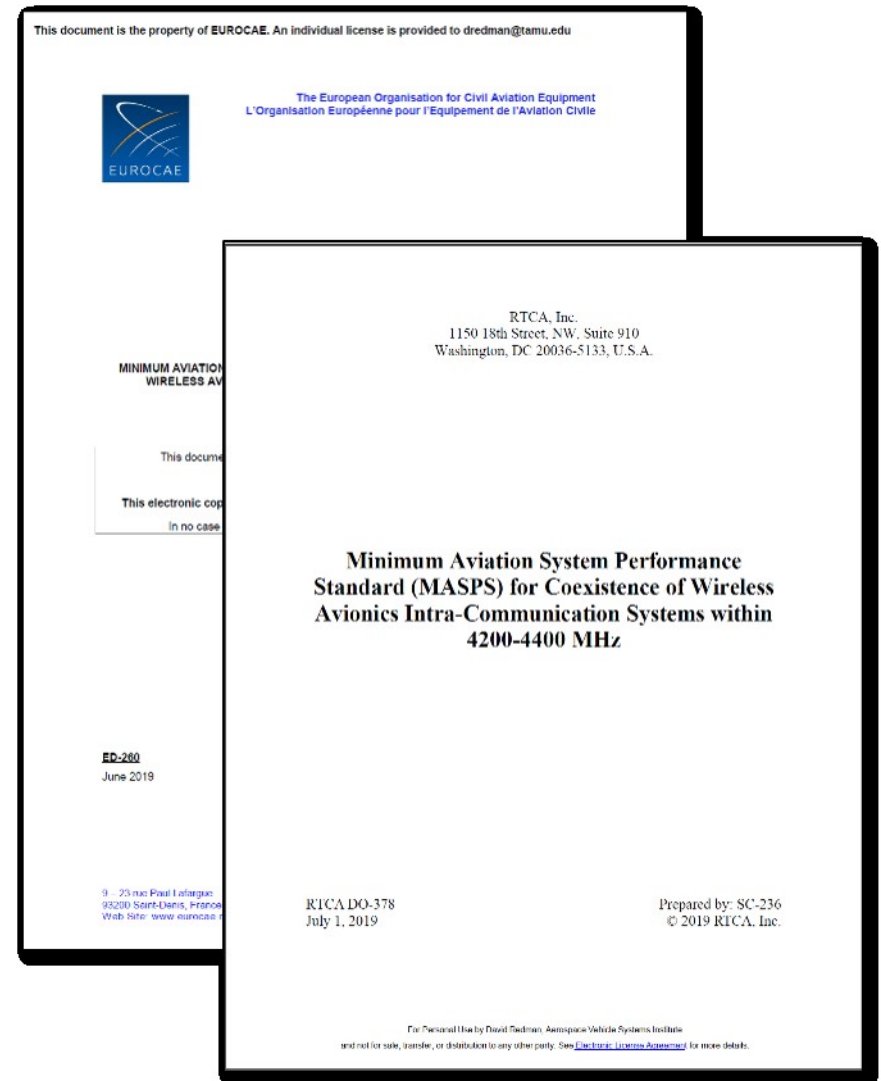
Laboratory Testing  
SARPS Development



# 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





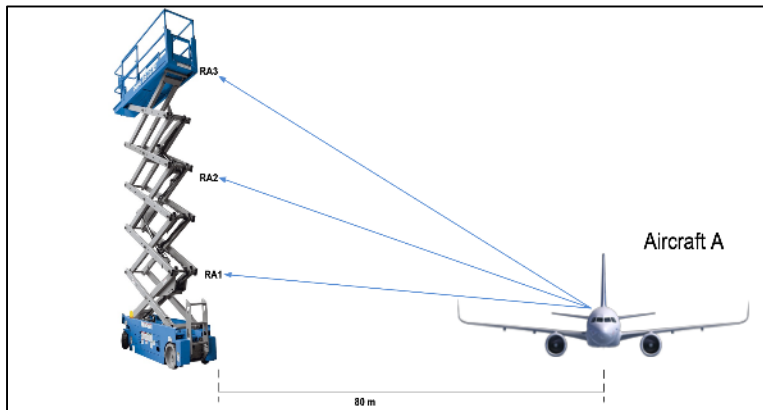
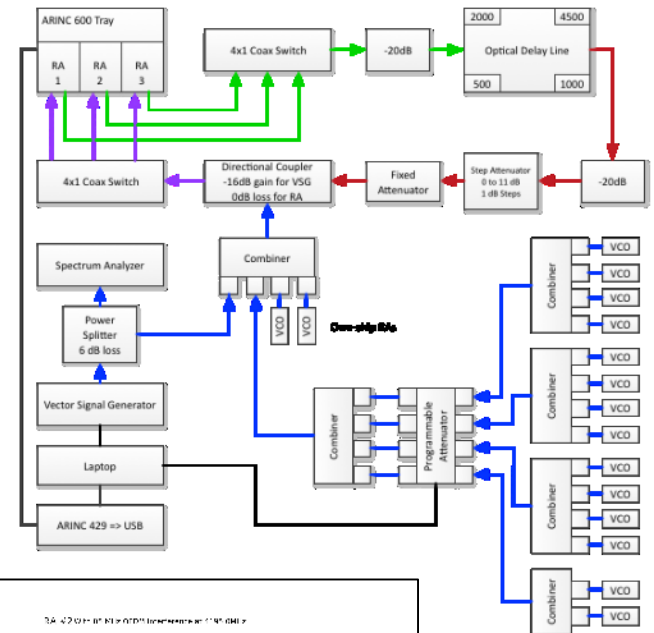
# ICAO (FSMP): WAIC SARPS

- 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.

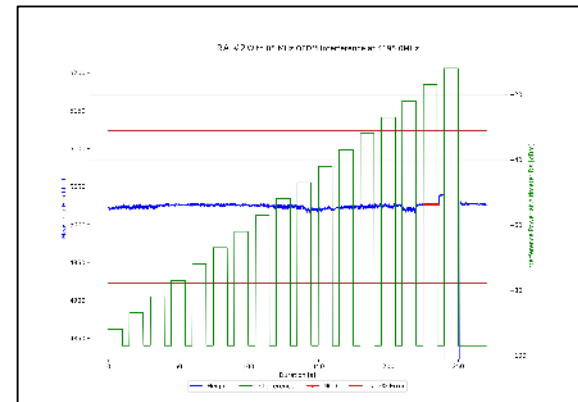
# AVSI: WAIC + RA Testing



Internal  
Propagation  
Measurements



Path loss measurements



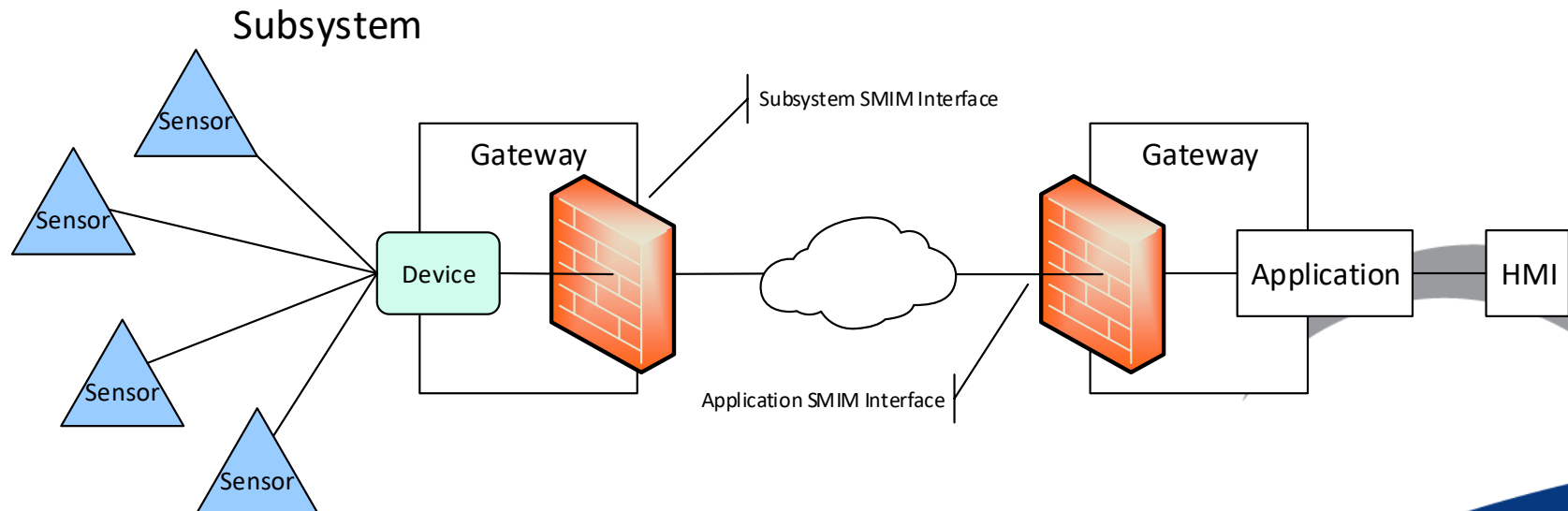
Laboratory interference testing

# ARINC: Security & Interoperability

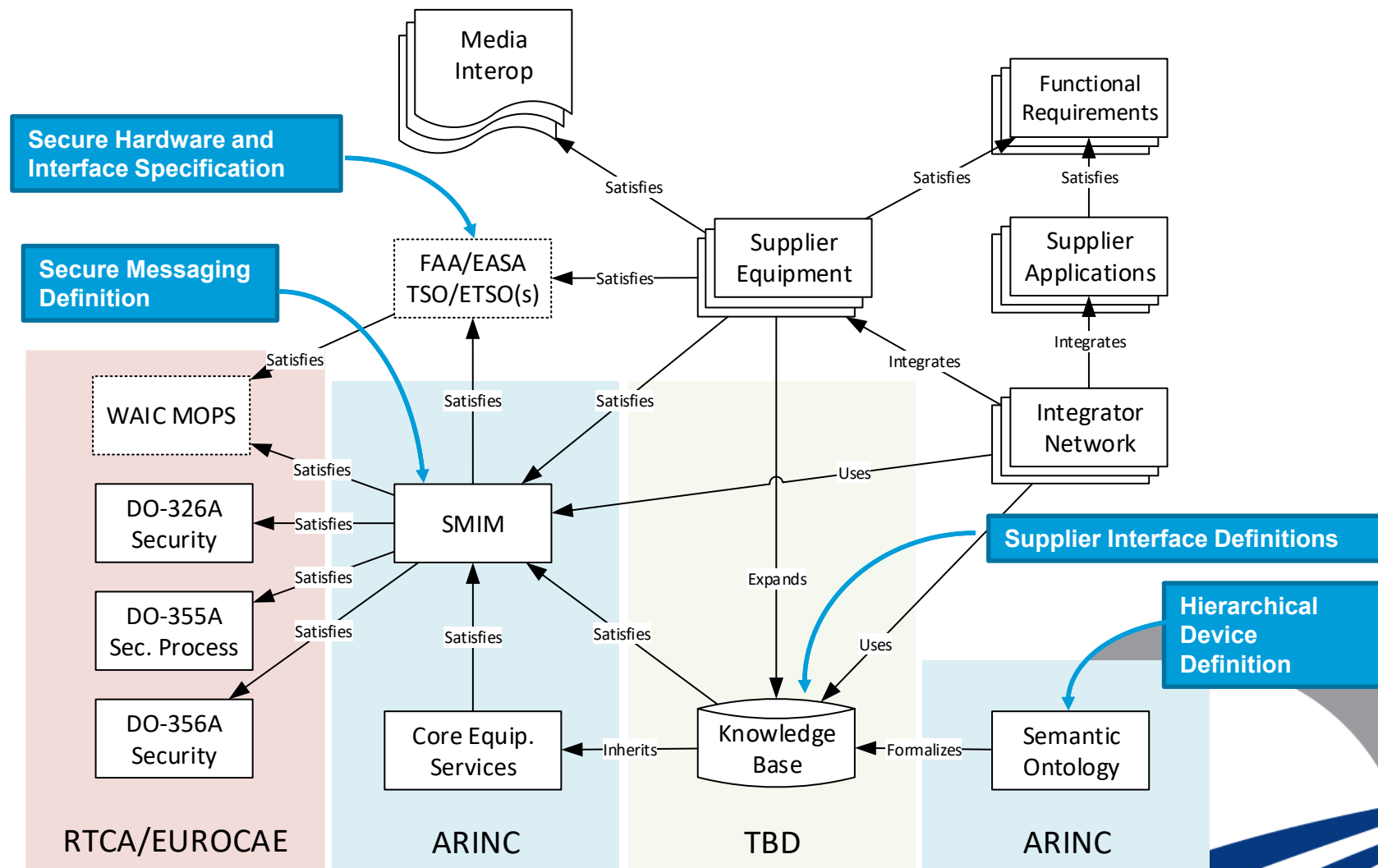
- SC-236/WG-96 defined WAIC requirements specifically to address security vulnerabilities introduced due to the use of wireless media for safety and regularity of flight applications.
- Security-related requirements derived by SC-236/WG-96 are not unique to WAIC.
- Planned FAA/EASA TSO/eTSO from WAIC 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

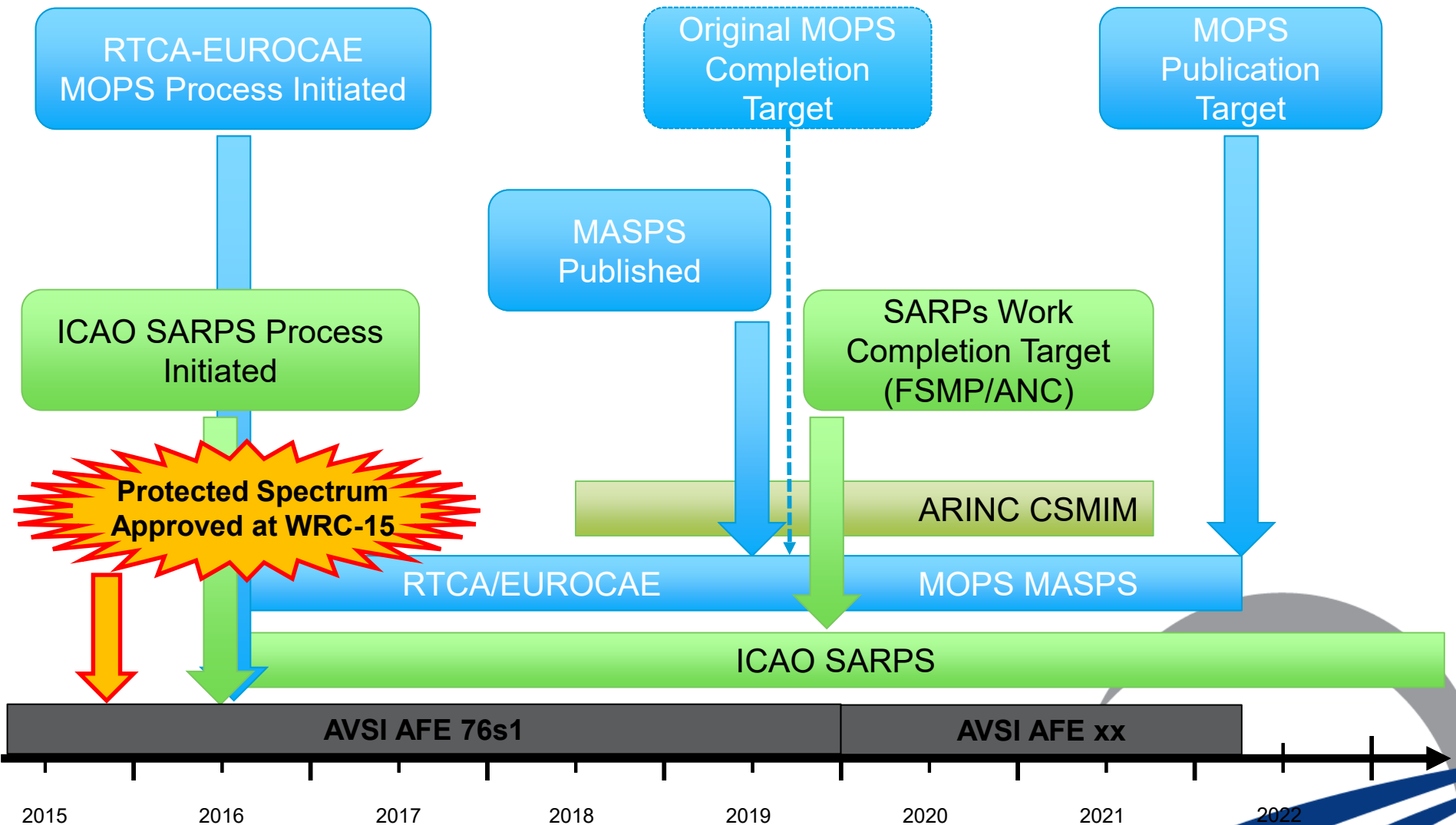
- As defined in WAIC MOPS, TSOed equipment and subsystems will be one of two basic types: Full Security Devices (FSD) and Minimum Security Devices (MSD).
- FSDs include a Trusted Execution Environment (TEE) and a gateway.
- Equipment and subsystems that are not FSDs must be isolated from other equipment 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?
- Dave Redman
  - [dredman@avsi.aero](mailto:dredman@avsi.aero)
  - 979-218-2272
- Steve Rines (SC-236)
  - [Steven.Rines@zii.aero](mailto:Steven.Rines@zii.aero)

