

## IEEE WISEE 2018

WIRELESS AVIONICS INTRA-COMMUNICATIONS (WAIC)

REQUIREMENTS FOR RTCA & ICAO CONSIDERATION

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11-13 December 2018

## WAIC and Aviation: An Acronym-rich Problem Space

- 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 Organisation for Civil Aviation Equipment
  - AVSI – Aerospace Vehicular Systems Institute (Texas A&M)
  - ARINC – Aeronautical Radio, Inc.
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- MASPS – Minimum Aviation System Performance (ICAO)
  - SARPS – Standards and Recommended Practices (ICAO)
  - MOPS – Minimum Operational Performance Standards (RTCA/EUROCAE)

The WAIC MOPS defines WAIC system and equipment characteristics which will be used by the FAA to create Technical Standard Orders (TSO) authorizing manufacturers to build compliant systems and equipment, and Advisory Circulars (AC) which provide guidance for installation and operations.

### FAA Terms of Reference (ToR) Requirements Short List:

- ...the committee shall develop a MOPS for a WAIC component that allows WAIC systems to safely co-exist with Radio Altimeters in the frequency band 4,200 - 4,400 MHz.
- The MOPS will allow WAIC systems to share the band with Radio Altimeters and other WAIC systems such 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 must take into account the key issue of spectrum availability, electromagnetic compatibility, and protection. [including]
  - > Protection of spectrum to ensure the required performances and availability;
  - > Protection of aircraft safety systems against unauthorized access (cybersecurity safeguards).

## WAIC MOPS Definitions

- A **WAIC Radio** is a module that, when combined with a sensor, control or a computing resource, creates a **WAIC Equipment**.
- A **WAIC Network** uses wireless communications to connect two or more WAIC Equipment to accomplish one or more aircraft functions.
- A **WAIC System** is the combination of one or more WAIC Networks on an aircraft.
- Verification of aircraft non-interference must be done to the WAIC System, which is the worst case aggregate emissions from all WAIC networks on an aircraft.

## WAIC at AVSI

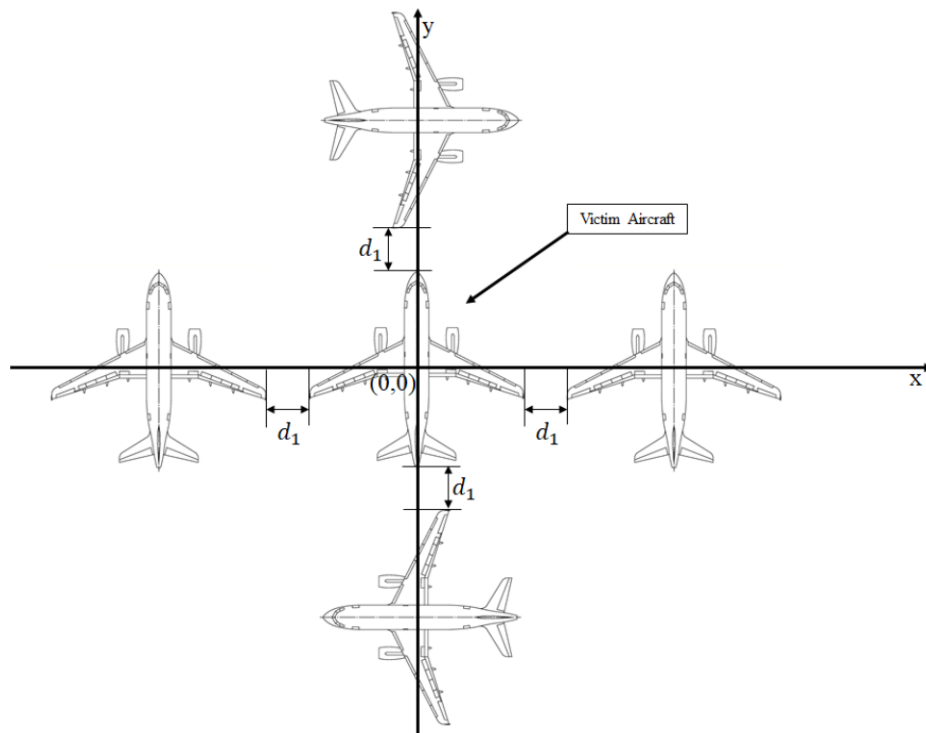
- Radio altimeter testing, SARPs definition and flight testing for WAIC are being performed by the Aerospace Vehicle Systems Institute (AVSI), an aerospace industry research cooperative whose members participate in collaborative applied research projects. AVSI is part of the Texas A&M University System.



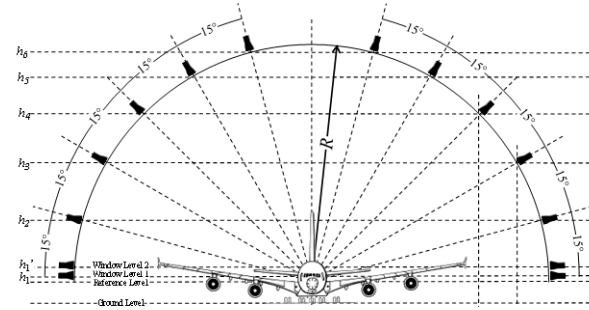
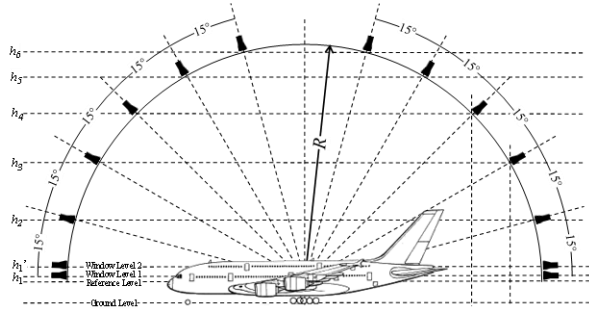
## MASPS and SARPs

- AVSI tested radio altimeters to establish acceptable thresholds for non-interference
- Draft MASPS and SARPs for WAIC systems have been presented to ICAO
- Draft MASPS recommends a WAIC spectral flux power density limit at a fixed distance from aircraft CG to ensure non-interference to other aircraft based on RA susceptibility (WAIC transmit) and aggregate RA from multiple aircraft (WAIC receive)
- Draft MASPS states WAIC devices can be used inside or outside aircraft as long as RF power limit at the defined distance is not exceeded
- Draft SARPS provides a test methodology for proving WAIC non-interference
- A radio altimeter SARPs is still to be developed that will ensure future radio altimeter designs will not affect or be affected by WAIC

# WAIC Potential Interference Model



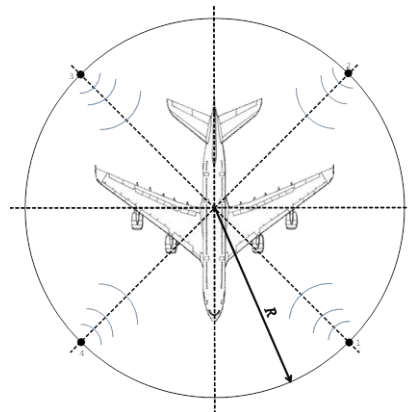
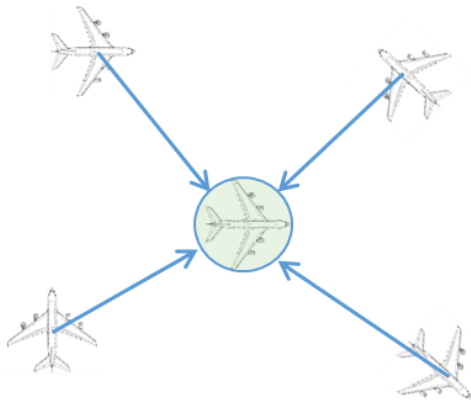
## WAIC Non-interference testing



Non-interference with other aircraft can be verified by measuring that the combined WAIC system power density limit does not exceed TBD [6] dBm/MHz at a distance equal to the fuselage length from the center of the aircraft.



## WAIC Performance Testing



WAIC system performance can be verified by deploying multiple transmitters radiating toward the center of the aircraft (to emulate other aircraft altimeters and WAIC systems) while simultaneously operating own aircraft WAIC systems at maximum capacity.

## Basic WAIC Architectural Considerations

- Because WAIC shares spectrum with radio altimeters, WAIC is designated for use only by functions associated with Safety And Regularity Of Flight (SAROF).
- Every SAROF function delivers information to an associated system or actor responsible for achieving or maintaining SAROF.
- Every WAIC-based function will communicate with a non-WAIC system or actor.
- Every WAIC network will in some fashion be connected to one or more external systems or actors.
- WAIC is a somewhat less reliable alternative to wire.



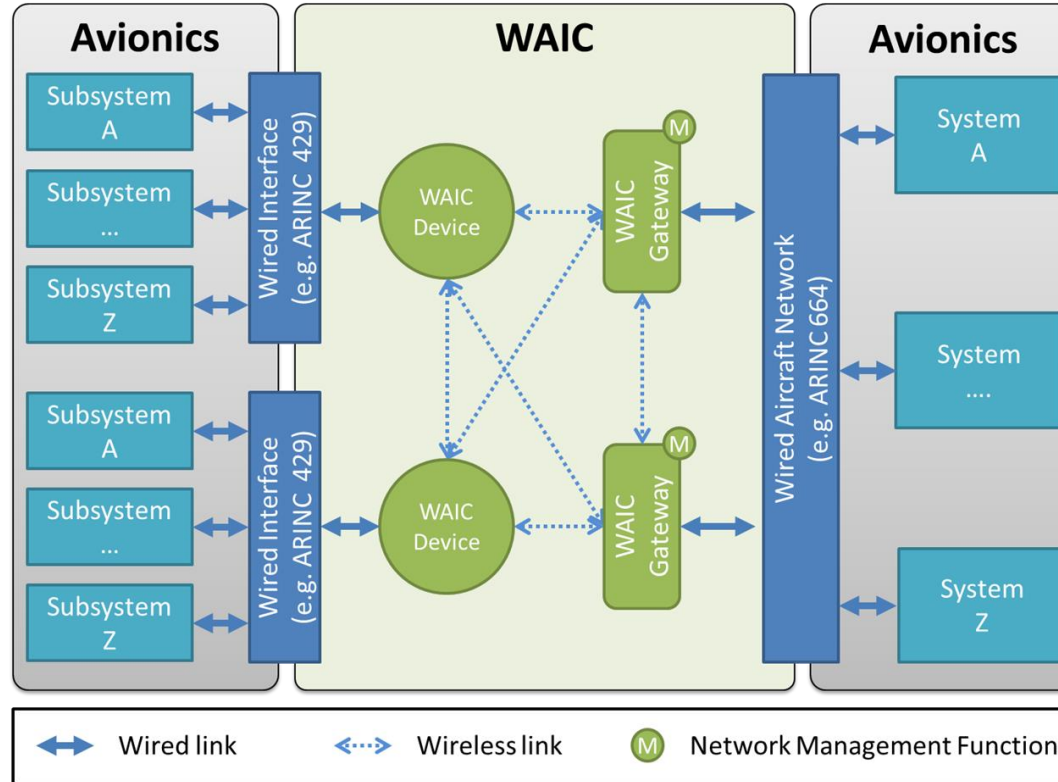
## WAIC Architectural Considerations (cont'd)

- There are no constraints on where WAIC equipment can be mounted inside or outside the aircraft
- There is no MOPS requirement to define equipment, network or application interoperability
- There is today no standard channelization or RF modulation scheme
- WAIC networks may be isolated from one another either physically or electrically
- WAIC spectrum usage must be allocated by the aircraft systems integrator (airframe manufacturer or airline MRO)

## WAIC DAL Considerations

- In some cases WAIC networks will offer a shared wireless media for use by multiple applications.
- Not all WAIC applications will require the same DAL.
- If applications on the same WAIC network are of different DALs then those applications must either
  - > Be commonly protected from WAIC applications of lower DAL; or,
  - > Protect themselves from WAIC applications of lower DAL.
- If WAIC network services are used to prioritize or isolate higher and lower DAL data then WAIC network services must be developed to the highest DAL level of using applications.
- Design Assurance Level (DAL) and Security Assurance Level (SAL) of WAIC Equipment and WAIC Networks can only be established based on a Fault Hazard Assessment (FHA) of the intended aircraft function, which includes information flows through external systems.
- WAIC applications with FHA > Minor may need to establish redundant signal paths based on dissimilar technologies to nullify the unquantifiable probability of intentional WAIC signal disruption.

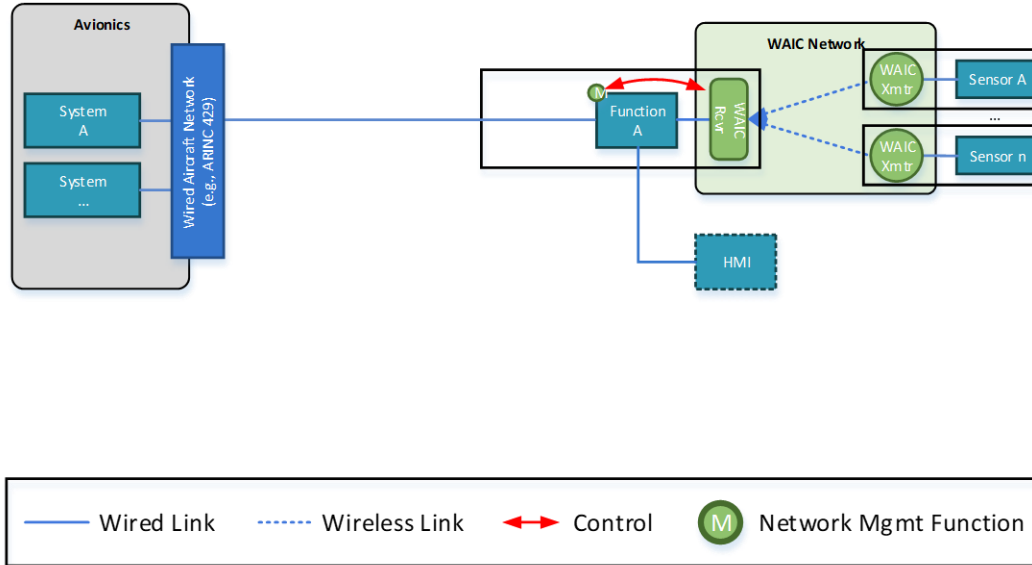
# WAIC Concept Diagram from EUROCAE ED-246 WOBAN



## WAIC Networks Are One of Four Architectural Models

- One-to-one
  - One-to-many
  - Many-to-one
  - Many-to-many
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- An aircraft network backbone would be an example of the many-to-many model.
  - Passive sensor applications will more typically follow the many-to-one model (e.g., tire pressure monitoring)
  - Passive control devices will more typically follow the one-to-many model (e.g., emergency oxygen mask release)
  - Interrogator power levels vs. distance at 4.2 - 4.4 GHz?

# WAIC Standalone Network with Distributed Processing



# WAIC Interoperability Will Be Established in ARINC Characteristics

## ■ Aircraft-specific Semantic Ontology for WAIC and other networks

## ■ Application-to-Application Messaging based on IoT

- > Device interface expressed in JSON and accessible via URI
- > JSON Schema replaces ICDs between aircraft network components
- > Aviation-unique: URIs map information in a fixed aircraft configuration. No Discovery, no Resource Repository, no external access

## ■ Ontological object inheritance with common core services, to include

- > Authentication/Privacy
- > Wireless Data Load
- > Wireless Configuration Management
- > Maintenance Reporting



## Shameless plea for participation in WAIC panel/discussion

On Thursday at 1300, instead of sneaking out early, please consider attending our one hour panel/discussion on:

- Use cases and potential PWST that could use WAIC to expand services for
  - ◆ commercial operations,
  - ◆ Instrumentation
  - ◆ flight test
- Selecting radio technologies and network configurations for PWST to make most efficient use of WAIC
- Design approaches to ensure functional availability of wireless communications in the presence of faults or intentional interference

## Slide title on one or two lines of text

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