



TOWARDS  
**'WIRELESS'**  
AIRCRAFT

# Integration of WAIC Systems into Aircraft

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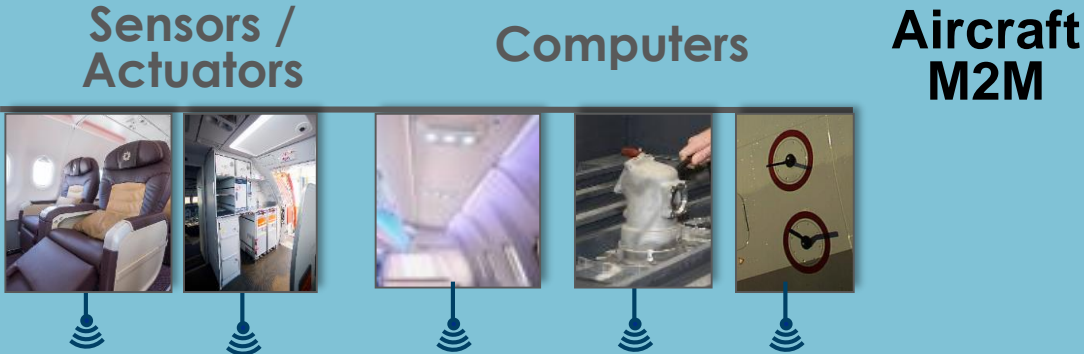
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# Wireless links in aviation

## In-flight Entertainment & PAX Connectivity



60GHz



~~Bluetooth~~

LTE / 5G  
GSM / UMTS



Only in-flight

Light: IrDA,  
VLC, Lifi



~~802.15.4 family~~  
(ZigBee, 6LoWPAN, ..  
ISA/ANSI100)

Vibration  
Waves – Acoustic



Low & High Capacity



# Wireless for machine to machine communications



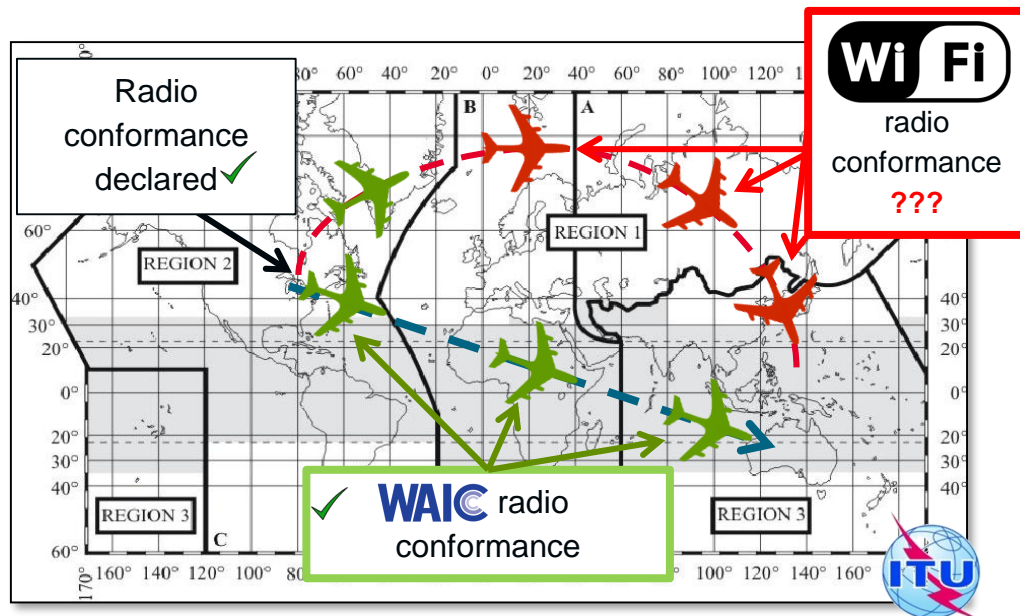
## Challenges for wireless communications

- Performance
- Interference (e.g. with PAX and IFEC equipment)
- Telecom regulations

## Criteria to use wireless for M2M:

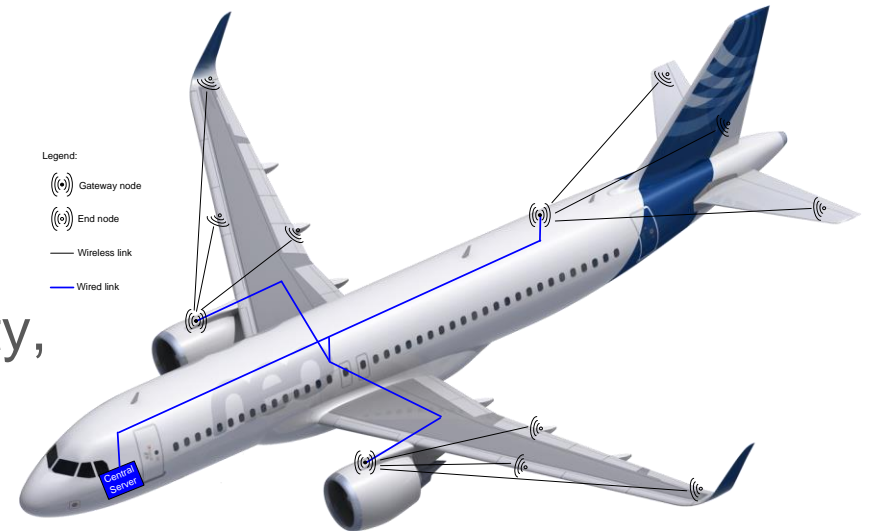
- Guaranteed Performance (QoS)
- Global certification standard (WAIC DO-XXX)
- Internationally harmonized telecom regulations
- Usage for aviation only
  - No competition with COTS supplier

→ supporting safety critical aircraft functions

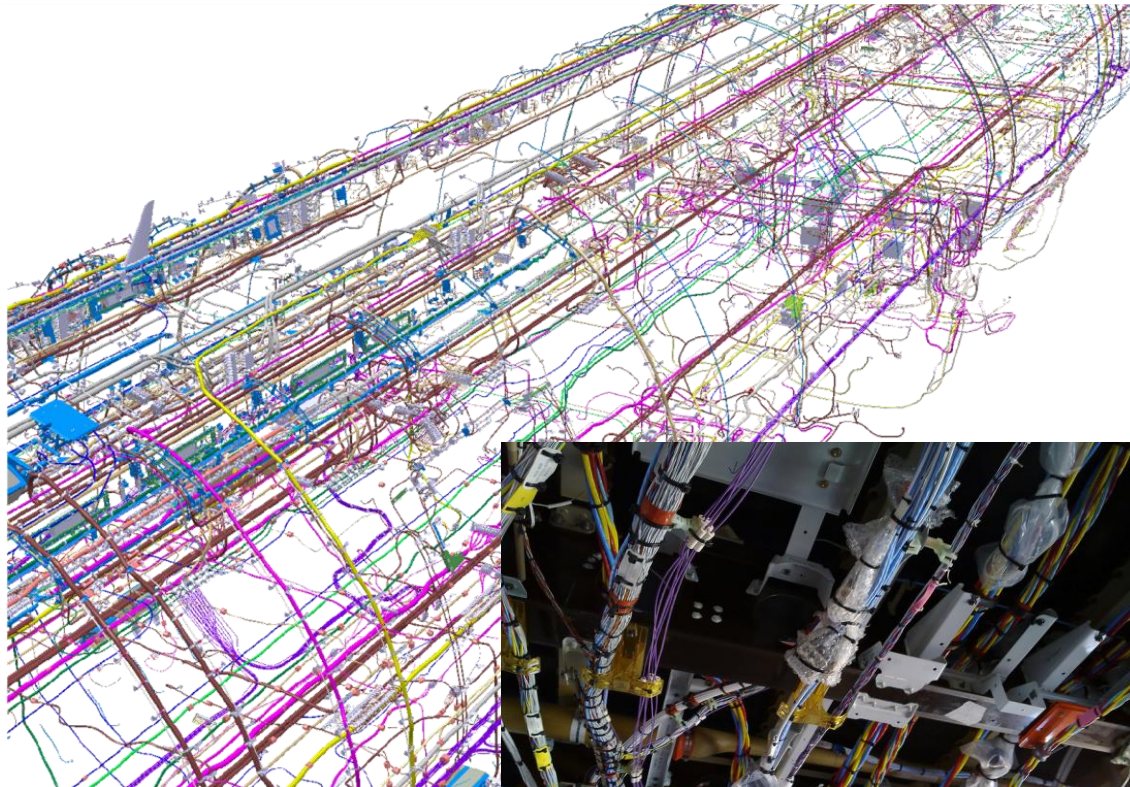


# Examples of potential WAIC applications

- **Sensors:** (autonomy required)  
cabin pressure, smoke detection, fuel tank/line, proximity, temperature, ice detection, landing gear (position feedback, brake temperature, tire pressure, wheel speed), flight controls position feedback, engine sensors and prognostics, air data, structural health monitoring, humidity/corrosion detection, removable cabin inventory
- **Actuators:**  
emergency lighting, cabin functions (illumination, signs, oxygen system, seat actuators...)
- **Communications:**  
FADEC-to-aircraft interface, flight deck and cabin crew audio/data, flight deck and cabin crew video/imagery, avionics communications bus

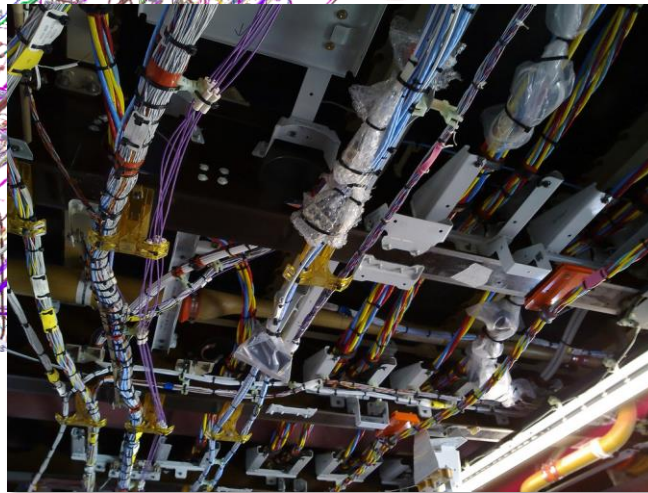


# Industry Motivation



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Typical electrical harness  
installation in modern aircraft



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## **WAIC is expected to provide...**

- ... weight saving.
- ... reduce system installation complexity.
- ... improved system reconfigurability.
- ... reduced system retrofit efforts.
- ... dissimilar redundancy.
- ... opportunities for new functionalities.
- ... enable new data collection functions

# RF Propagation & coexisting to RA and other WAIC A/C

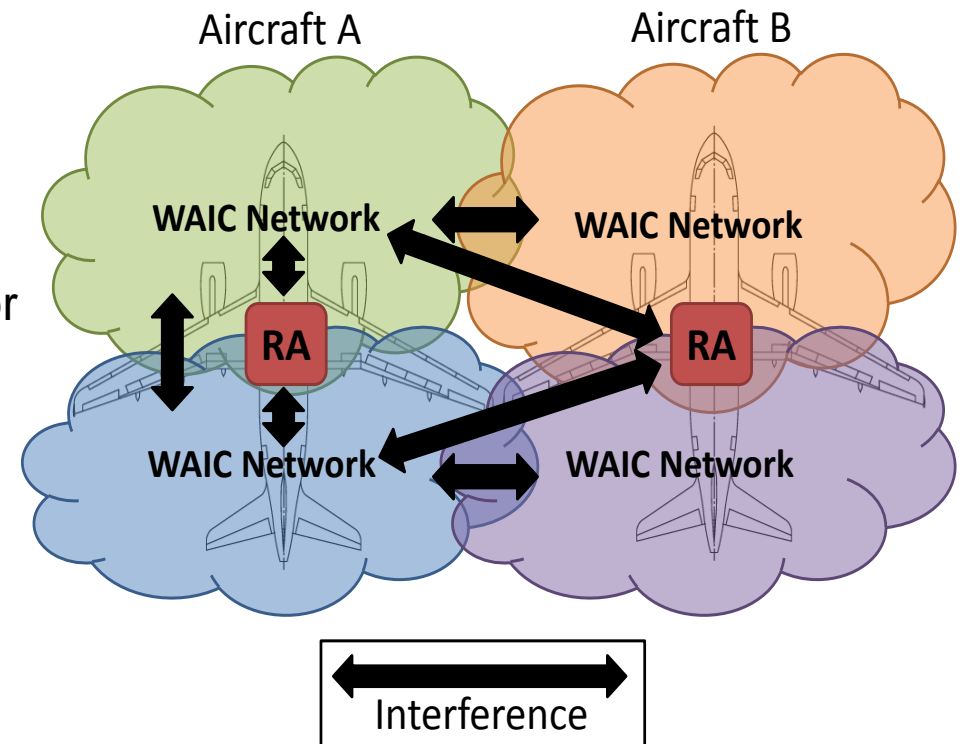
Problem: How to ensure sufficient Quality of Service for all application in one airplane?

WAIC / Wireless is shared media:

- WAIC and Radio Altimeter (RA) must coexist (4.2-4.4GHz)
- Integration, configuration, performance is dependent of neighbor systems (in my & neighbor A/C)
- Worst case scenario is on Gate (A/C has closest proximity)

Proposals:

- Measure / simulate radio frequency behavior for worst case
- Consider ICAO MOPS / SARPS
- Consider what already has been installed (Wireless, Type of RA)
- Design protocol, schedule and coexisting appropriate



ICAO (International Civil Aviation Organization)  
MOPS (Minimum Operational Performance Standard)  
SARPS (Standards and Recommended Practices)  
RA (Radio Altimeter)

# Simulation for validation and verification

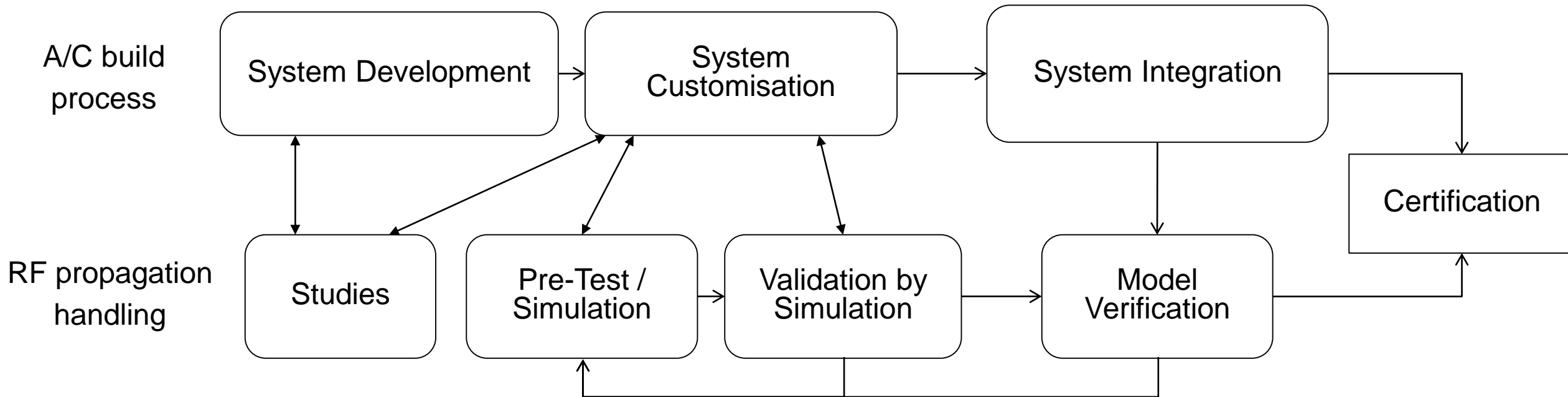
Problem: How to ensure that the A/C RF behavior will be as specified?

→ especial for highly customized areas

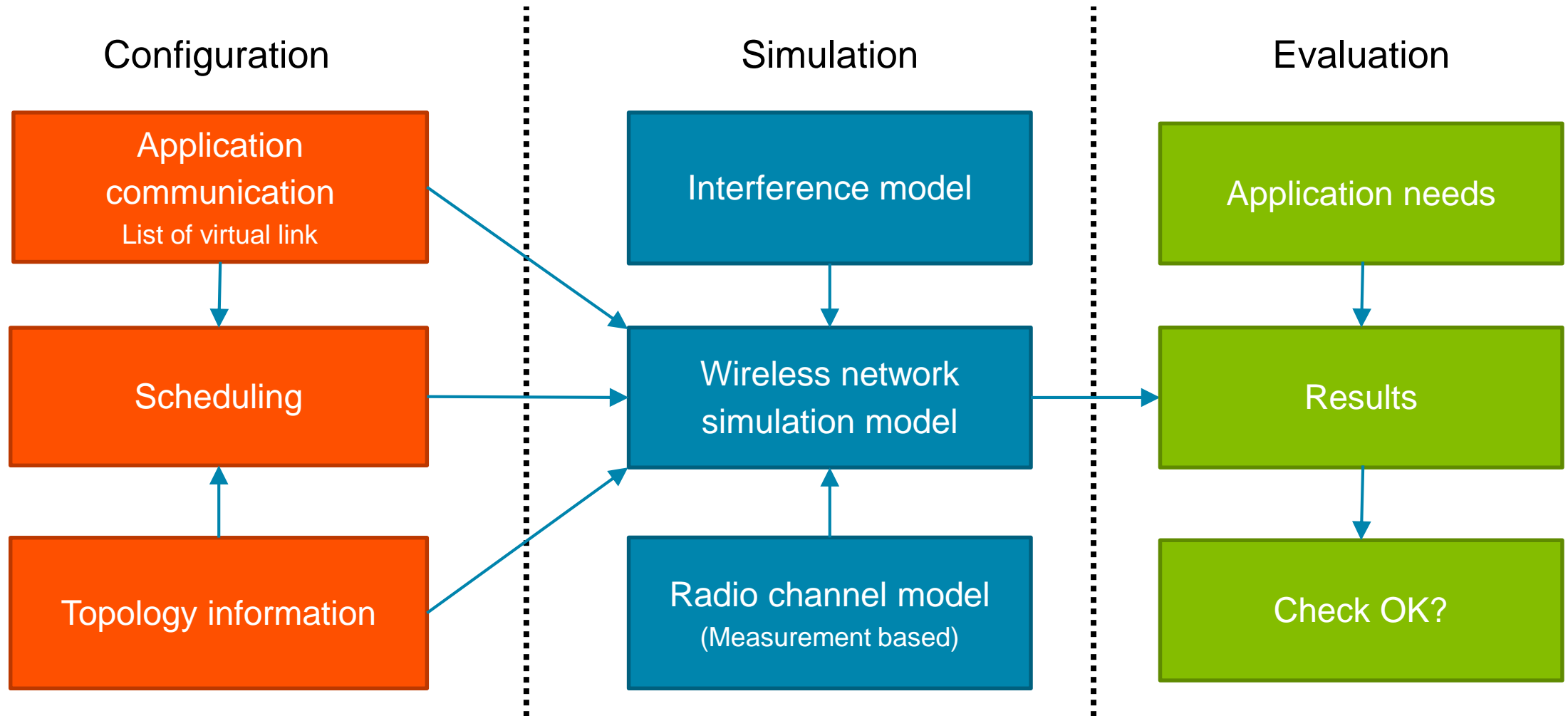
Proposals:

A. Build the A/C, measure and pray!!

B. Simulate before build to A/C → A precise model is required



## Example for Simulation



# Certification aspects: Health

Problem: Will we get an crew or passenger health issue?

- Health: Use of ICNIRP “Guidelines for limiting Exposure to time-varying electric, magnetic and electromagnetic Fields” consider
  - multiple equipment factors
  - distance to humans
  - 10..50mW max for single WAIC transmitter

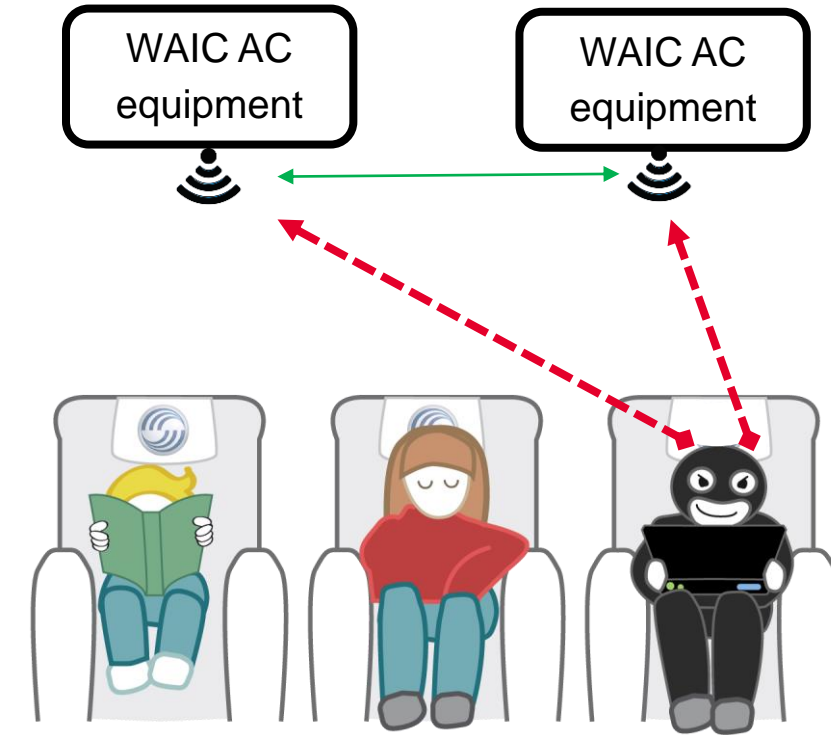


**Usage of high power passive sensors or power transfer techniques  
must consider the health impact**

# Certification aspects: Security

Problem: How to protect A/C systems from security threats?

- Perform security risk analysis on end-to-end threats driving the architecture & integration of WAIC
- Provide defence-in-depth with multiple security barriers (e.g. cryptographic protection of WAIC, firewalls, validity checks, ...)
- Perform security V&V (incl. penetration testing)
- Manage security in operation
  - Guidance material on securely operating and maintaining WAIC
  - Threat monitoring and management
  - Revise design, implementation, and procedures when needed



# Certification aspects: Jamming

Problem: What will happen if jamming occurs?

- Non Intentional → treated as “classical” EMC / EMI
- Intentional → Security threat
  - Has to be considered in system design (like a broken wire), install detectors, inform the crew
- Jamming is considered as security threat



**Effective methods for jamming resistance / monitoring required**

**Usage of high power passive sensors or power transfer techniques  
must consider the EMI / EMC impact**

# Configuration (System, Equipment)

Problem: How to configure a system / equipment when you produce hundreds of A/C?

Assign a location & function

- A. Pre-configure the system / equipment's
  - Software & configuration installation before A/C assembly
  - Requires a precise part number handling
- B. Use of automated means
  - Provide a functional identification number to the equipment's (when equipment is installed)
  - Use of auto config & installation means for software

Example Rotary Coding Switches

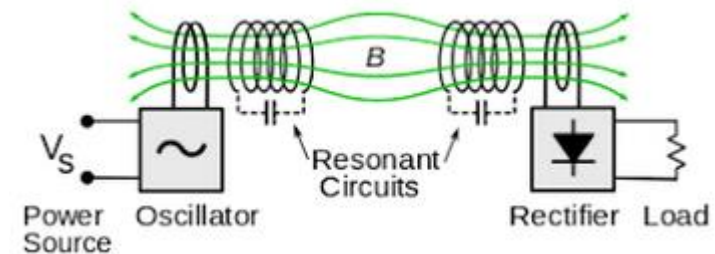
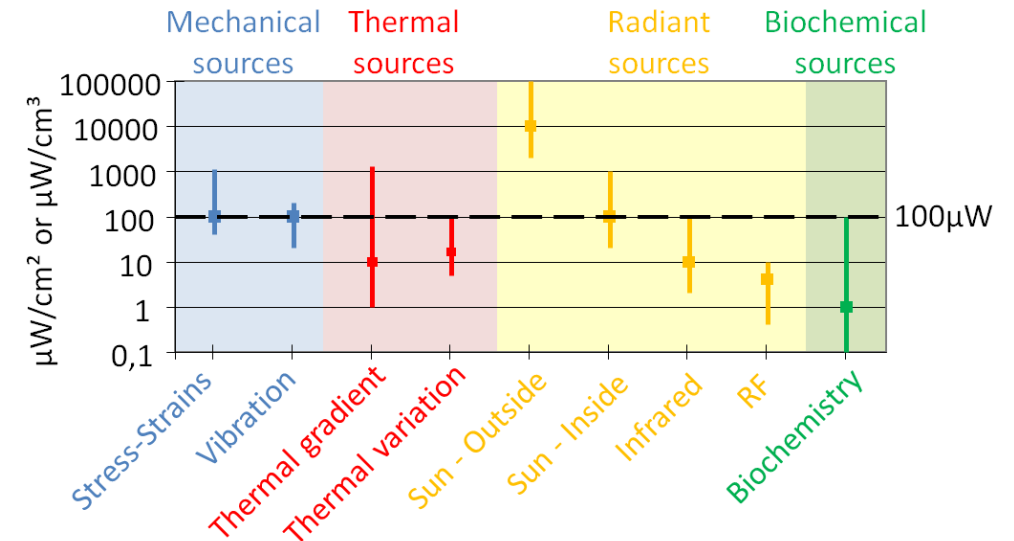


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# System / Autonomy

- Energy Harvesting:
  - Energy source very depending of the application (one doesn't fits all)
  - Ambient sources is not always available could have impact to operation
- Batterie:
  - Environmental challenges
  - life time
- Power transmission:
  - ?



Requires future research

# Summary

- WAIC standardization is running – finalisation expected for begin of 2019
- Many attractive applications are foreseen
- Some industrialisation aspects are new for aviation (STC & A/C manufactures)
- Key challenges are:
  - Interdependency to other wireless systems (WAIC and RA)
  - Security including jamming
  - Availability of WAIC components (transceiver, filters, antennas)
  - Continuous power supplies for autonomous operation
  - Huge number of wireless devices

STC      (Secondary Type Certification)  
RA      (Radio Altimeters)

Thank you

# Introduction to WAIC

## Prerequisites for implementation of WAIC

Globally available radio frequency spectrum  
Protection from harmful interference  
Slim and practical radio transmitter licensing process

Internationally harmonized regulations through World  
Radiocommunication Conference (WRC) Decision  
→ ITU, ICAO



**Industry initiative formed in 2007 to jointly foster development of harmonized regulations for wireless communications for safety-related aircraft functions (aka WAIC)**

ITU (International Telecommunication Union), ICAO (International Civil Aviation Organization) → United Nations Specialized Agencies

