Certifiable Wireless Data Buses

Vic Thomas
vic.thomas@honeywell.com
Honeywell Labs

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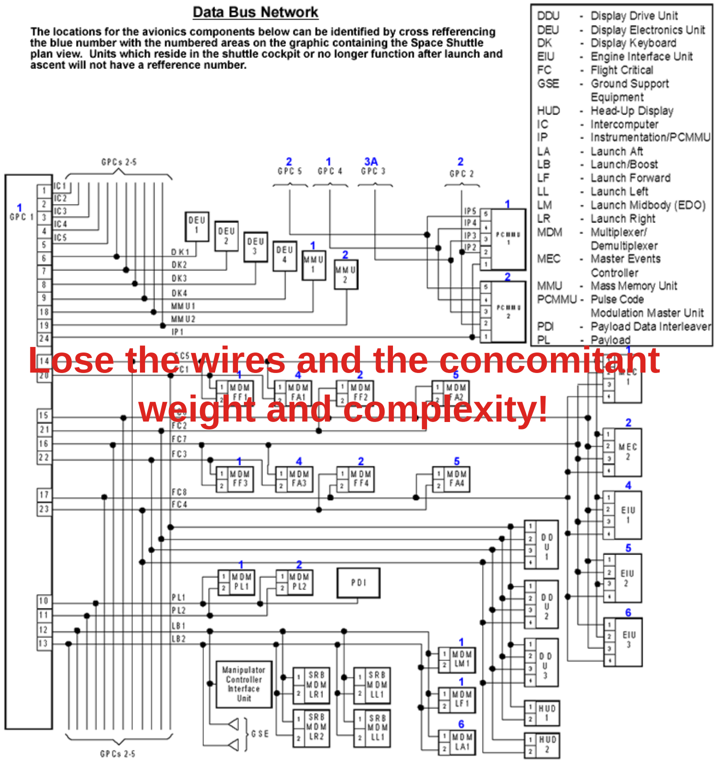
- Objective: Replace wired avionics data buses with wireless data buses
  - Can we replace a wired bus such as ARINC 629 with a wireless equivalent?

- Rationale:
  - Reduced weight
    - Translates to lower fuel costs
  - Ease of re-configurability of aircraft
  - Lower installation and maintenance costs



Data Bus Network

The locations for the avionics components below can be identified by cross refferencing the blue number with the numbered areas on the graphic containing the Space Shuttle plan view. Units which reside in the shuttle cockpit or no longer function after launch and ascent will not have a refference number.

DDU	-	Display Drive Unit
DEU	-	Display Electronics Unit
DK	-	Display Keyboard
EIU	-	Engine Interface Unit
FC	-	Flight Critical
GSE	-	Ground Support Equipment
HUD	-	Head-Up Display
IC	-	Intercomputer
IP	-	Instrumentation/PCMMU
LA	-	Launch Aft
LB	-	Launch/Boost
LF	-	Launch Forward
LL	-	Launch Left
LM	-	Launch Midbody (EDO)
LR	-	Launch Right
MDM	-	Multiplexer/ Demultiplexer
MEC	-	Master Events Controller
MMU	-	Mass Memory Unit
PCMMU	-	Pulse Code Modulation Master Unit
PDI	-	Payload Data Interleaver
PL	-	Payload

Lose the wires and the concomitant weight and complexity!

Wireless Data Buses on Aircraft: State of the Practice

- **Wireless data buses are being used for**
  - **Cabin entertainment systems**
    - Reduces cost associated with changing seat pitch, seasonal changes in configuration (number of 1st class seats)
  - **Lavatory smoke detectors**
    - Today airplanes have superfluous wiring to accommodate different configurations used by different airlines
  - **Cargo hold smoke detectors**
  - **Emergency lighting system**

All wireless data buses used today are for non-critical applications

CTQs for Wireless Data Buses for Critical Functions

- Reliability
- Availability
- Data integrity
- Determinism
  - Bounded delivery times, low jitter
- Security
  - Low susceptibility to denial-of-service attacks (jamming)
  - Authenticated messages
  - Encryption?
- Non-interference
  - Must not interfere with existing radios and avionics
- Bandwidth
  - Provide bandwidth comparable to modern wired data buses
- Certifiable
  - Convince appropriate authorities that system meets above properties

Challenges

- **Certification is the biggest challenge**
- **Requirements are not well understood**
  - **E.g.: “How much” jamming resilience is required?**
    - How is this specified?
    - How “jamming resistant” are today’s avionics when personal radios are not allowed on board
- **Lack of a good understanding of the faults suffered by wireless networks**
- **Current certification processes may inadequate**
  - **Limited to understanding the effects of on-board wireless systems on existing radios and avionics**
- **Where in the RF spectrum should these networks operate?**
  - **The only globally available frequency band is the 2.4 GHz ISM band**
- **Requires a change in the mind-set of the certification authorities**
  - **Knee-jerk reaction is to reject anything wireless as being inherently un-certifiable**

Designing a Wireless Data Bus

- Given any dependability and security requirements it is possible to design a wireless data bus that meets those requirements
  - Must have sufficient spectrum available

Commonly Used Techniques for Dependability and Security

- A combination of techniques will be needed to meet dependability, determinism and security requirements
- Different techniques provide tolerance for different kinds of faults and are implemented at different layers of the protocol stack

Techniques for Jamming Resistance

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- **Spread spectrum techniques**
  - **Spread energy over larger part of the spectrum**
  - **Frequency hopping and Direct Sequence Pseudo Noise are commonly used**
    - Time Hop and Transform Domain spread spectrum techniques less common
- **Typically use combination of techniques**
  - **Frequency hopping + direct sequence**
    - Permits use of widely spaced bands (hop among bands and spread energy within band)
- **For additional protection, send same bit(s) over multiple frequency hops**
  - **Keeps a narrow-band jammer from taking out a part of the communication**
- **For Frequency Hopping, hopping sequence must not be guessable**
  - **Cryptographic techniques**
    - Can’t guess seed of random number generator by observing generated numbers
  - **Re-seed all random number generators during scheduled maintenance**

Techniques for Reliability, Determinism and Security

- Physical/Link layer
  - Bits transmitted over multiple frequency hops
  - Determinism
    - Build on deterministic MAC technology developed by Honeywell
- Network layer: At least N independent pre-computed routes between any two nodes
  - Tolerates failures on nodes
  - Build on Honeywell ACS routing protocol that guarantees two independent routes between a data source and a data sink
- Application layer: Control applications that can tolerate delayed or lost messages
- Security
  - Needed for authentication and possibly encryption
    - Build on Beep-Beep embedded encryption algorithm developed by Honeywell
  - Aircraft wide-key, changed during scheduled maintenance

Spectrum Considerations

- Availability of spectrum that can be used world-wide is a problem
- Option 1: Work in the 2.4 GHz unlicensed band
  - Very crowded with consumer electronic devices
- Option 2: Petition ITU for new spectrum allocation
  - Very difficult and time-consuming process
- Option 2: Reassign unused spectrum already allocated for Aeronautical use
  - E.g. Microwave Landing Systems (MLS)
    - MLS systems are being made obsolete by GPS precision landing systems
  - Other promising portions of the RF spectrum have been identified

Reliability Advantages of Wireless

- **Wireless data buses will be more tolerant of certain faults commonly suffered by wired data buses**
  - **Loose cable connections**
    - Most common cause of network failure
  - **EMP**
    - Easier to design EMP protection for wireless data buses

Phased Approach to Deploying Wireless Data Buses

- Wireless data bus as a backup to a wired data bus
  - Will help gain experience with the use of wireless for essential functions
- Replace segments of a wired data bus with a wireless data bus
  - Use wireless in areas where network reconfiguration would be required when aircraft is reconfigured
  - Use wireless in places hard to reach with wiring
- All wireless systems

It's only a matter of time before we see wireless network based critical avionics systems.