Model Based Testing of Avionics

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Avionics I have known

Rolls Royce Trent 700
Airbus A400M
Boeing 767
Airbus A330
BMW/Rolls Royce BR710
Airbus A380
Avionics = Computer + Other

- Avionics not just a computer – hybrid with other electrical/electronics
- Hard to differentiate avionics from the aircraft system
How are Avionics Special?

• High cost of failure
• Operate in hostile environments
• High reliability
Reliability

• **Availability** (does what we want)

• **Integrity** (doesn’t do what we don’t want)
Avionics Software Growth

- F-4A (1958) - 1000 lines-of-code
- F/A-18 (1978) – 1 million lines-of-code
- F-22 (1997) - 1.7 million lines-of-code
- F-35 (2006) - 8 million lines-of-code
Auto v Aero

10’s million loc*

* Terms and conditions apply
Aircraft Flight Test

- $10k’s per flight
Aircraft Flight Test

~10 deaths per decade

Gulfstream G650, 2011

Airbus A400M, 2015
Boeing 767 Production Flight Test
Ground Testing

“Iron bird” rigs:
• Avionics
• Hydraulics
• Electricals
• Pneumatic
“Lab” Testing

- e.g. Fuel Systems Test, Bristol UK
- Organisation to test and integrate Fuel System & avionics
- Sister department tests Landing Gear
Avionics Testing

Why?

• *Nothing* works first time
• Need lab testing for Flight Test certification

How?

• Simulate all mechanicals in software
• Simulate all interface devices electronically
Avionics evolution: A330-A380

- “Federated”
- 100’s of signals

- “Integrated”
- 10,000’s of signals
A380 Fuel Avionics SIB

- Interface verification
- 95% of tests for reversionary modes
- SIB functionality expanded with avionics updates
SIB evolution for A380

• Scaling, scaling, scaling
• More sophisticated avionics demanded more accurate models
• State-space explosion demanded more comprehensive models
Fuel Avionics Automated Testing

- Scripted or semi-scripted
- In fuel, need to support 1-12 hour test runs
- Automatic logging of results & data
Model Development

- **1-250 millisecond** iteration periods typical
- *Simulink* for models
- Use of COTS libraries (e.g. SimPowerSystems) often replaced with proprietary solutions (e.g. WrightSolver™)
- **C S-functions** for appropriate functions and legacy code
- Auto-generation of ~500,000 loc
Model Deployment

- **VxWorks** for real-time execution
- **Windows** for user interfaces
- **PowerPc/VME** for model execution and IO
- **C++** distributed real-time middleware (*in-house*)
- **Tcl/Tk & Java** for UI development
- **Tcl** for test execution
- Much commonality between aircraft rigs (~80%)
SIB Architecture

- Windows user interface
- Distributed real-time middleware (*in-house*)
- VME model execution
- VME IO
- Some proprietary IO (e.g. capacitance emulation)
A380 Avionics Rig Failure
A380 Avionics Rig Failure
Where next?

• Virtualised testing (i.e. iteration or cycle accurate)
  • Low cost COTS hardware & software (obsolescence?)

• Formal test construction?
In conclusion

- Avionics test is needed for cost, time, and certification reasons
- Has a need for flexibility and expandability
- The future is more software: IO, virtualisation, automated test...
Questions?