Final presentation

Ultra-Wideband as a Multi-Purpose Robust and Reliable Wireless Technology for Testing, Spacecraft and Launcher Communications

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Honeywell

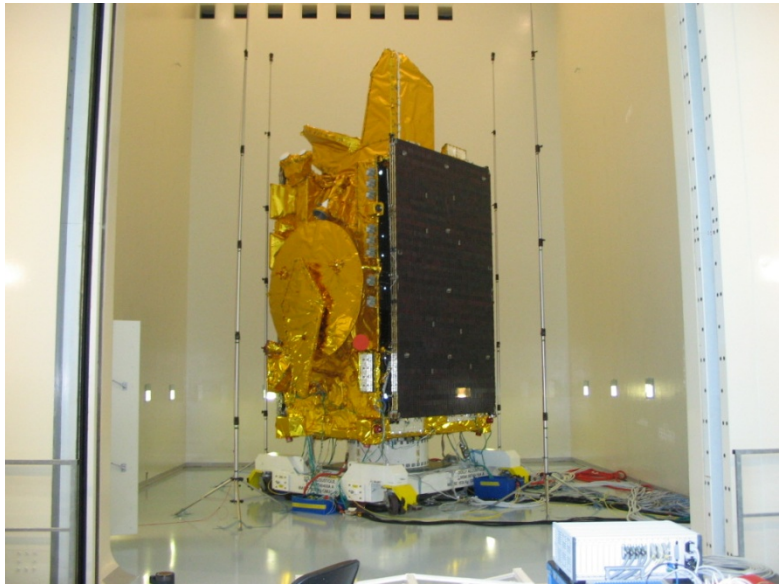
UWB demonstrator

- Goal:
  - Assessment of IR-UWB suitability for space applications and development of reliable and deterministic network demonstrator

- Project phases:
  - 1) Use case identification and requirements capture
  - 2) Analyzes of technology candidates (PHY and protocol stack)
  - 3) Simulations
  - 4) Demonstrator development
  - 5) Measurement and testing

Use cases considered

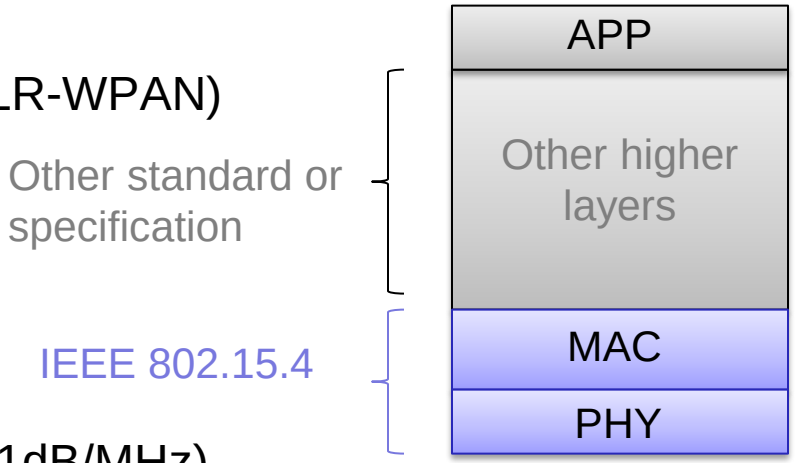
- **AIT sensor network**
  - Thermal testing
  - Vibration testing



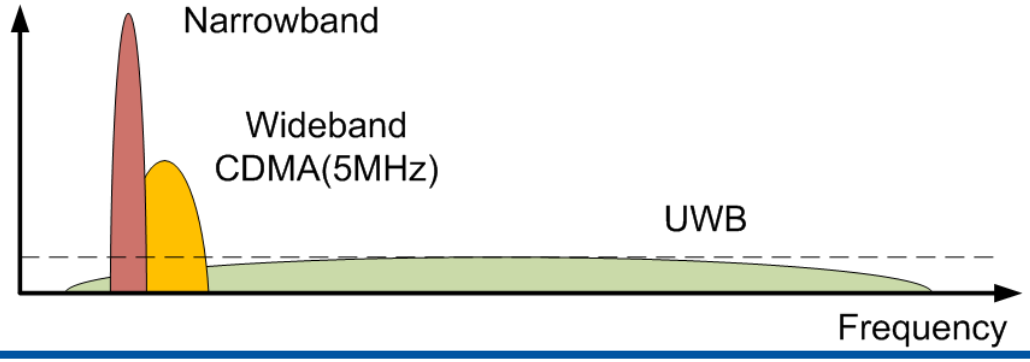
- **Onboard sensor network**
  - Housekeeping subsystem
  - Navigation subsystem
- **Command and Control**
  - Highly reliable with high throughput
- **Inter-stage wireless link for launchers**
  - Challenge of stages connectivity without LOS

IR-UWB technology overview

- Alternative PHY of IEEE 802.15.4
  - Low power, low rate wireless PAN (LR-WPAN)
  - Covering PHY and MAC layer



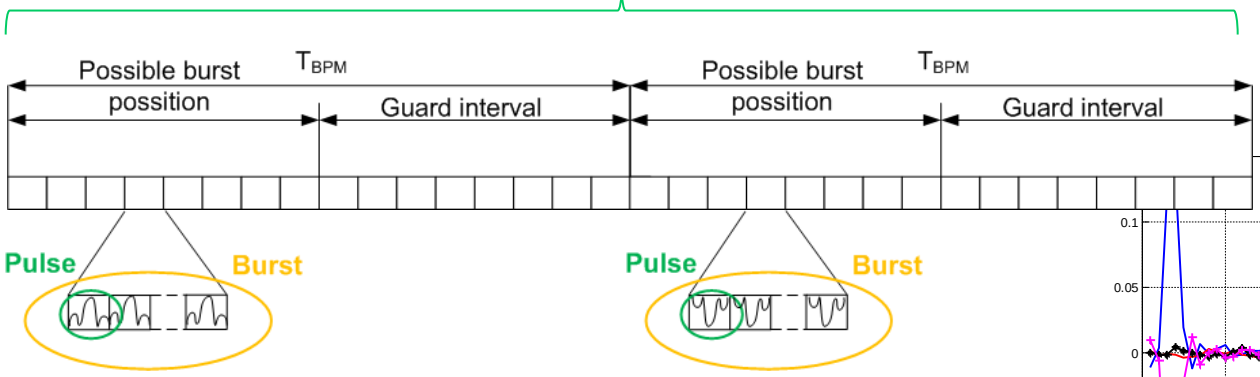
- Advantages
  - Low power, low energy emission (-41dB/MHz)
  - High data rate (up to 27 Mbps) – 6.8Mbps
  - Lower vulnerability to interference (other systems or jamming)

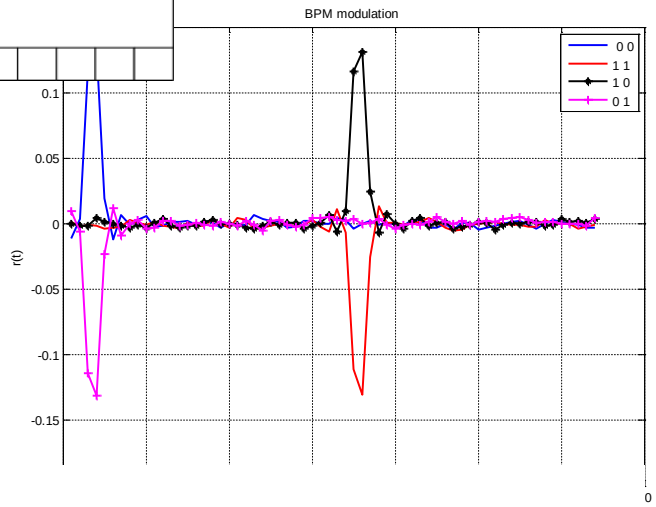


IR-UWB Key aspects

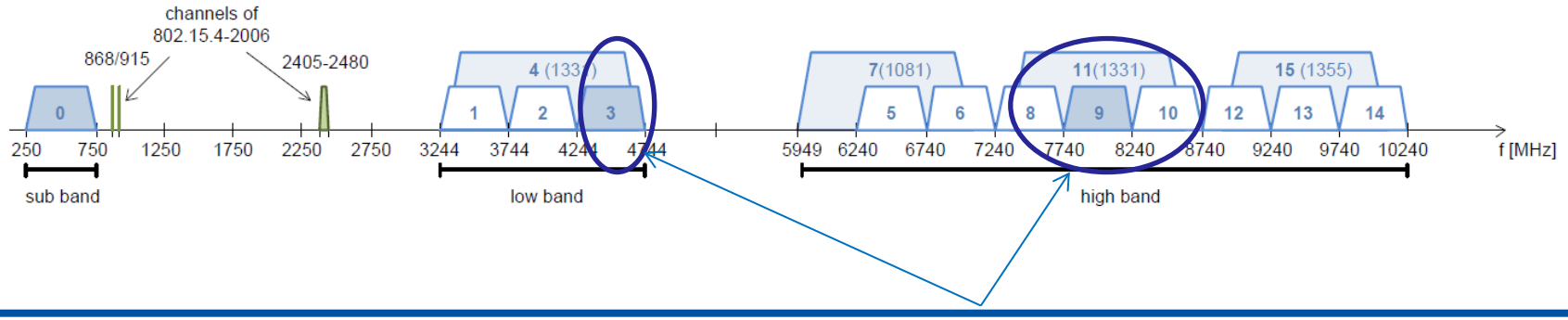
- **Pulse based modulation**

UWB Symbol – 2 information bits





- **Frequency spectrum**

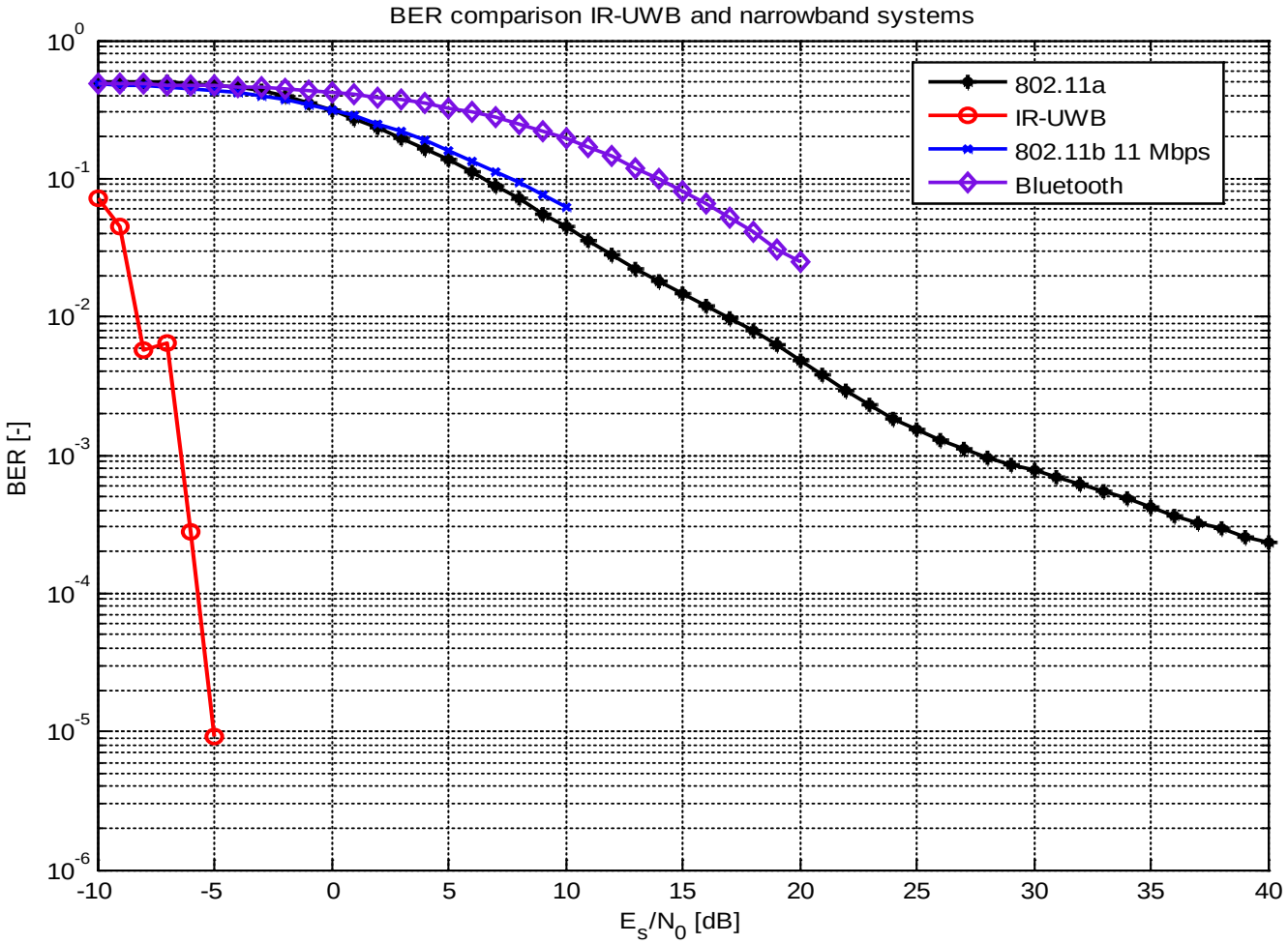


World-wide available frequency bands

Comparison of wireless candidates I

	Wi-Fi	ZigBee	Bluetooth	IR-UWB	WiMedia
Frequency band (GHz)	2.4, 5	2.4	2.4	subGHz, 3-10	3.1-10.6
Channel Bandwidth (MHz)	20, 22, 40	5	1	499.2, 1081, 1331	528
Range (m)	100-200	10-100	10-100	10-100	4-10
Data rate (Mbps)	2, 11, 54, 600	Up to 0.25	Up to 24	Up to 27.24	Up to 1024
Modulation	DSSS, OFDM, MIMO	O-QPSK, BPSK	pi/4-DQPSK	PBM-BPSK	MB-OFDM
Power emission	< 20dBm	< -3dBm	< 20dBm	< -41 dBm/MHz	< -41 dBm/MHz

Comparison of wireless candidates II

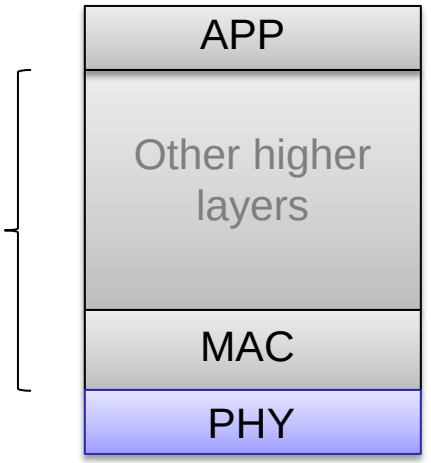


Reliability and determinism

- **… satisfied by appropriate protocol stack**
  - Standard vs. proprietary solution

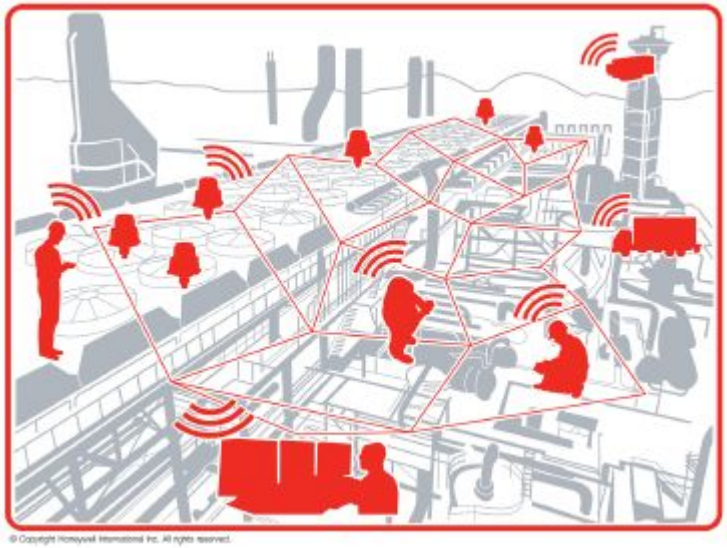
- Standardized candidates (from industry automation)
  - ISA100.11a
  - WirelessHART
  - In progress
    - IEEE802.15.4e + TiSCH
    - AVSI standardization activity for aerospace

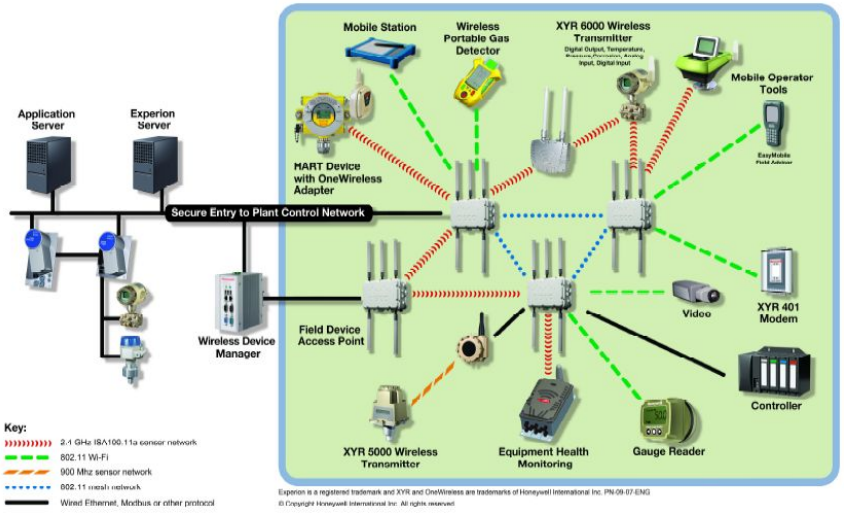
Other standard or specification



ISA100.11a

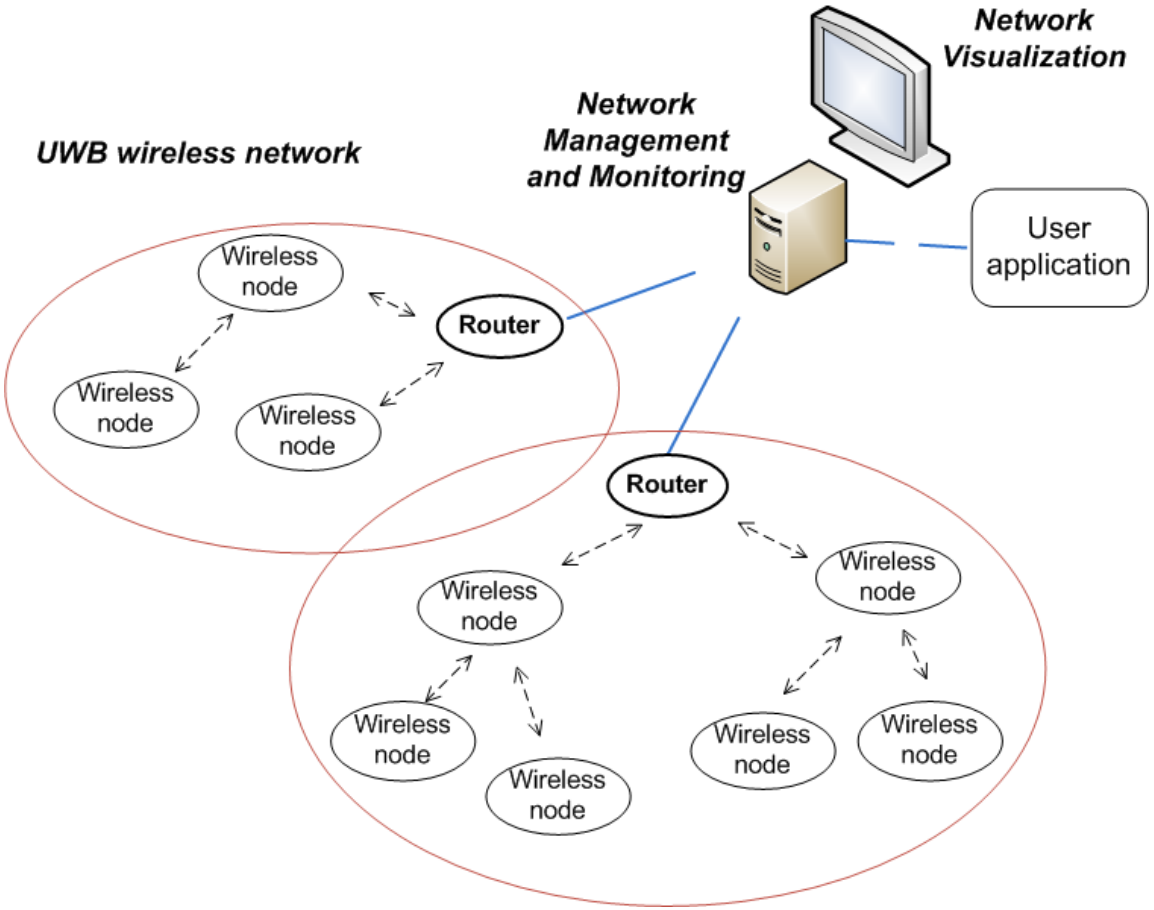
- Scalable and flexible network
- Determinism using TDMA
- Reliability given by centralized management and redundancy
- Industrial proven solution
- In-house implementation – OneWireless – wireless system for automation and control



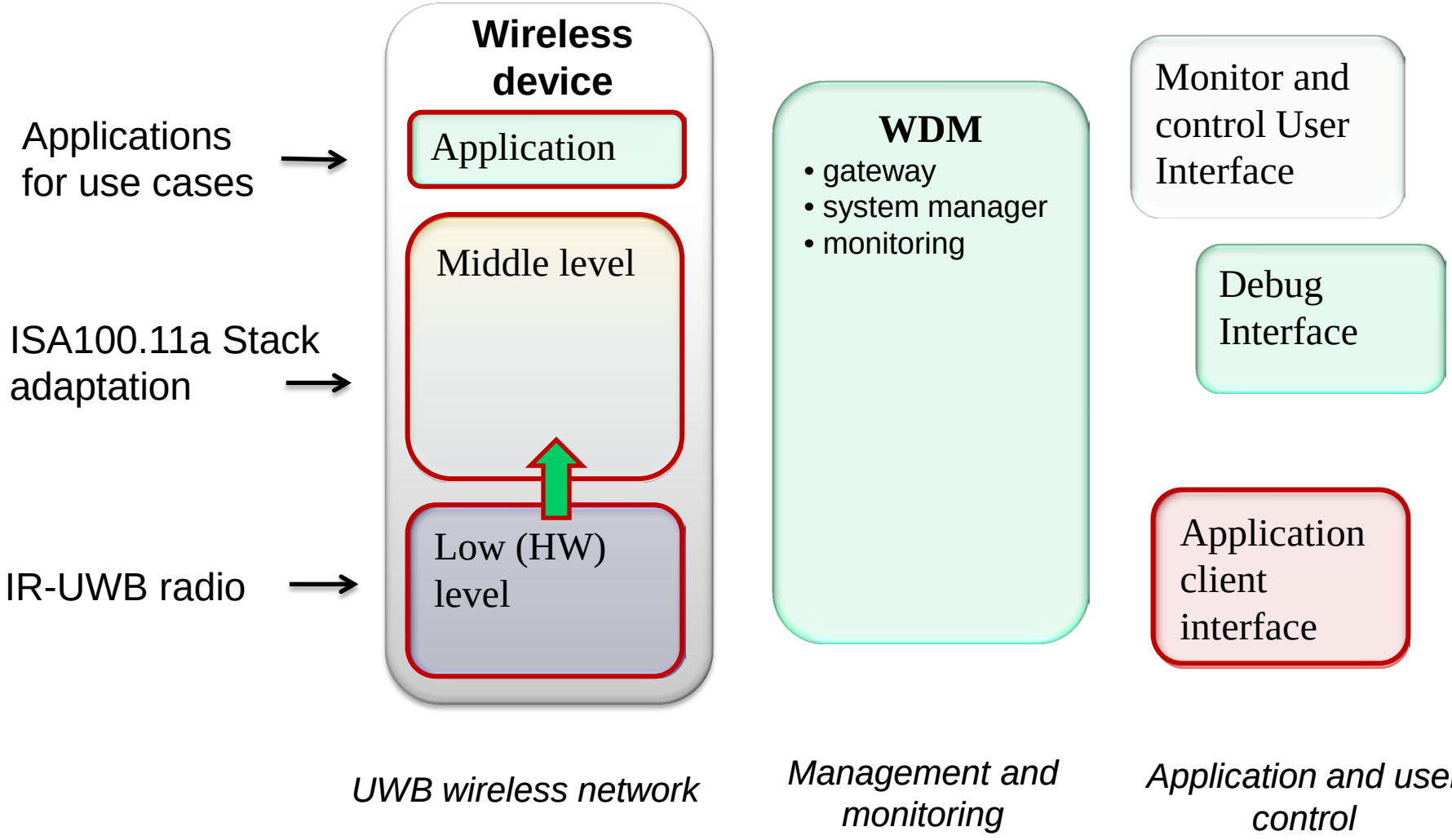


Demonstrator Design Concept

- Adaptation of ISA100.11a compliant network with IR-UWB PHY layer



Demonstrator SW design



Summary of ISA100.11a modifications

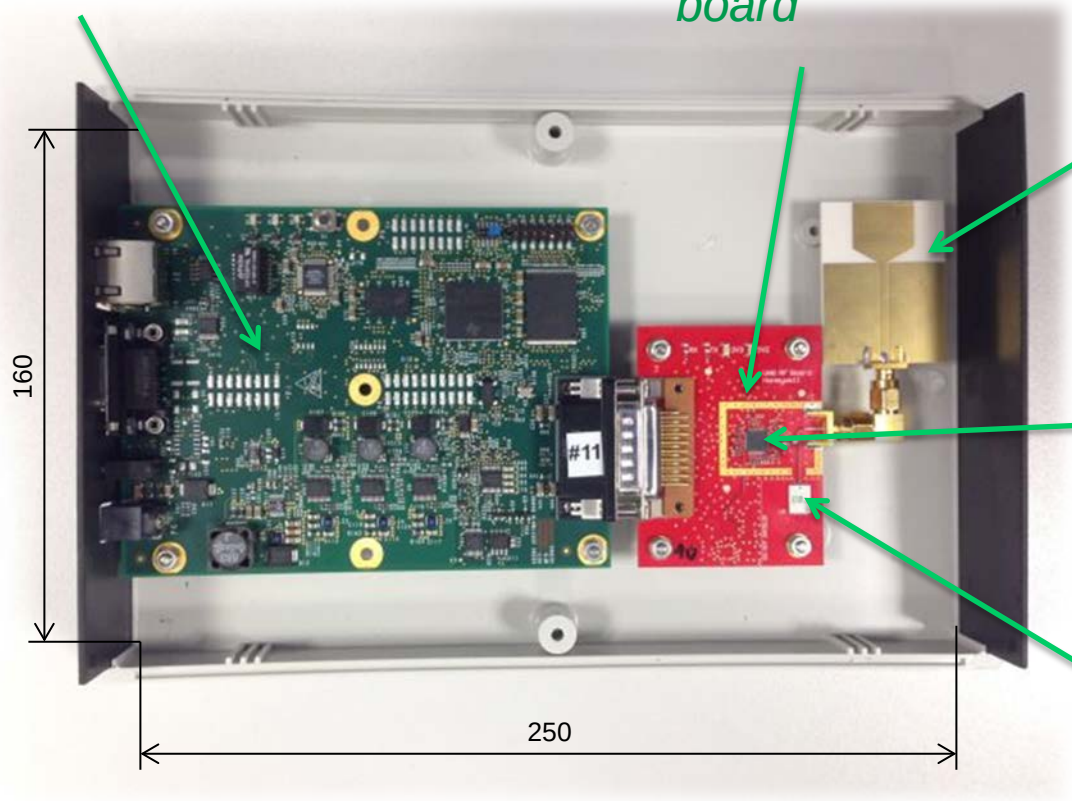
- New PHY definition (ISA100.11a considers currently only 2.4GHz)
  - Channel management
  - Power setting
  - Integrated MAC functionalities
- Without frequency hopping
- Without encryption on
  - Data link layer
  - Transport layer
- Timeslot duration shortened

Demonstrator HW Design

Main board with OMAP138L

IR-UWB radio board

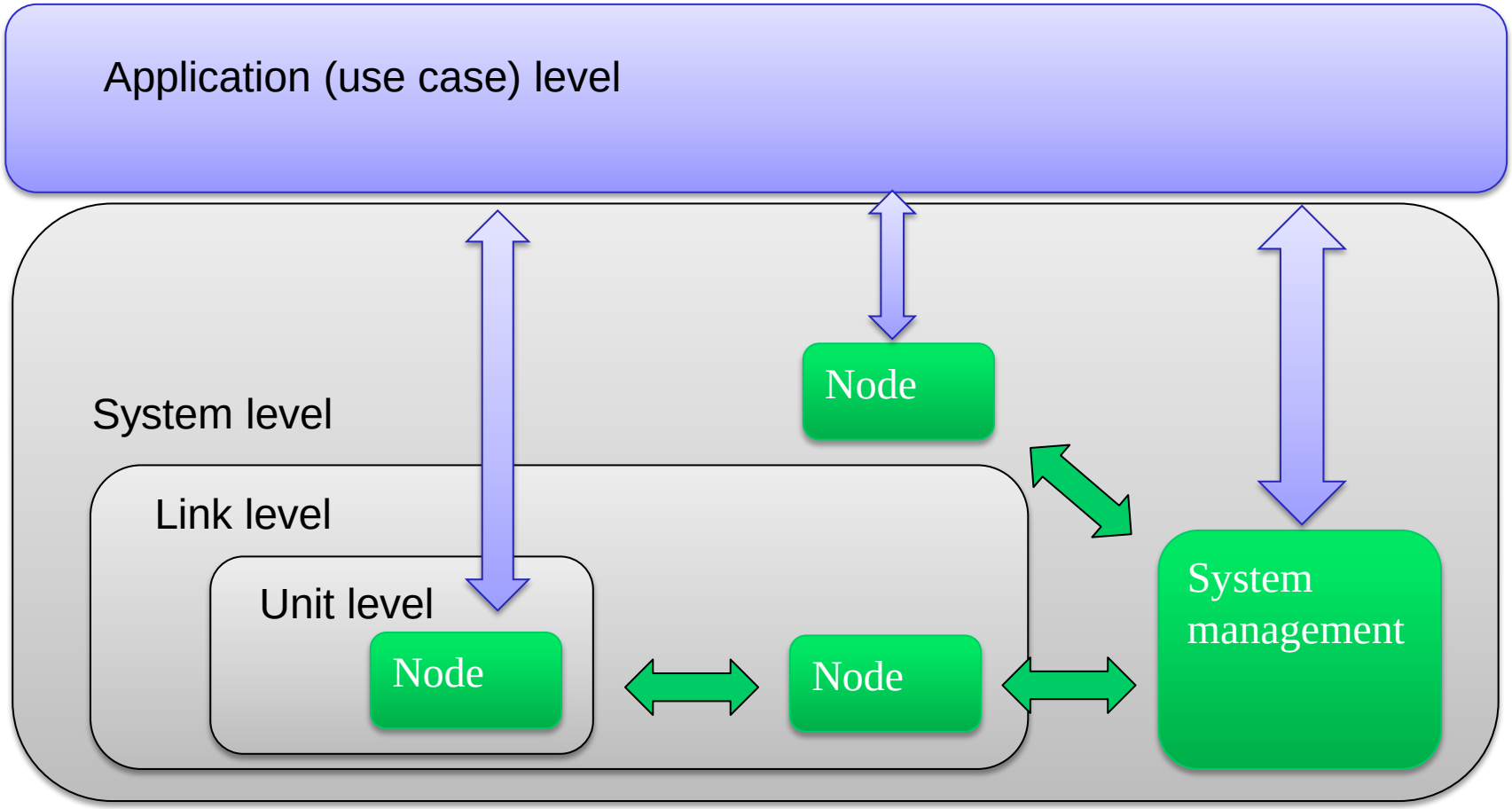
Planar antenna



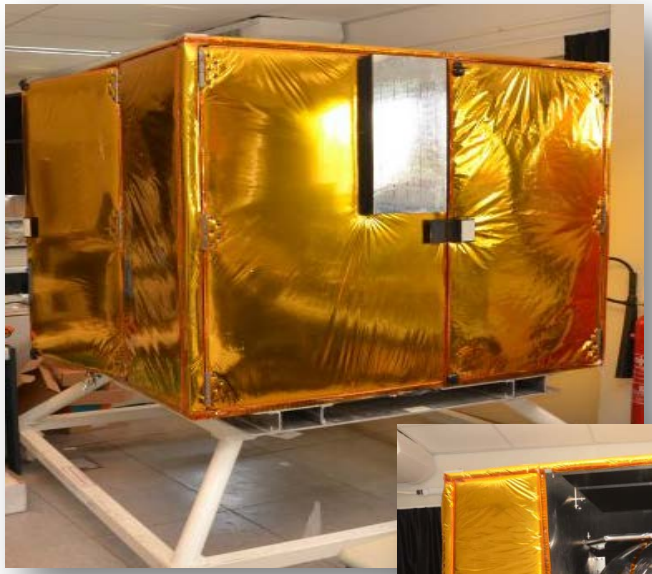
Decawave RF chip
- Max data rate 6.81Mbps
- 4 channels up to 6.5GHz
- additional non-standard features (preamble length, payload size)
- no HW encryption

Chip antenna

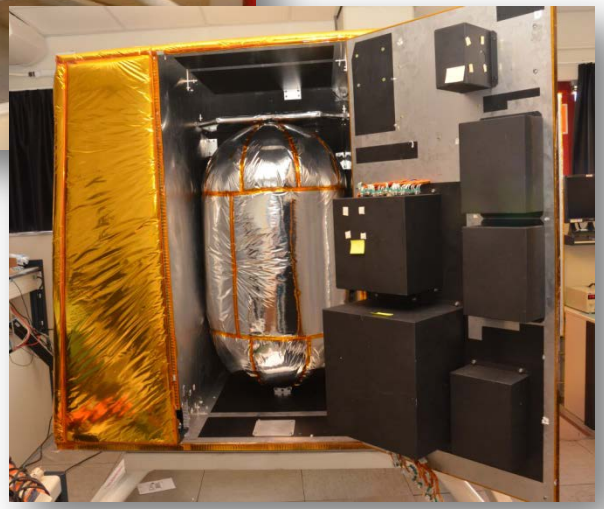
Tests and measurements



Hi-Fi Testing – Venus Express Mock-up



Inter cavities

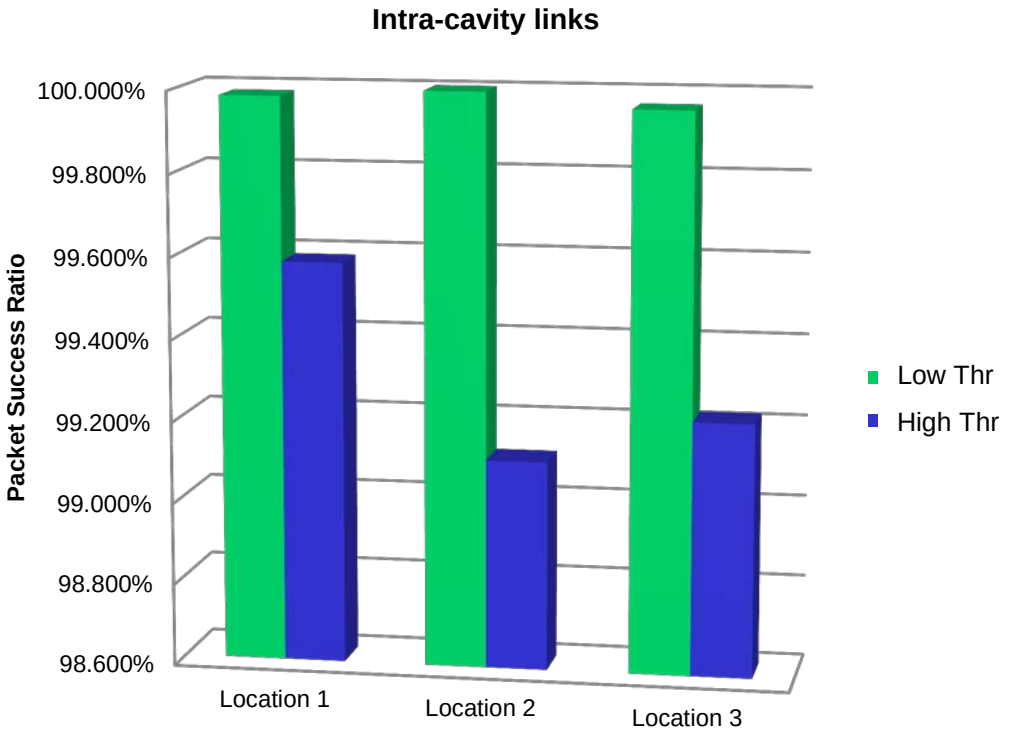


Intra cavity

In-Out
communication

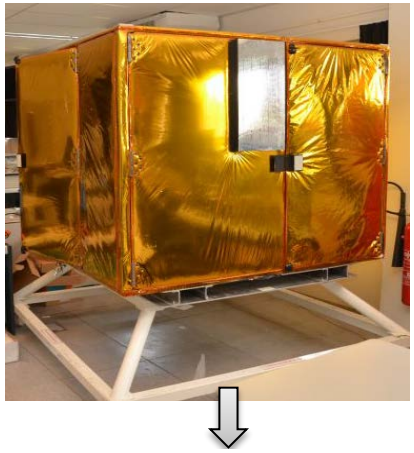
Satellite Mock-up Measurement I

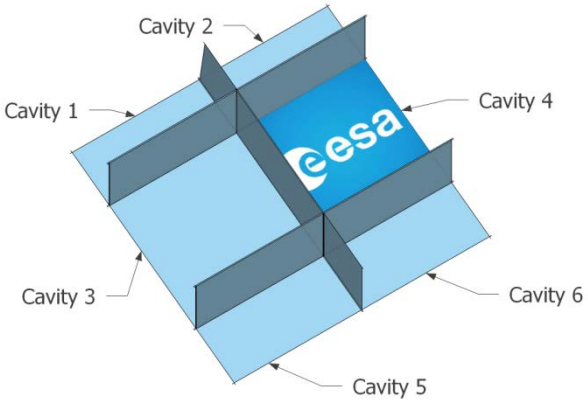
- *Intra-cavity*

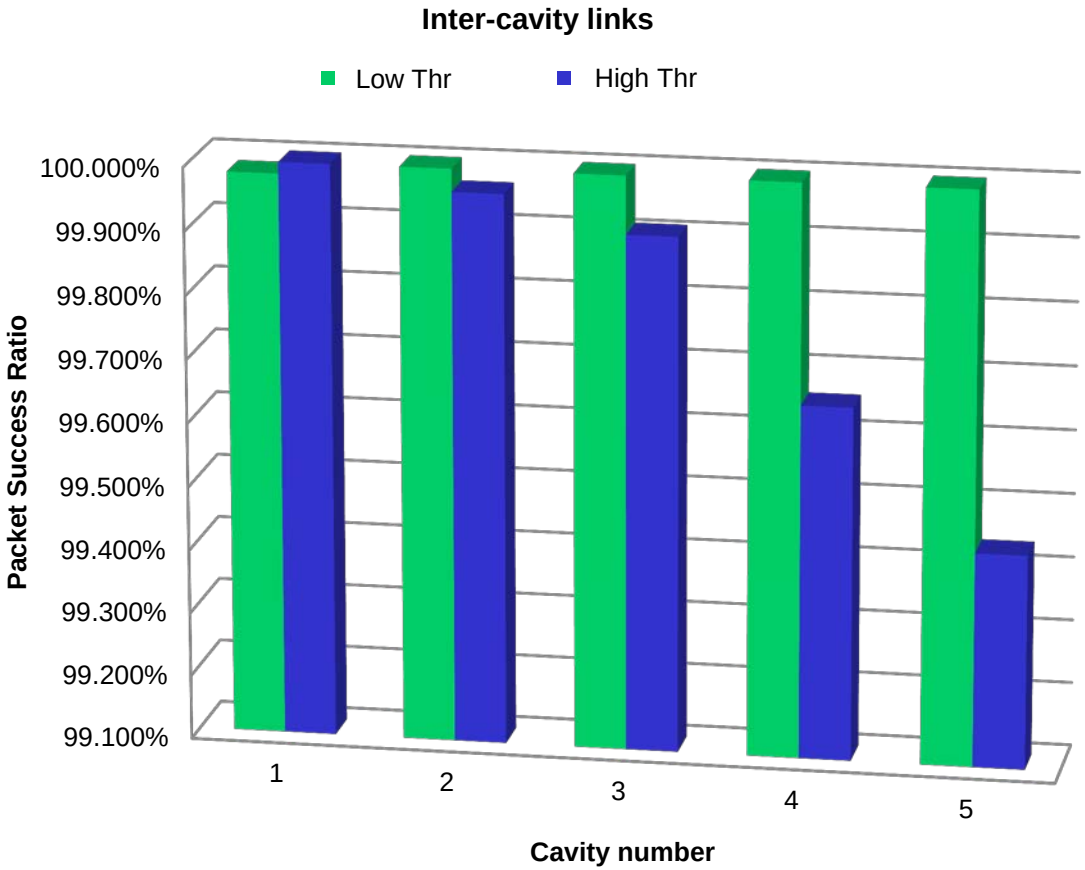


Satellite Mock-up Measurement II

- *Inter-cavity*

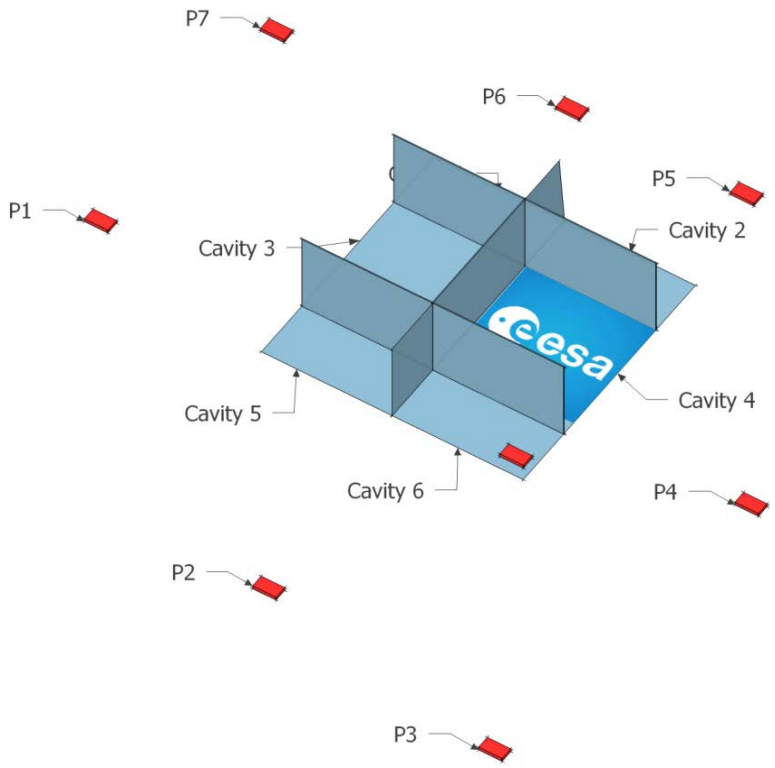


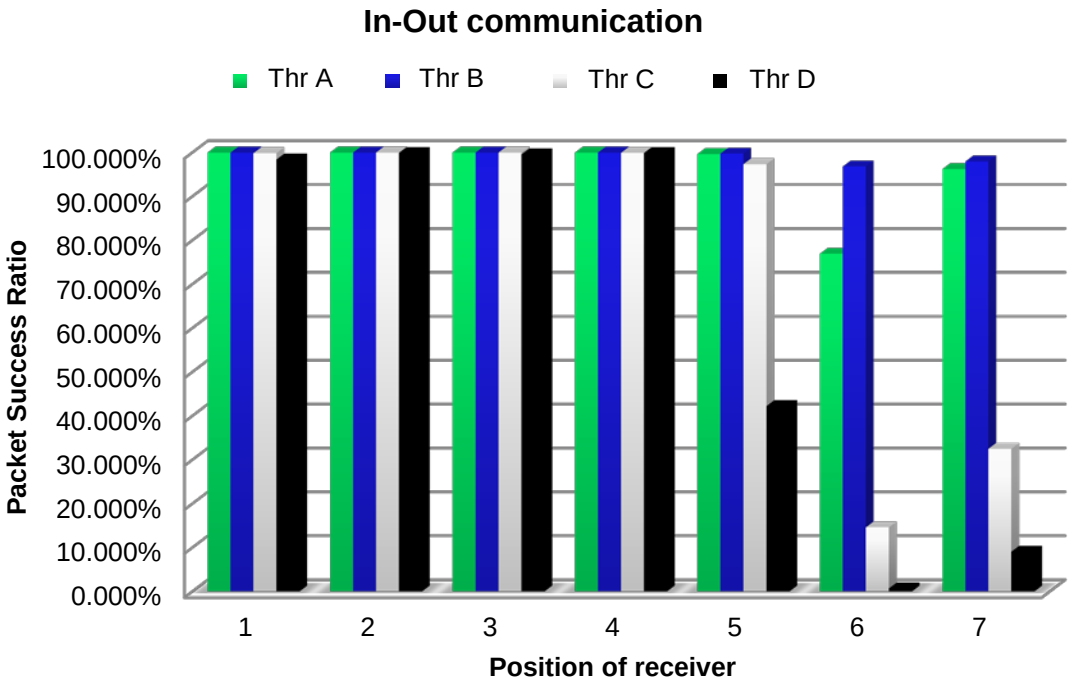




Satellite Mock-up Measurement III

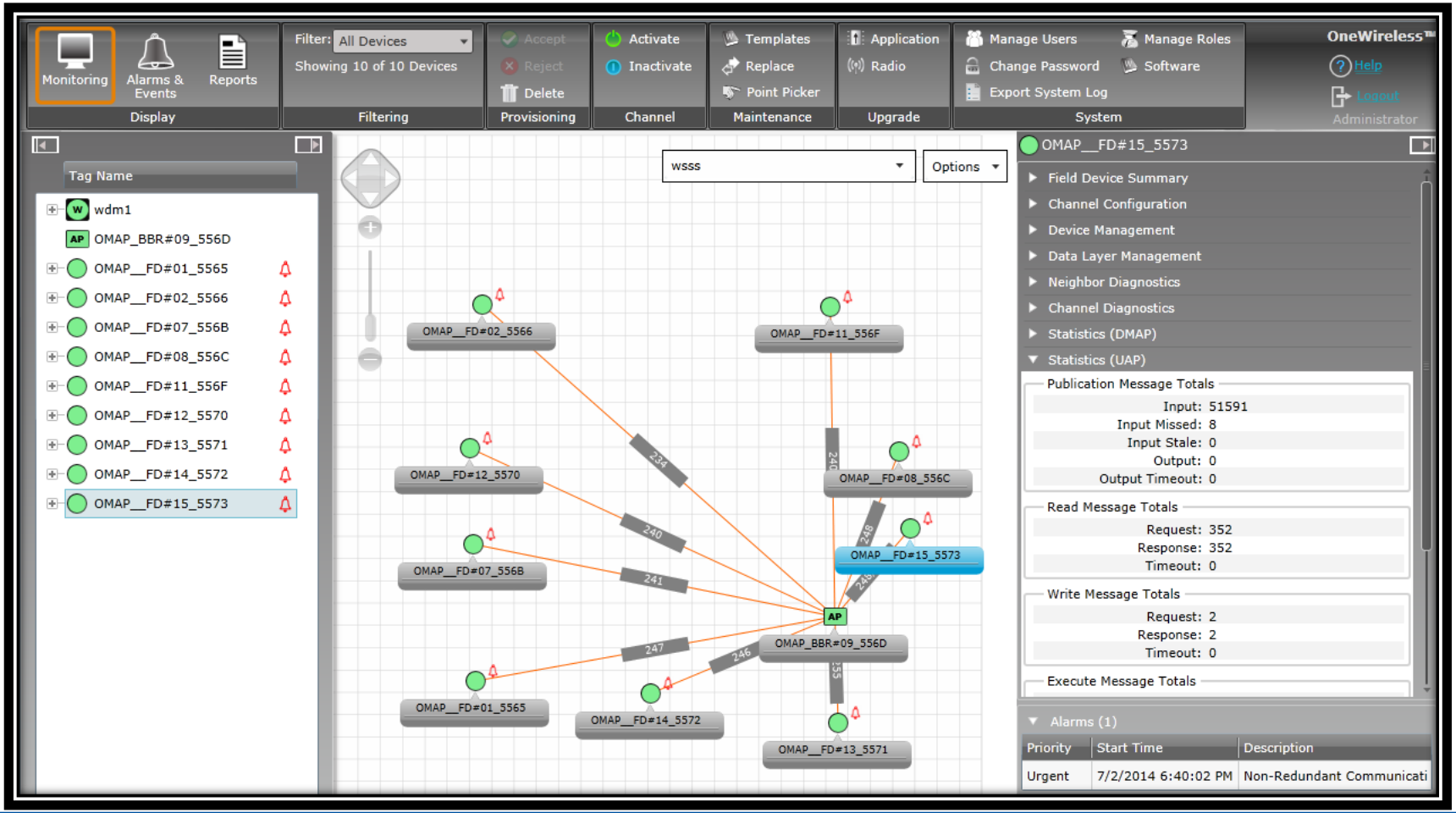
- *Inside-outside*





Satellite mock-up measurement IV

- *Onboard sensor network use case (PER = <0 - 1.55E-4>)*



Measurement - summary

- Measurement campaign showed feasibility of IR-UWB for all use cases from the connectivity perspective
  - Best inter-cavity PER achieved 9.75E-6
  - Open space environment is different due to reflections
- Open or closed doors have little impact (AIT)
- TX power can be reduced to -54.5 dBm/MHz (77.27 dBμV/m)
- Lower throughput offers higher robustness and reliability
- Maximal distance: 9.5 m from satellite
- Narrow band interference has little impact
- Chip antenna offers good performance

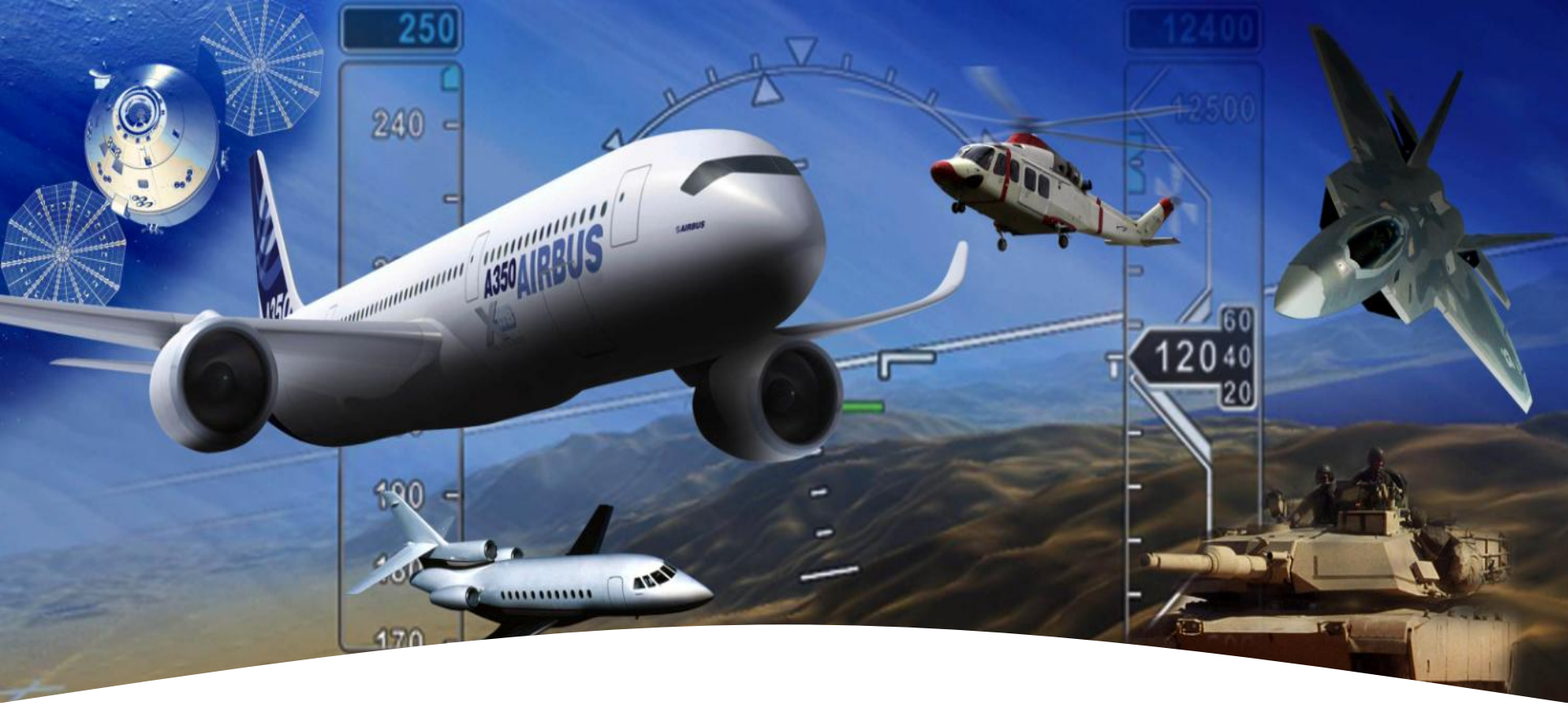
UWB demonstrator summary

- IR-UWB is robust against narrow band interference and multipath environment and offers higher performance than narrow band systems
  - Measurement on satellite mock-up proved usability in relevant obstructive environment
- ISA100.11a is extendable with new PHY
- ISA100.11a offers reliable protocol stack for deterministic communication in complex network systems
  - High scalability and modularity vs. complexity and efficiency
- ISA100.11a specifies strictly user applications (interoperability)
  - Inflexible application layer

⇒ IR-UWB offers promising solution for space wireless communication
⇒ Higher layers of protocol stack can be designed for higher efficiency

Future Work

- Coexistence EMC tests
- HW design
  - Space-graded components (RF chip!!)
  - Reduce form factor
  - Power supply (battery, harvesting, power subsystem)
- SW design
  - Link management for UWB PHY
  - Protocol stack optimization – adjustment for space use case
- Integration to satellite platform/test system



Thank you

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