

Launcher Wireless Internal Infrastructure Perspectives

Johannes Sebald, ArianeGroup
11th of December 2018

OUR COMPANY: ArianeGroup

Created by **Airbus Group** and **Safran** in **2015**



CEO

Alain Charneau

9,000

EMPLOYEES
IN FRANCE
& GERMANY
(500 IN BREMEN)

11

SUBSIDIARIES
& MAIN AFFILIATES

50/50

JOINT COMPANY
BETWEEN
AIRBUS & SAFRAN

**€3.4
BILLION**

REVENUES



CIVIL LAUNCHERS

- ▶ Ariane 5
- ▶ Ariane 6
- ▶ Launch services



DEFENSE

- ▶ M51 program



EQUIPMENT & SERVICES

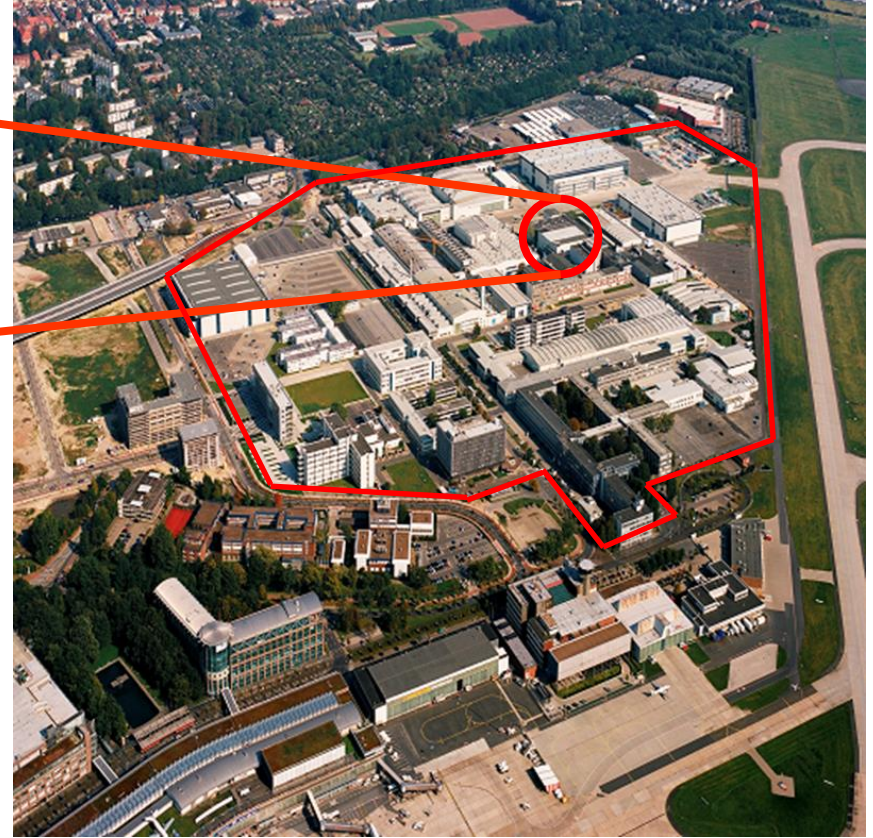
- ▶ For satellites, spacecraft
- ▶ For launchers
- ▶ For defense, security, critical infrastructures, and industry

OUR SITE: Bremen (together with Airbus)

Integration of Ariane 5 **Upper Composite**



containing the **Upper Stage**
and the **Vehicle Equipment Bay (VEB)**



OUR ORGANIZATION:



JO Operations

JOW Vehicle Cluster

JOWF Avionics & Software

JOWF1 Avionics

JOWF17 Electrical Engineering & AIT Support BRE



Engineering Upper Stage Avionics

- Procurement & Subcontractor management for avionic equipment
- Support of electrical integration and qualification tests
- A6 avionic development
- R&T activities for future launcher



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Ariane 5 Upper Stage avionics and wiring

Vehicle Equipment Bay
(VEB)

Upper Stage

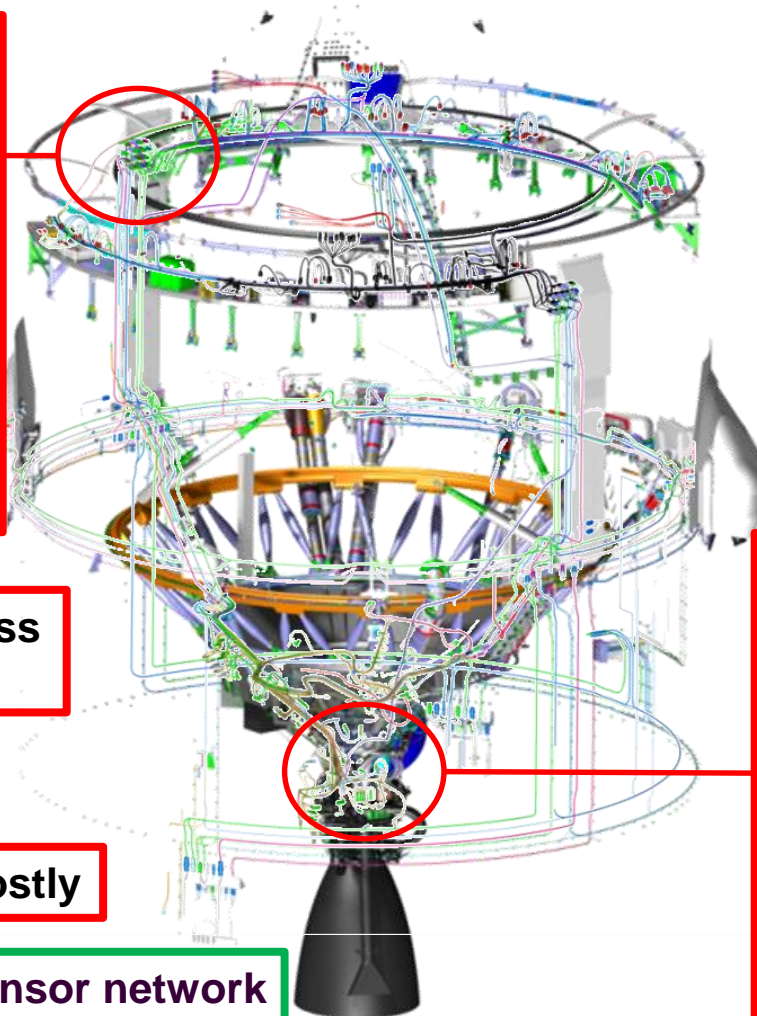
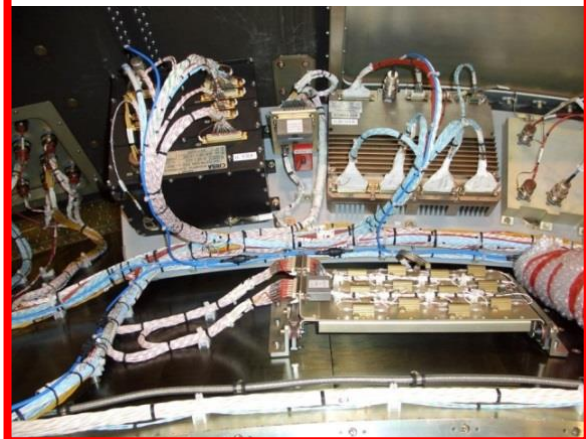
InterStage Structure



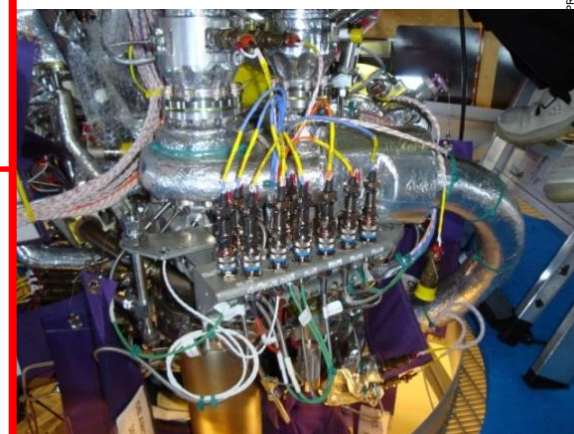
Upper
Composite



VEB Equipment



Engine Thrust Frame



→ Over 25 % of Avionic mass is Harness related

→ Harness length ≈ 7 km

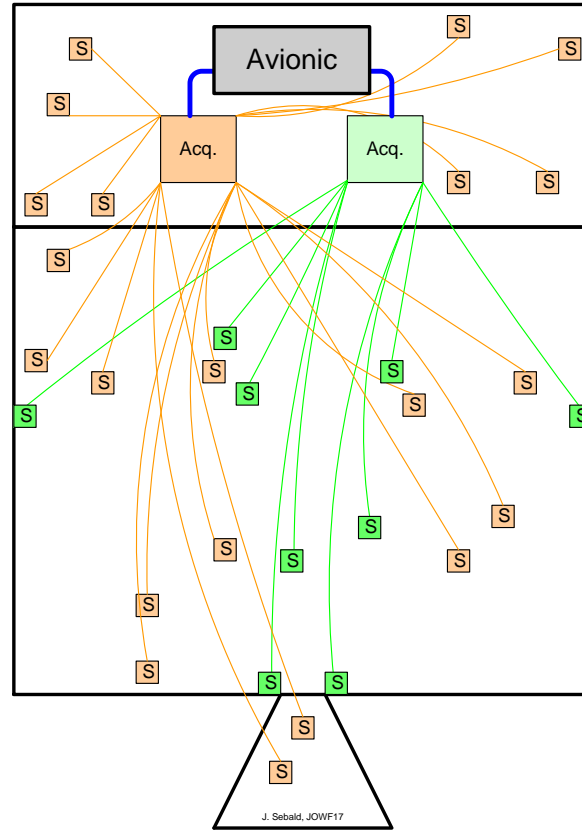
→ Harness integration is costly

→ Reduce complexity of sensor network

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Sensor Networks today and tomorrow



Sensor Network Topology today: Ariane 5, Upper Composite

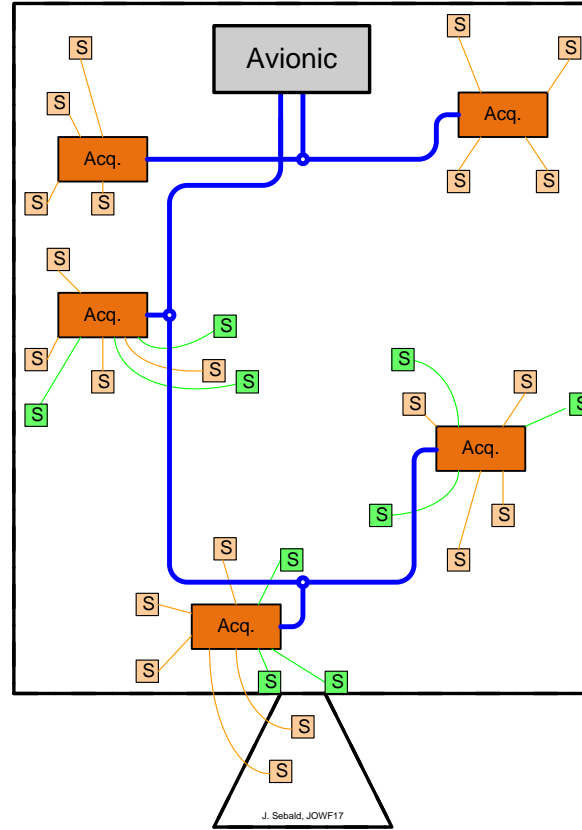


 Functional Sensor



 Telemetry Sensor

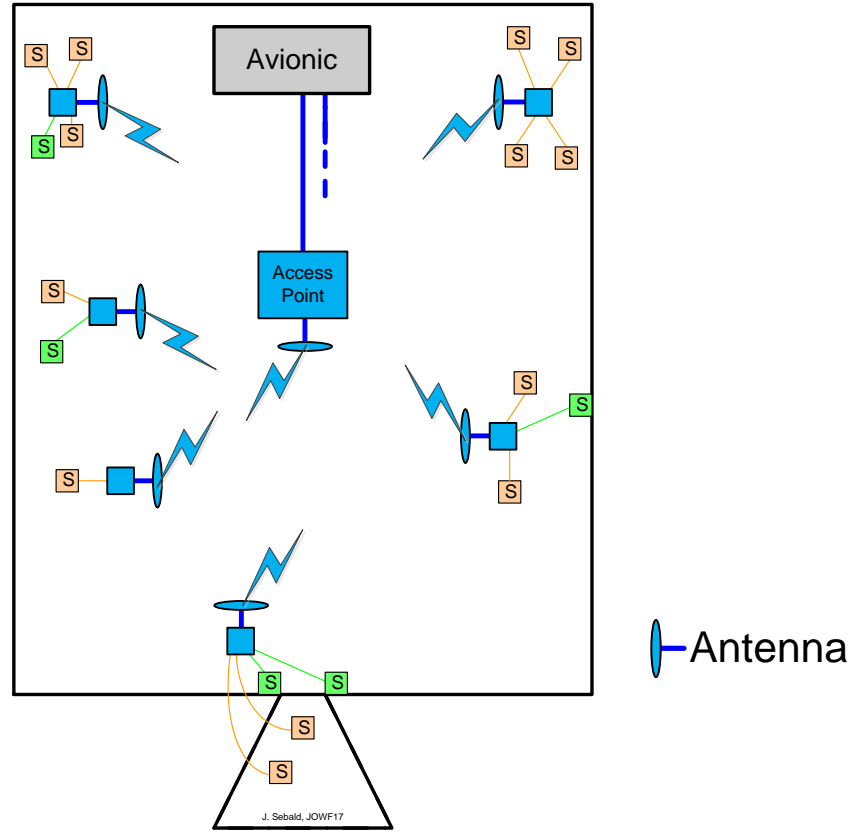
Sensor Network Topology tomorrow: Ariane 6

 Functional Sensor
 Telemetry Sensor

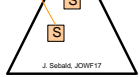
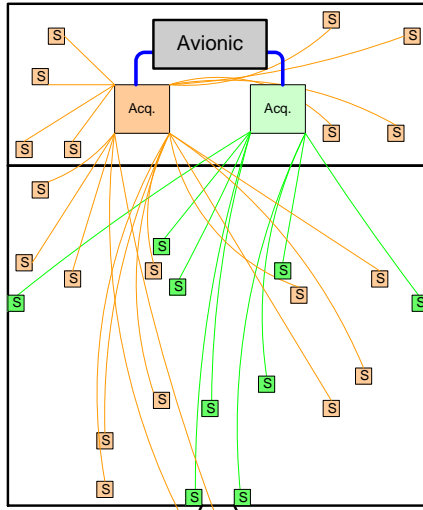


Sensor Network Topology in the future: wireless!

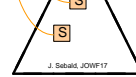
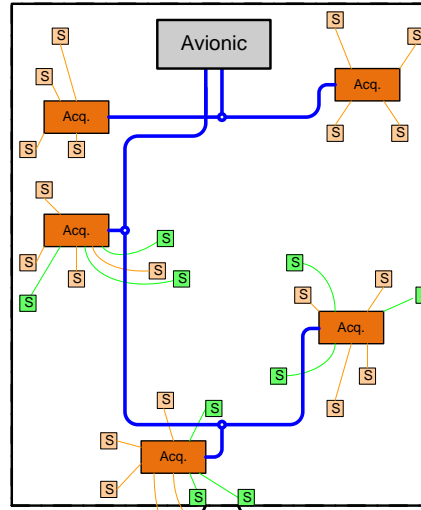
 Functional Sensor
 Telemetry Sensor



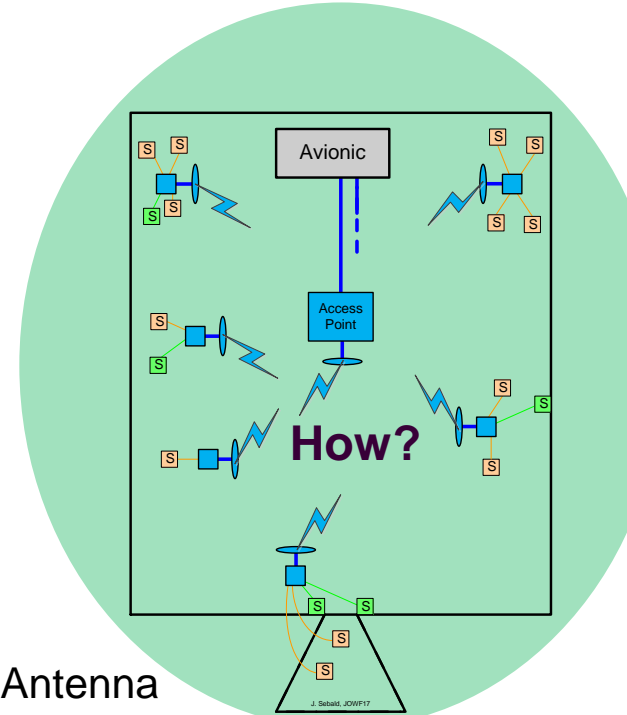
Sensor Network Topology evolution



Functional Sensor
Telemetry Sensor



Antenna



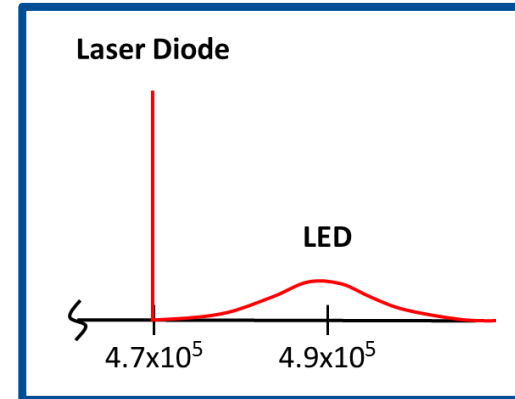
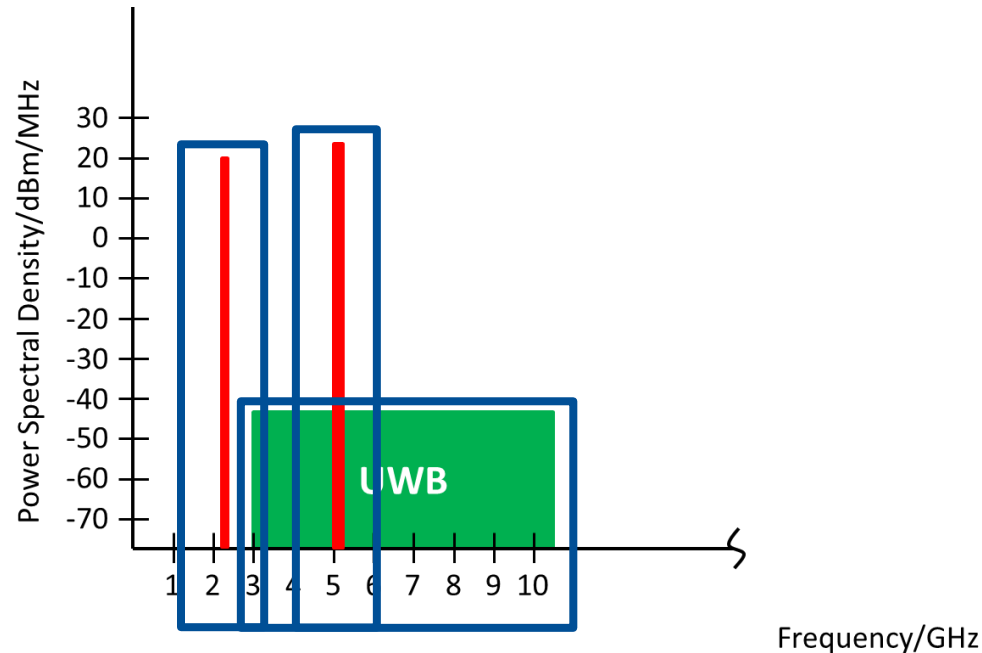
Today: Ariane 5

State of the Art: Ariane 6

Future

Potential wireless technologies (active)

- Optical/Infrared (LED, Laser Diode)
- Narrow Band radio frequency like WiFi, Bluetooth and ZigBee
- Ultra-wide band, radio frequency (UWB)



The good the bad and the ugly...

Physical Channel	Frequency/ Wavelength	Data Rate	Standard	Comments
Infrared	850 – 900 nm	2,4 kbit/s to 1 Gbit/s	Infrared Data Association (IrDA)	
Radio Frequency Narrow Band	ISM*: 2,4 GHz, 5 GHz	Up to 6.9 Gbit/s	WLAN IEEE 802.11ac	
Radio Frequency Narrow Band	ISM*: 2,4 GHz	2Mbit/s	WPAN IEEE 802.15.1 Bluetooth 3.0	24 Mbit/s with add. 802.11 link (Bluetooth 3.0 + HS)
Radio Frequency Narrow Band	ISM*: 2,4 GHz	250 kbit/s	WPAN IEEE 802.15.4, ZigBee	
Radio Frequency Narrow Band	ISM*: 865 MHz, 2,4 GHz, 5 GHz	typically < 100 kbit/s	RFID	Mainly for MAIT purposes 865 MHz passive, else active
Ultra-wide band	3,4 GHz to 10 GHz	110 Mbps (at 10m)	High Rate HR-WPAN IEEE 802.15.3a UWB	Standardization activities stopped
Ultra-wide band	499 MHz, 3,4 GHz to 10 GHz	27,24 Mbit/s	Low Rate LR-WPAN IEEE 802.15.4 UWB	

*ISM: Industrial, Scientific and Medical Band

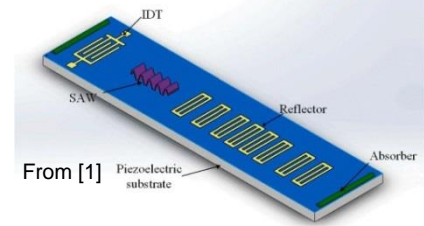
Wireless technology performance

Aspect	Narrow Band	Optical	UWB
Hardware			
Data Rate			
Non Line of Sight			
Localization			
Power			
Multipath			
EMC			
Security			

Potential wireless technologies (passive)

Surface Acoustic Wave sensors

- Piezoelectric material, beware of Curie temperature!
Eg. 380 °C [1], 850 °C [2] for high temperature materials
- Access to multiple sensors via TDMA, CDMA and FDMA
- Measurement of all physical quantities with SAW sensitivity possible like:
 - Temperature down to 0.1K
 - Cryogenic liquid level
 - Strain
 - Gas sensing



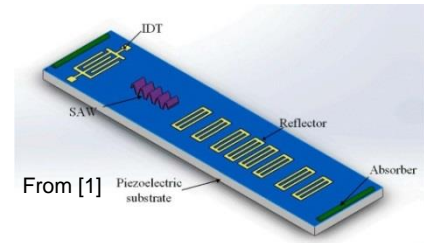
[1] "Piezoelectric materials for high temperature transducers and actuators, T. Stevenson, D. G. Martin, P. I. Cowin, A. Blumfield, A. J. Bell, T. P. Comyn, P. M. Weaver, J Mater Sci: Mater Electron (2015) 26:9256–9267

[2] <http://www.omegapiezo.com/high-temperature-lead-free-piezoceramics/>

Potential wireless technologies (passive)

Surface Acoustic Wave sensors interesting:

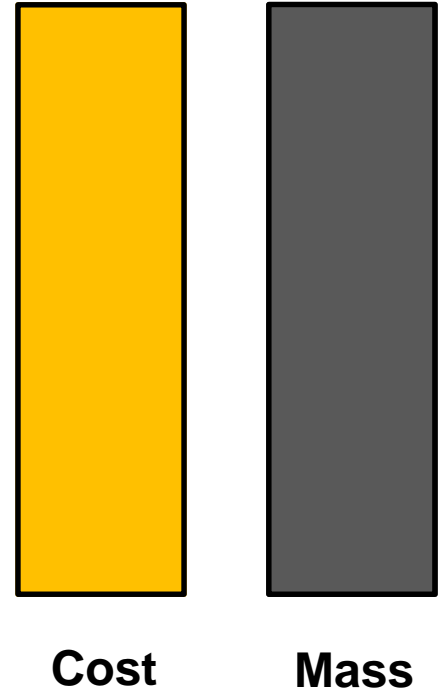
- in areas challenging to access like cryogenic tanks
- for structural health monitoring especially of CFRP elements
- for sensors difficult to supply with electrical energy



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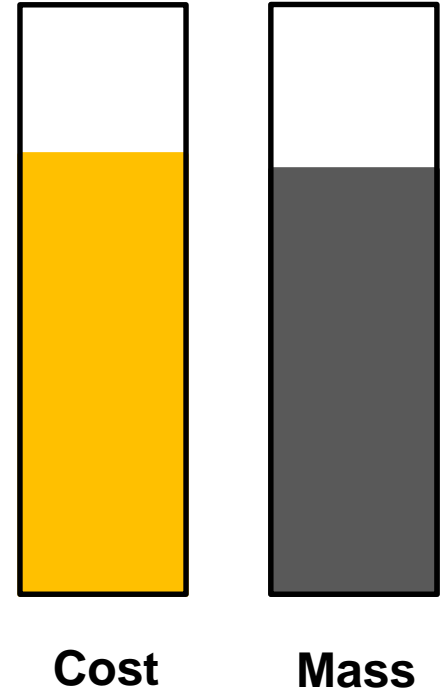
Wireless benefits

Wireless benefits, the obvious



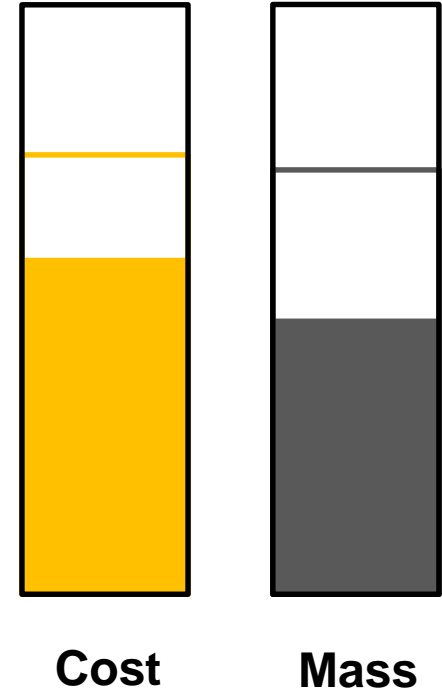
Wireless benefits, the obvious

- Reduction of Hardware



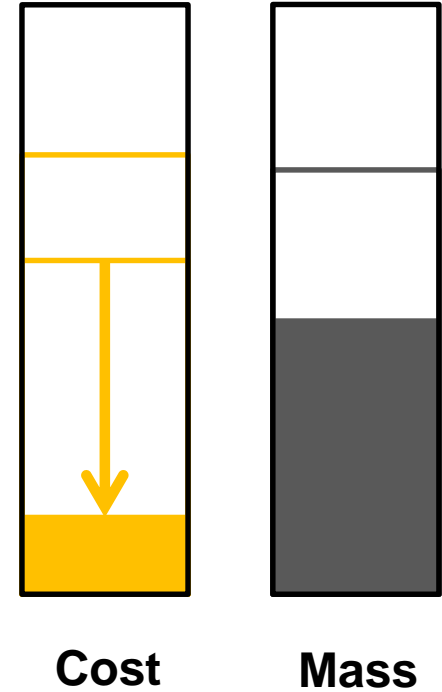
Wireless benefits, the obvious

- Reduction of Hardware
- Reduction of Structural Elements



Wireless benefits, the obvious

- Reduction of Hardware
- Reduction of Structural Elements
- Optimization of Assembly, Integration and Test (AIT)



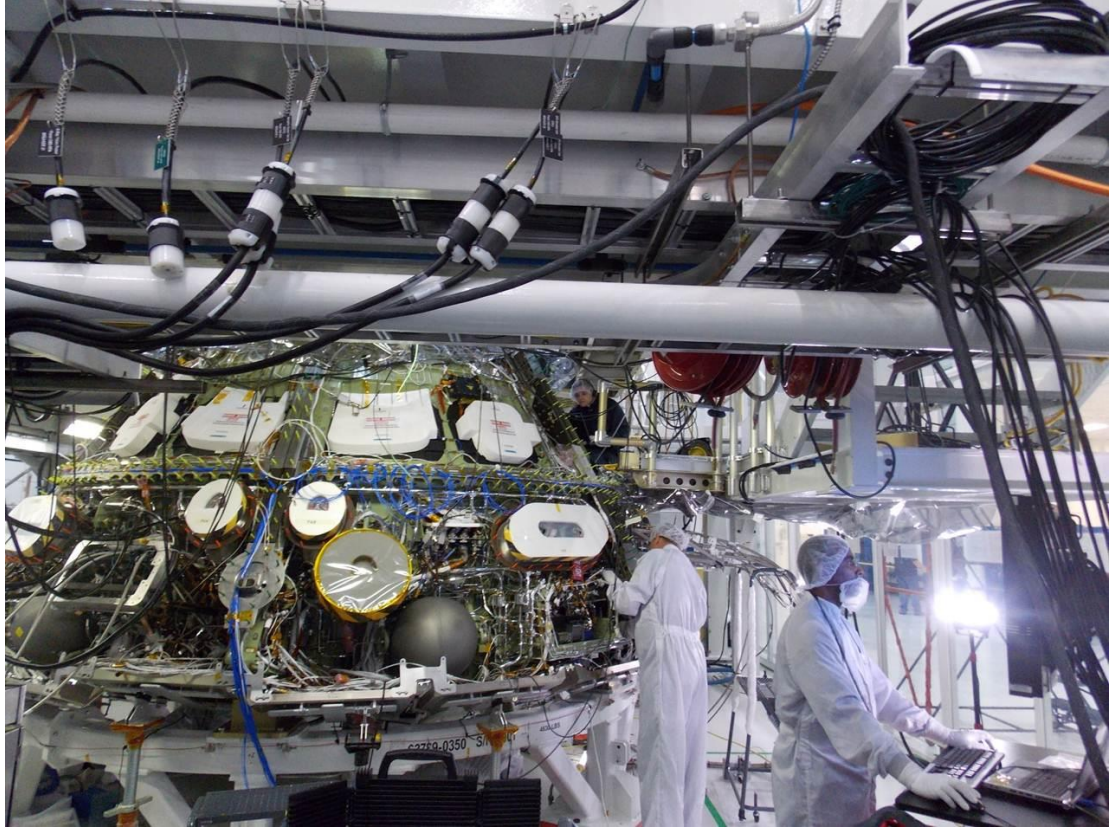
Wireless benefits, the non so obvious

- Telemetry Kit Solutions



Wireless benefits, the non so obvious

- Dense space solutions
-> Routing requires room



Avionics testing on the Orion spacecraft, Credit: Lockheed Martin

Read more at: <https://phys.org/news/2014-04-nasa-orion-spacecraft-powers.html#jCp>

Wireless benefits, the non so obvious

- Independent side by side operation with wired sensors



Smooth transition to new technology



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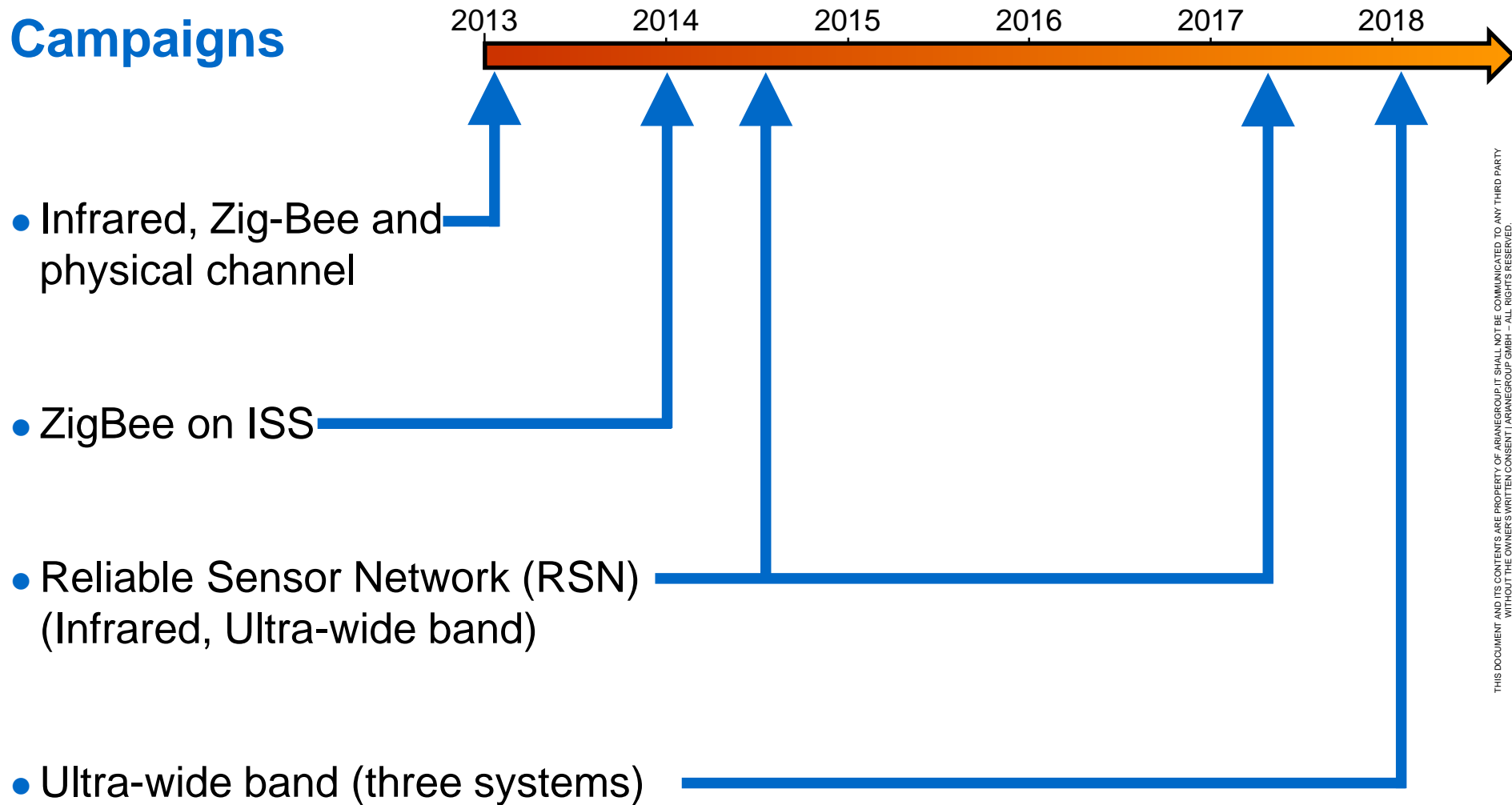
Wireless research

Ariane Testbed

- Measurements have been done in a VEB qualification model

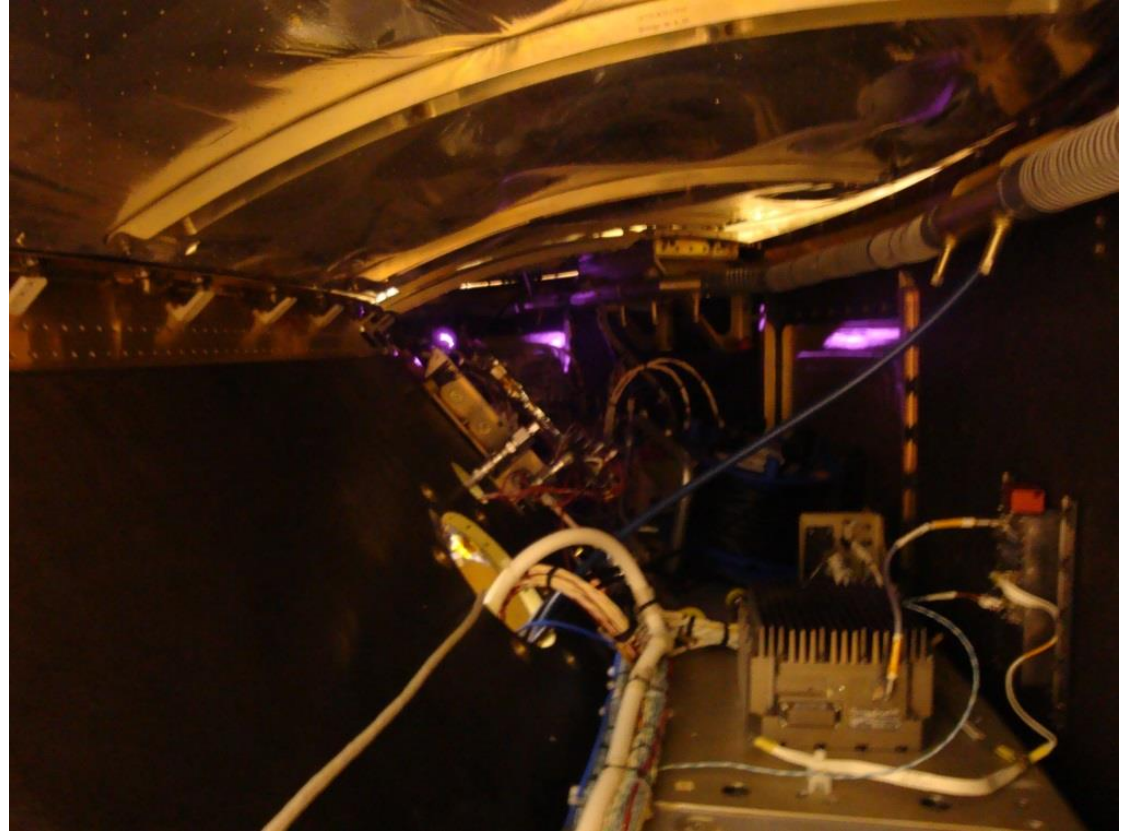
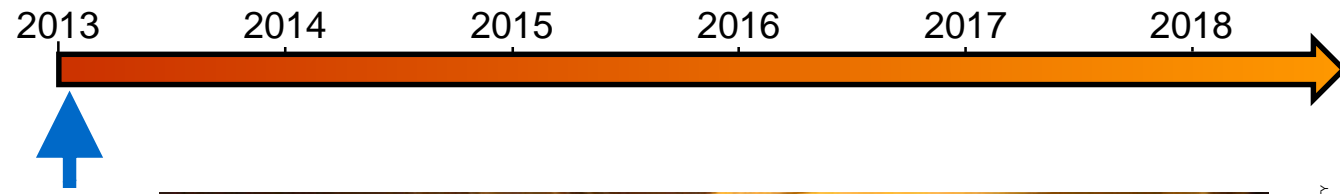


Campaigns



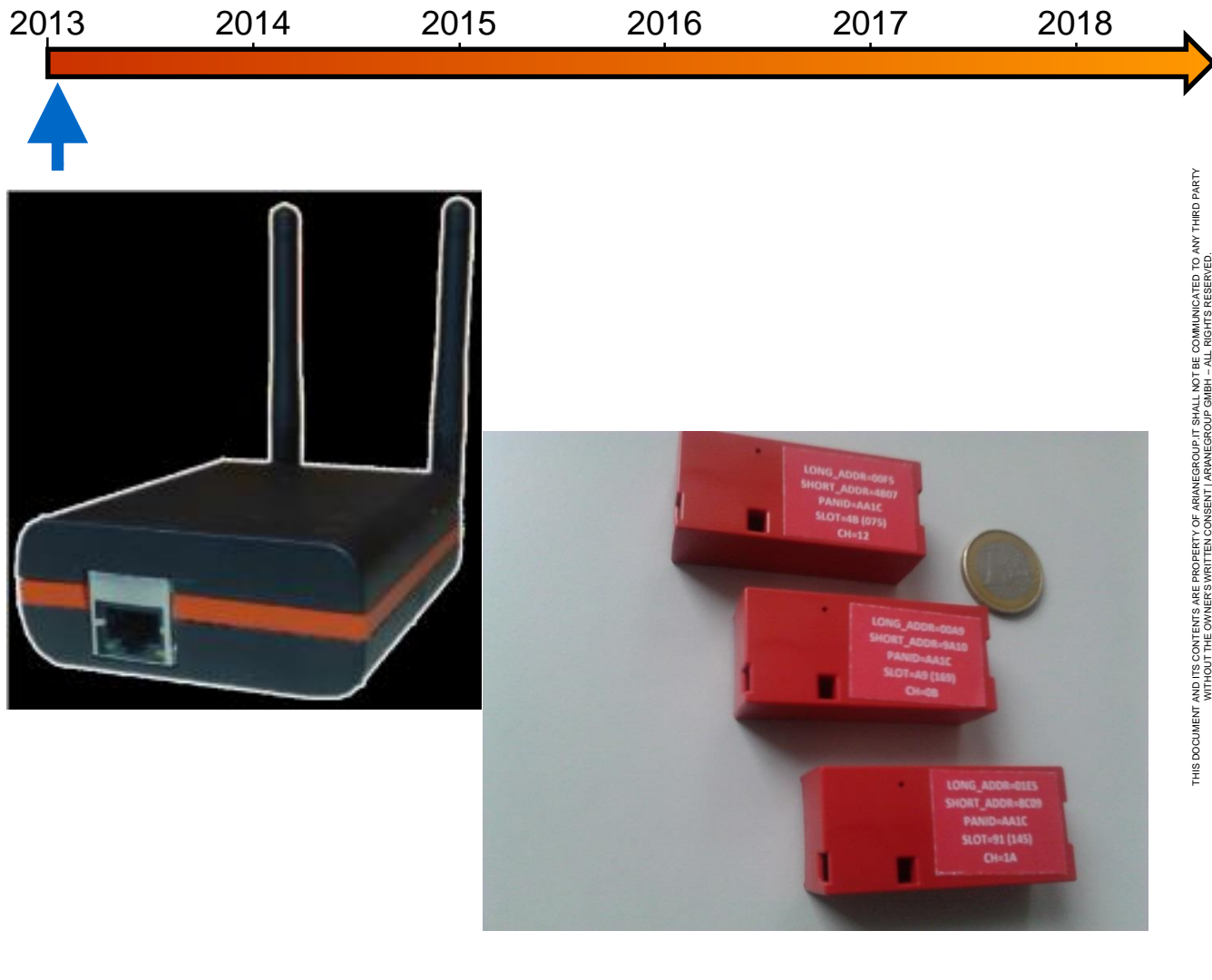
Infrared

- Video transmission



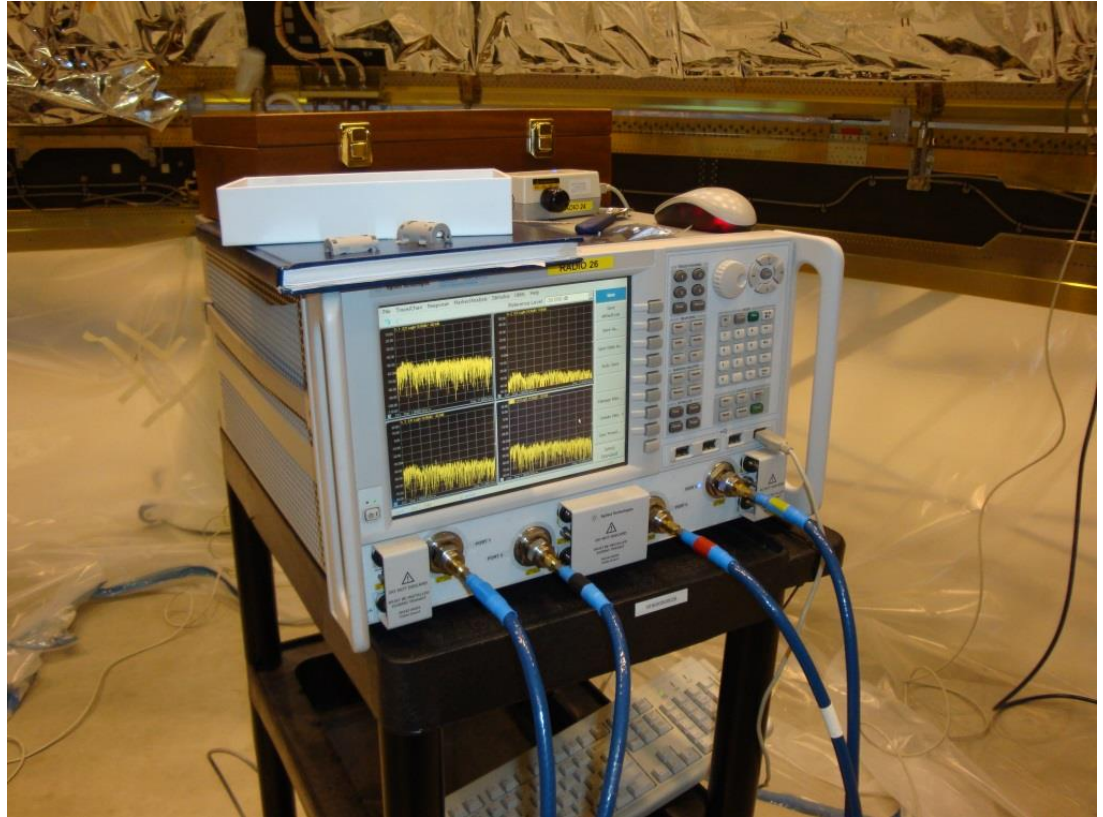
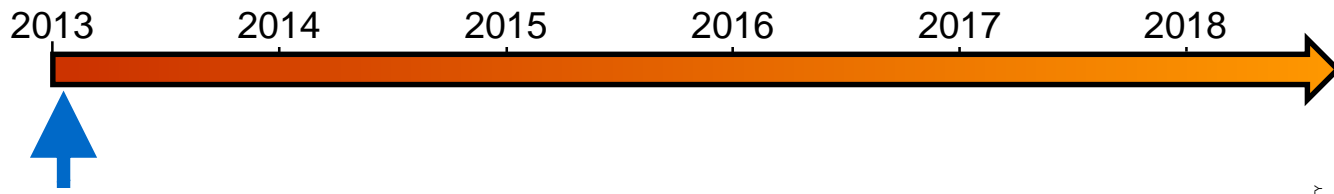
ZigBee system

- Four access points
- Customized protocol
- 80 Sensors

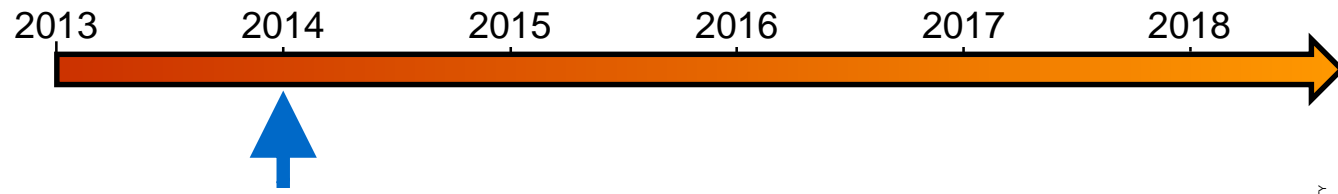


Physical channel

- S-Parameter
between 1 GHz and 10 GHz

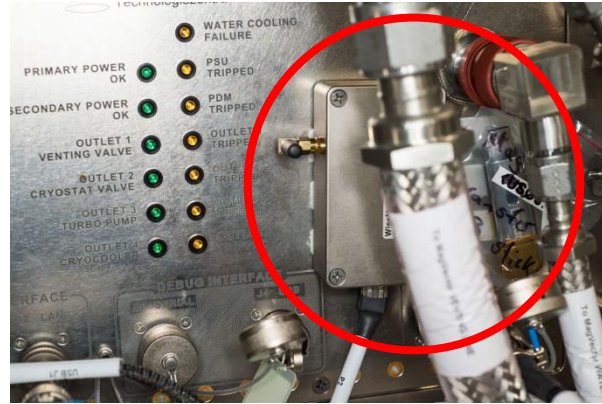
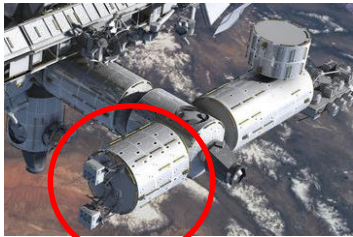


ZigBee on ISS

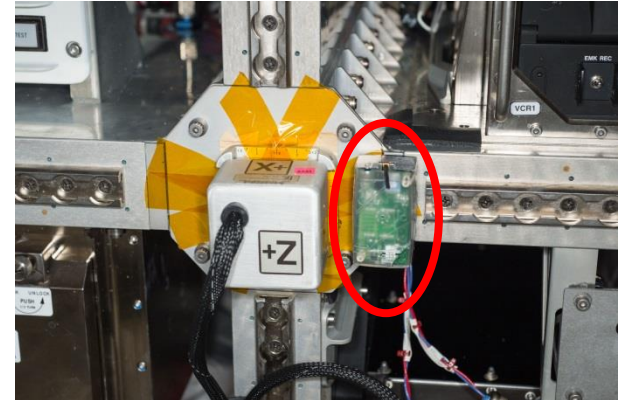


WiSe-Net

- One access point
- Customized protocol
- Four sensors in Columbus Module

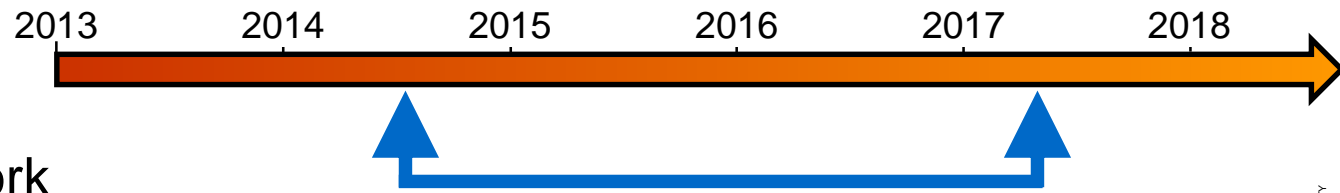


Base-station (Courtesy NASA)



Sensor Node (Courtesy NASA)

RSN project



Reliable Sensor Network

- 3 years, FLPP 3
- End to End function proven
- Wireless worked inside VEB



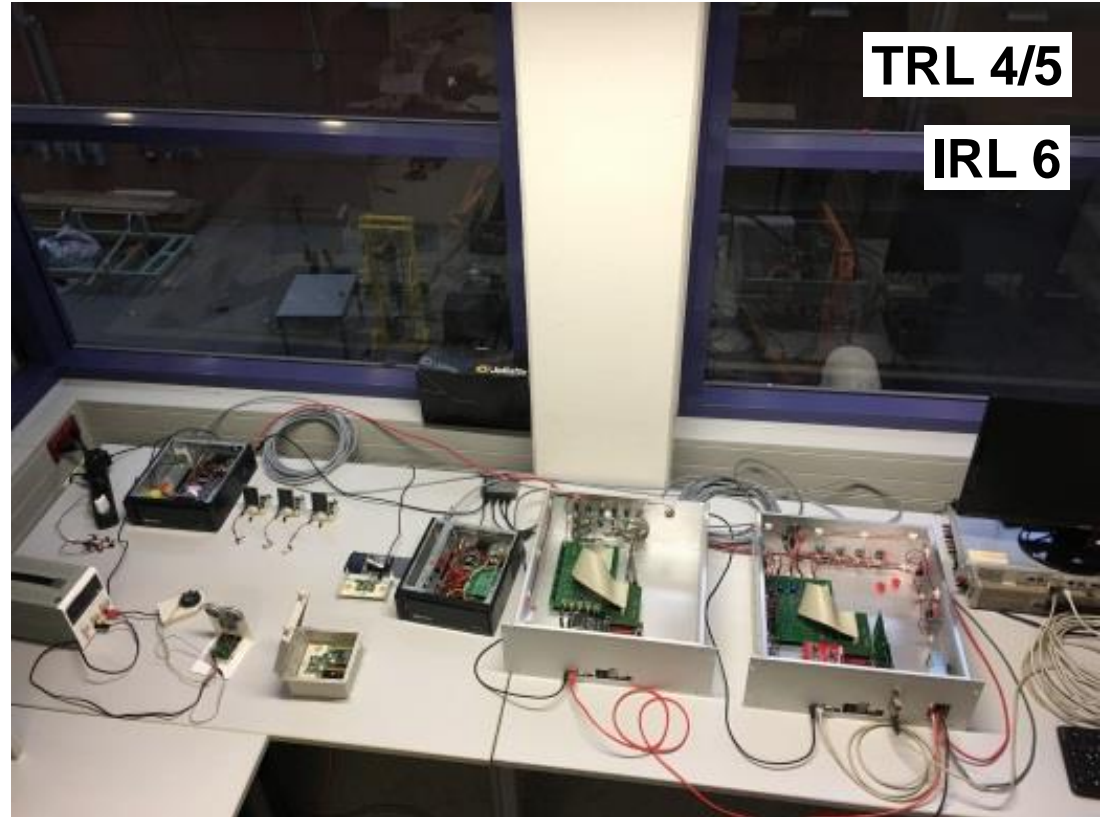
Universität
Bremen

Hochschule Bremerhaven



Holst Centre

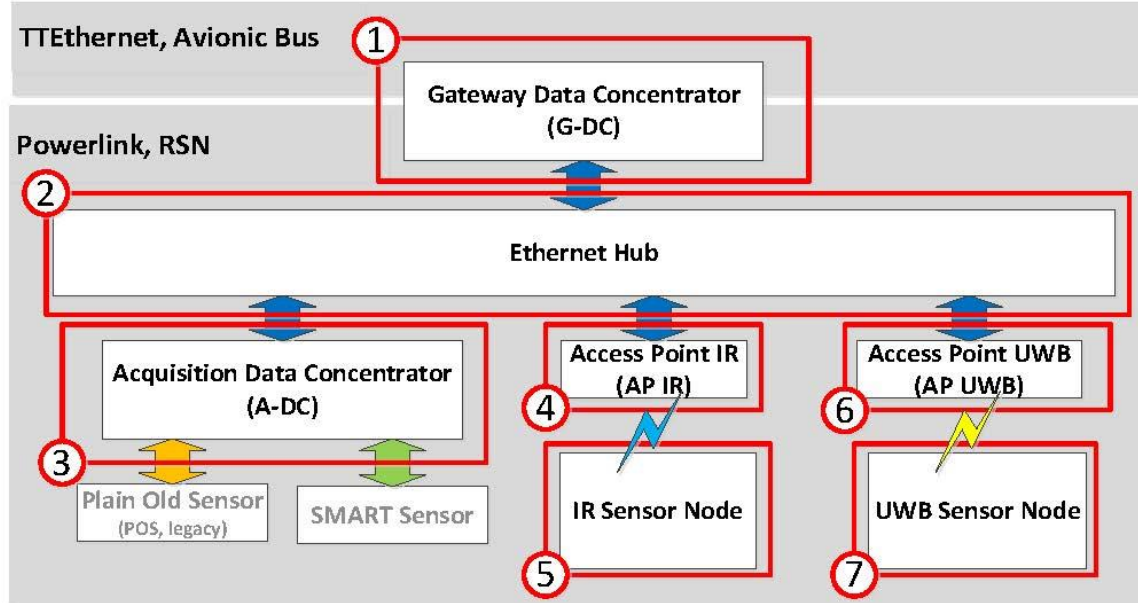
Open Innovation by IMEC and TNO



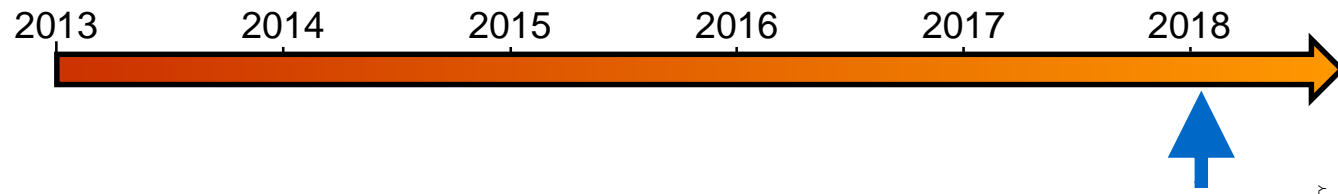
RSN, what we have done

- Proper function of RSN Functional Demonstrator shown
(End to End including TTEthernet Avionic Bus Communication)
- Function of IR and UWB wireless technologies shown
in electromagnetic representative Launcher environment (VEB)
- Architecture:
 - compatible with Ariane 6
 - compatible with functional sensor needs
(deterministic POWERLINK network inside RSN)
 - compatible with Ariane 5 sensor baseline
(wired part)
 - generic digital interface for SMART (digital) sensors
- Shown current limits of UWB Frontend hardware

RSN Details



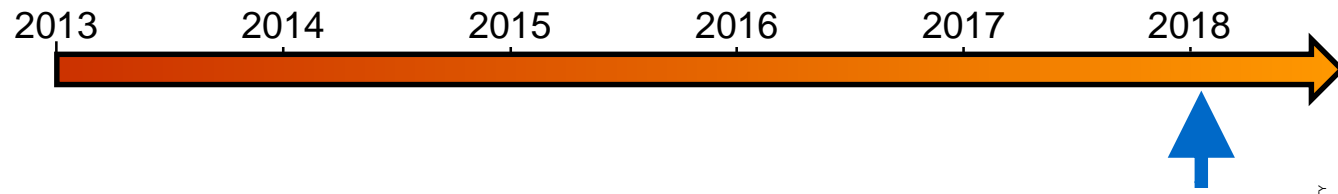
- 1 Gateway Data Concentrator (G-DC) with Interface between Powerlink and TT Ethernet
- 2 Ethernet Network with Hub (used with Powerlink protocol)
- 3 Acquisition Data Concentrator (A-DC) for connection of analog and digital wired sensors
- 4 Access Point Infrared (AP IR)
- 5 IR Sensor Node
- 6 Access Point UWB (AP UWB)
- 7 UWB Sensor Node



CDS, Romania

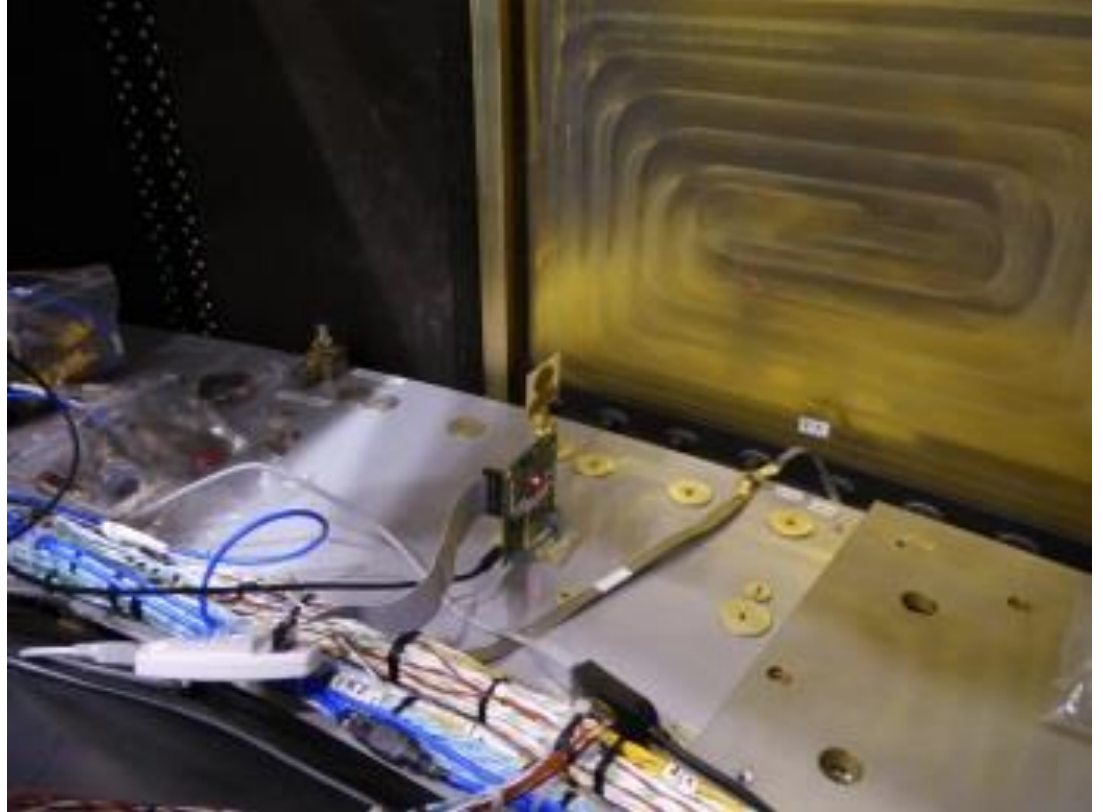
- ISA 100.11a Protocol
- COTS UWB frontend

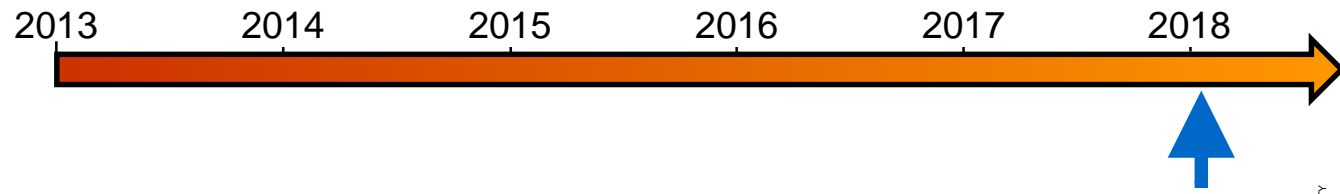




Airbus

- Customized Protocol
- COTS UWB frontend



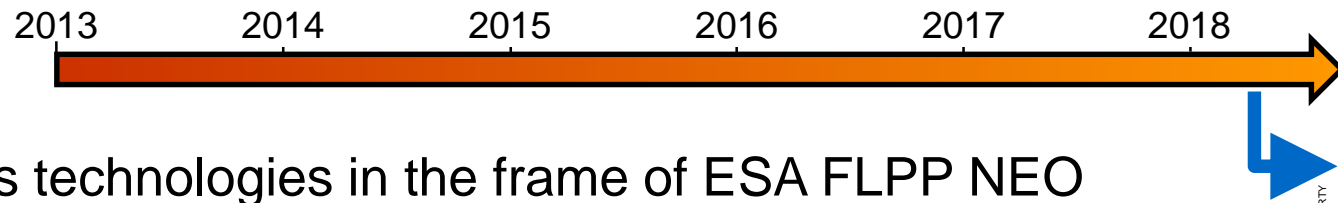


IHP

- Own protocol
- Own UWB frontend



Next to come



- Maturation of wireless technologies in the frame of ESA FLPP NEO

1

Wireless for Ariane 6 and beyond



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Résumé

- **Infrared, Narrow Band** and **UWB** usable inside Ariane Launcher ✓

- Hardware Maturation needed - 

- **Wireless is the future!**



Thank you for your attention!



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LET'S FLY TOGETHER!

For further discussion
feel free
to contact me:

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Engineering
Upper Stage Avionics

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Backup Area

Enter on your own risk!