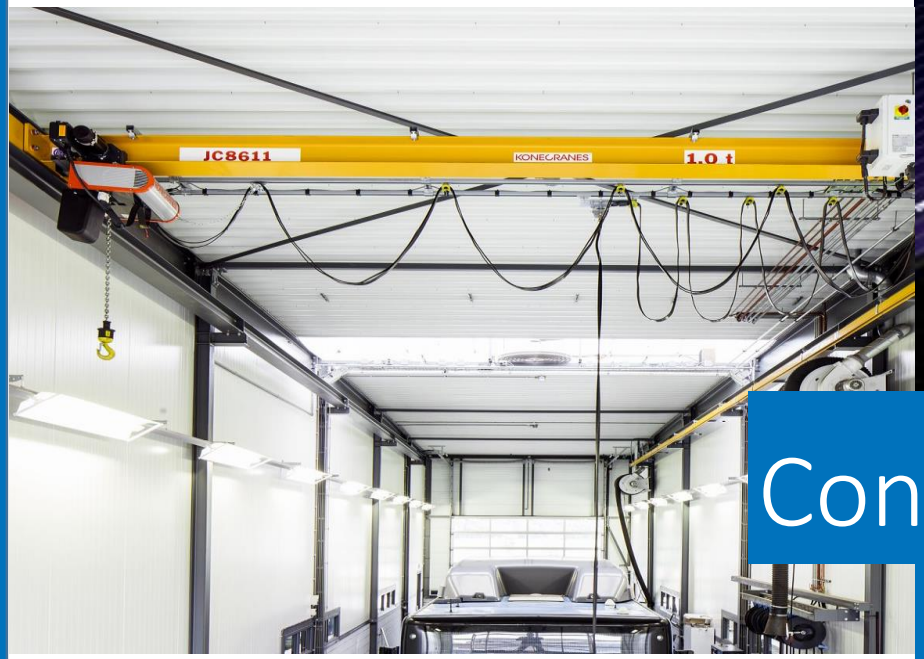
ISA100 Wireless for Control Applications

ISA100 Wireless End User Conference
Rotterdam, The Netherlands
27th September 2016

Andrei Rusu, CDS Wireless



Control Data Systems

Industrial Wireless Communications

Use case 1 – **Industrial Remote Controls**

End User is **IKUSI VELATIA SPAIN**, Remote Controls Division

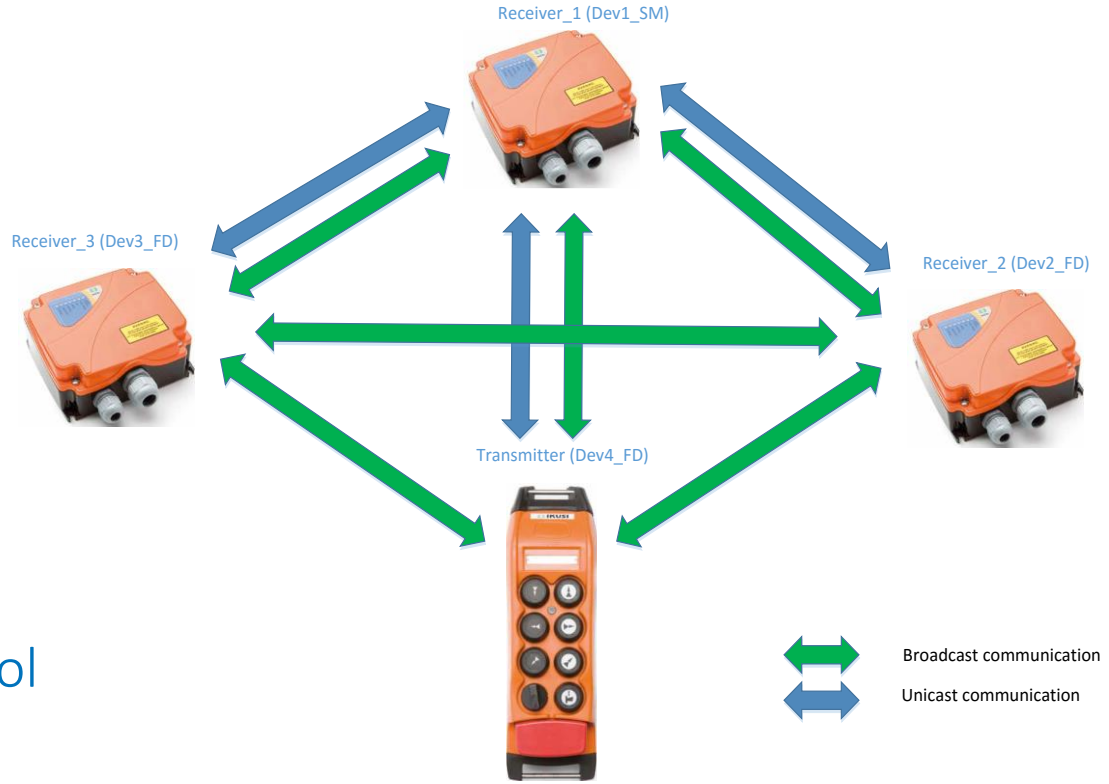
Remote Controls operate Industrial Cranes and Lifts

Requirements and planning:

- Reliability
- Low latency
- Security
- Fast startup
- Star network topology with 4 devices (usually)
- Line powered SM
- Battery powered nodes

ISA100 Remote Control – Solution

- **ISA100 Wireless** was selected for solving the problem
- API flexibility
- ISA100 Wireless data frame covers the needed bandwidth
- One node has the role of **System Manager**
- **Any** node can be selected as System Manager
- Each node follows the ISA100 standard **join process**
- The join process takes **less than 1s**
- There are 2 types of **ISA100 messages** used:
  - **Unicast** messages are used for management
  - **Broadcast** messages are used for process control
- Application processor developed by the end user
- Minimum standard modifications



ISA100 Remote Control - Solution

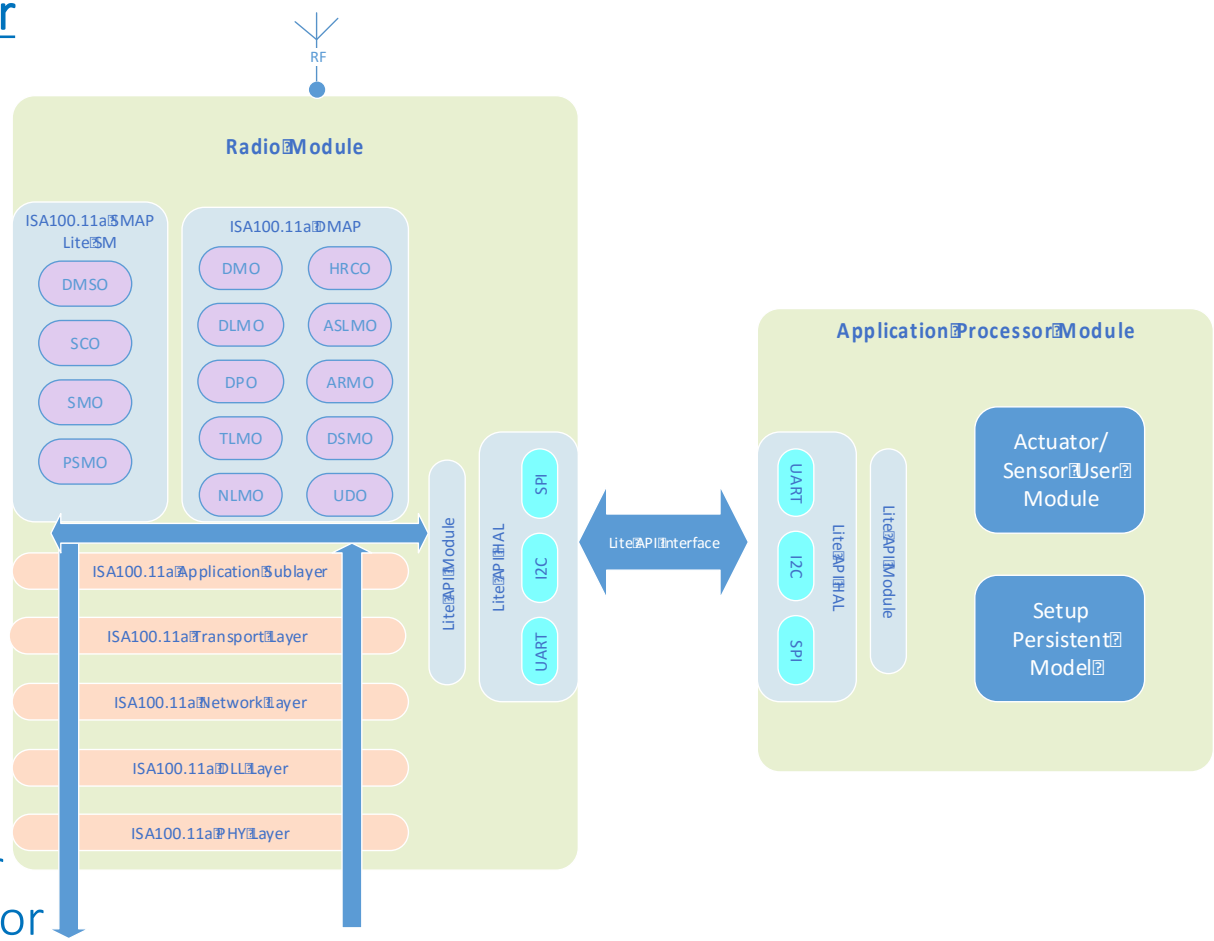
- ISA100 TDMA mechanism is used to avoid message collisions
  - Time is divided in 10 ms timeslots
  - Time slot sequence repeats after 12 slots
  - 3,000 time slots make a superframe
  - Each time slot has a dedicated role:
    - Advertisement
    - Shared transmission
    - Reception
- ISA100 Channel hopping mechanism is used to avoid interference
  - 16 channels available
  - Blacklisting mechanism

Advertisement Tx
Shared Tx for Join Response or unicast DPDU for each FD
Shared Tx for Join Request
Generic Rx
Broadcast Shared Tx and Generic Rx(lower priority)

SuperframeOffset	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	… 2999
Device_1(SM)																
Device_2(FD)																
Device_3(FD)																
Device_4(FD)																

ISA100 Remote Control - Solution

- The ISA100 Network is controlled by a **System Manager**
- Traditionally the System Manager is running on a **large computer system**
- **ISA100 Wireless** can be optimized for a particular application
- A light version (**Lite SM**) of the System Manager was developed specifically for this project
- The Lite SM can run on an **embedded platform**
  - 32 bit **ARM Cortex M3** processor
  - **91 KB** Flash (code)
  - **72 KB** RAM
- **Any node** in the network can become the Lite SM
- The Lite SM communicates via a **Lite API** interface over **UART, SPI and I2C** with an external Application Processor

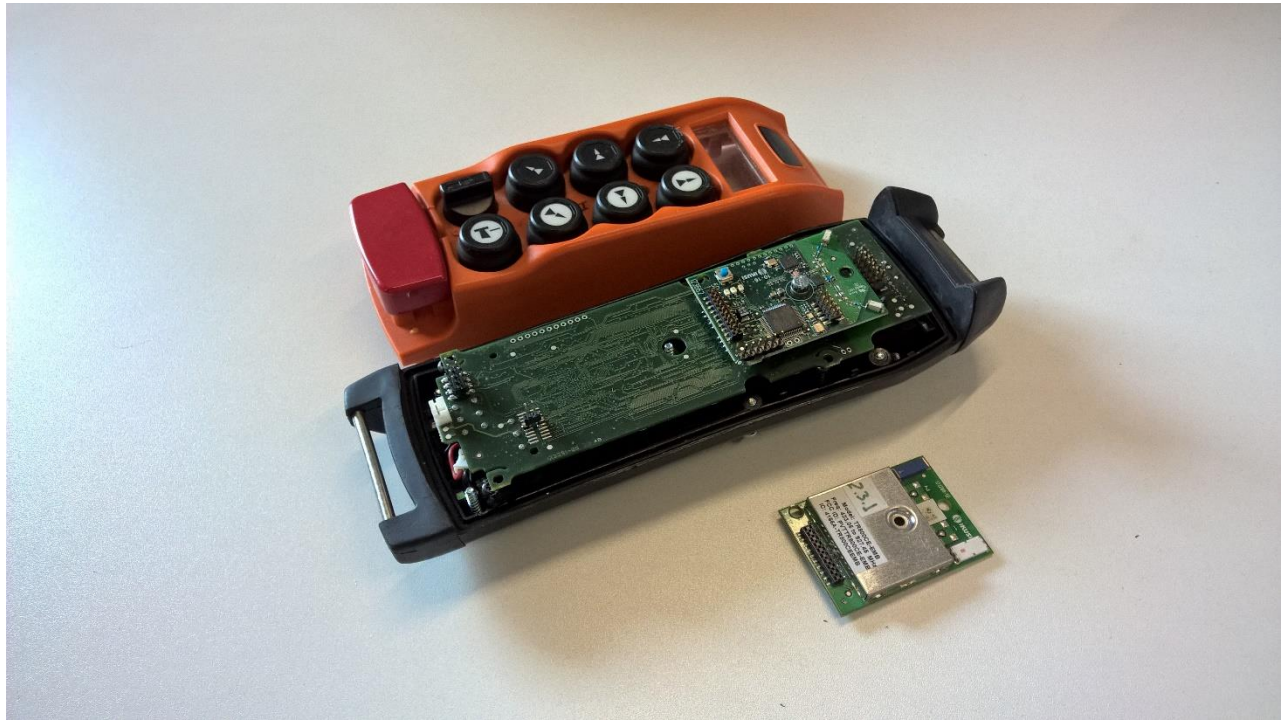


ISA100 Remote Control – Operation

- The Lite SM capabilities (maximum size network) have been estimated at
  - 150 nodes
  - 200 links
  - 120 control packets in Queue
- Using a setup of 1 Transmitter and 3 Actuators the following performance was measured:
  - Join Duration for the entire network from power on: ~1 second
  - Minimum granted discovery duration = 380 ms
  - Control packet latency with no retry at DLL level: ~20 ms
  - Clock synchronism between any 2 nodes: < 100 us
- Future improvements
  - A Dynamic Persistent Model will support control applications for larger, mesh networks

ISA100 Remote Control – Operation

- Standard firmware upgrade
- Device diagnostics on SM
- One time radio configuration via the Persistent Model
- Channel blacklisting
- Easy replacement of a faulty radio
- Adaptive channel usage

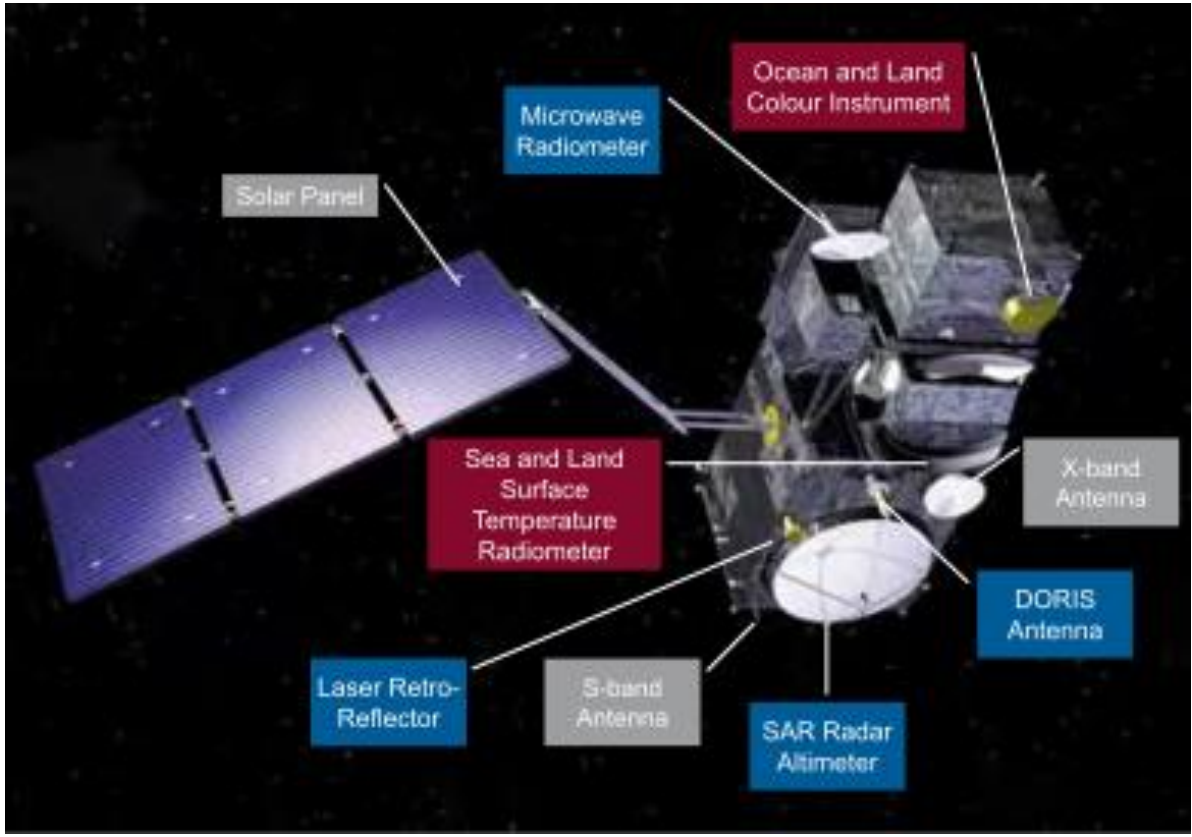


Use case 2 – Intra-Satellite Communications

End User is the **European Space Agency (ESA)**

Planning and requirements

- Node dimension and emission restrictions
- 2 meters inside the S/C for communication
- Low power to minimize reflections
- Guaranteed 16 KB/s bandwidth from 3 sensors
- Signal quality vs. node positioning
- Star topology
- Same hardware for all types of nodes
- Guaranteed 5 KB/s bandwidth for one actuator



Intra-Satellite Communications - Advantages

Wireless advantages

- Reduction of mass
- Lower assembly cost

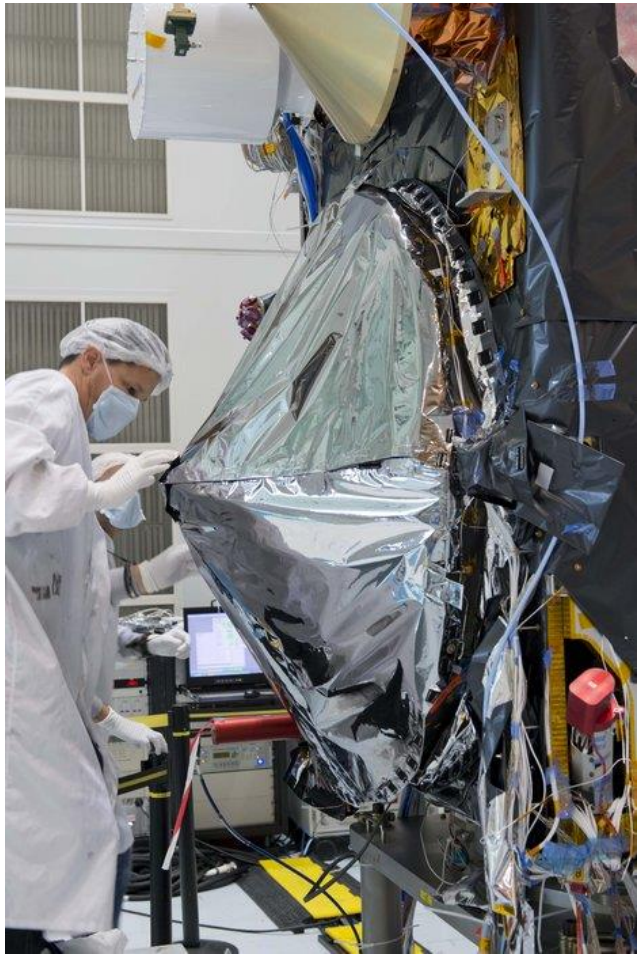
ISA100 Wireless advantages

- Node time synchronization
- Network extensibility
- Path redundancy
- Low latency

Intra-Satellite Communications - Integration

Equipment integration

- Node UART interface to connect the sensors
- Additional interfaces are available (SPI, I2C)
- SpaceWire and CAN via adapters
- The BBR/SM forwards the data to the central control system
- Emission and radiation tests to remove interference with on-board equipment



Intra-Satellite Communications - Solution

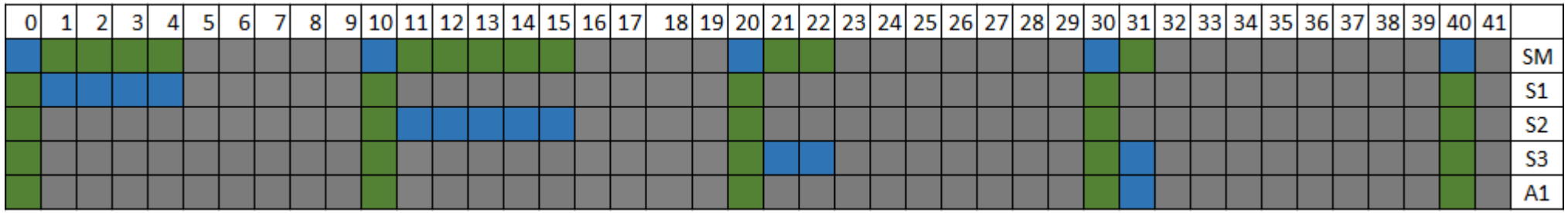
Due to the **flexibility** of the ISA100 Wireless standard, the following solution was applied to meet the requirements:

- **Replacement of the physical layer**
  - The 802.15.4 2.4 GHz PHY layer was replaced with **802.15.4 UWB (Ultra Wide Band)**
  - The data rate was increased from 250 Kbps to **6.8 Mbps**
  - This **high data rate** allows the transmission of data generated by the satellite instruments and sensors
- **Increase of the packet size**
  - The packet size was increased from 127 B to **1023 B** in order to optimize the network for traffic size
- **Superframe duration**
  - Increased from 250 msec to 1 sec

Intra-Satellite Communications - Operation

- 5 node network
  - 1 BBR/SM
  - 3 sensors
  - 1 actuator
- Test performed on 2 satellite mock-ups
  - Venus Express (at ESA)
  - Sentinel 3 (at CDS)

Legend	
Idle slot	
Receive slot	
Transmit slot	



Intra-Satellite Communications - Conclusions

- **ISA100 Wireless** is suitable for Intra Satellite Communications
  - The ISA100 Wireless network can handle the required **data throughput** which is 126,472 bps or 15,809 Bps (15.43 KBps) generated by the sensors and instruments
  - The ISA 100 Wireless network meets the **required latency** of less than 1s with actual number of **less than 1 ms**
  - The ISA100 Wireless network is **resistant** to interference and **does not interfere** with on board instruments and equipment

- The ISA100 Wireless network is **flexible** enough to allow for
  - PHY layer change to UWB with 6.8 Mbps data rate
  - **Data throughput optimization** by using the 1023 B frame length, in case priority is given to data acquisition from instruments
  - **Latency optimization** by using the 127 B frame length, in case priority is given to control of actuators

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