



# Ethernet for Space with TSN (Time Sensitive Networking)

ADCSS 2019

DEFENCE AND SPACE

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13 Nov. 2019

**AIRBUS**

# Context

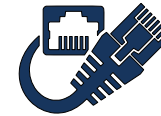
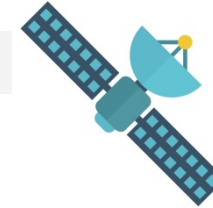
## On board communications

Direct data links, buses and networks:

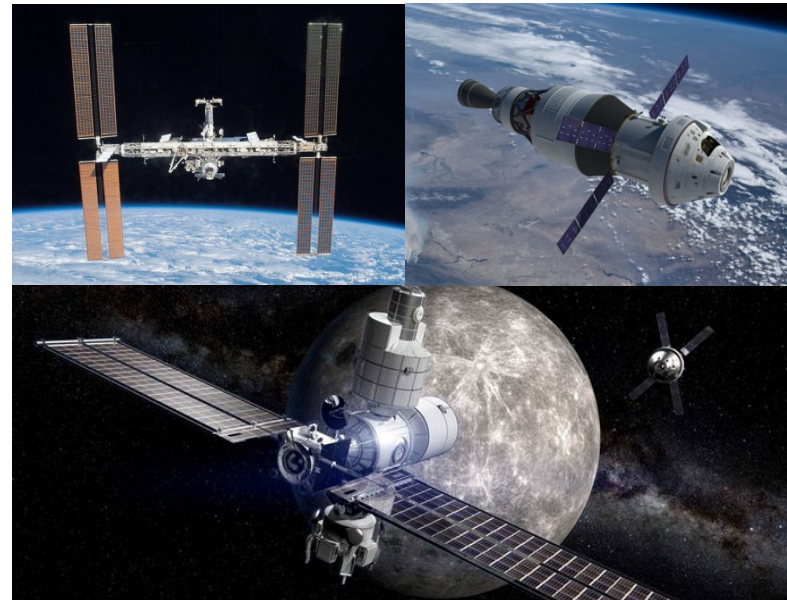
- 1553 for platform and payload control
  - SpaceWire for Payload data
  - Can bus
  - RS422
- + others standards and specific links...



SpaceWire2



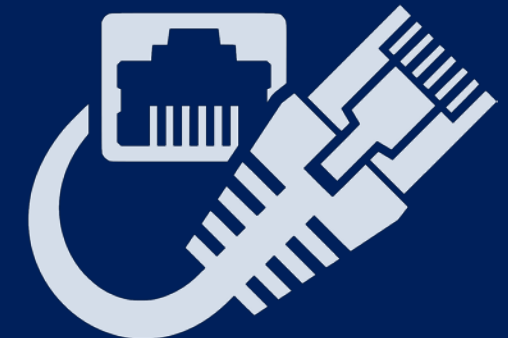
# Ethernet



# Ethernet for Space

Ethernet (IEEE.802.3)

Time Triggered Ethernet (SAE AS6802)



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I definitely need more Bandwidth with better Quality of Service

# Three good reasons for developing Ethernet for Space

01

## Market

- Ethernet is a Worldwide technology, with a dynamic market
- High number of COTS and low cost components
- Plenty of test equipment available
- Plenty of highly skilled and trained people and labs

02

## Maturity

- Billions of Ethernet devices in all kinds of applications
- Standard Ethernet used in space for 20 years (International Space Station)
- Switched Ethernet networks used in critical applications - Millions of hours of flight on Aircrafts with AFDX
- Used with TTE protocol on launchers and manned flight (Ariane 6 and Orion/MPCV) - Flight devices

03

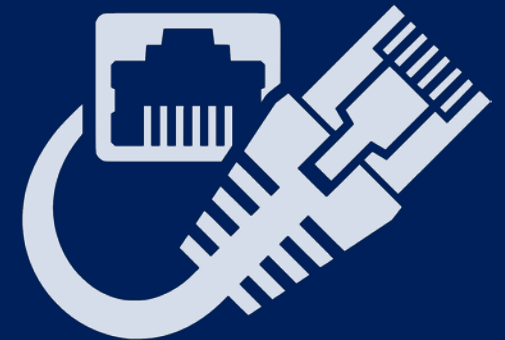
## Synergies

- Using industrial standards in general reduces costs through trans-domains synergies
- Ethernet TTE is likely to be widely used on all Lunar exploration systems
- Ethernet TSN is already baseline for communication system on MIURA micro launchers
- Ethernet TSN is targeting autonomy on critical applications such as Automotive

**We expect a wide development of TSN products & ecosystem**

# Ethernet for Space TSN

## Time Sensitive Networking



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## TSN for Space application

- Studies on the suitability of Time Sensitive Networks technology for the space usage
- Presented by Franck Wartel

## TSN Networks Test system

- ESA Study led by TELETEL for adapting the iSaft Product to the TSN standard
- Presented by Vangelis Kollias

**Optional**  
 > IEEE 802.1Qch

**Mandatory:**  
 > IEEE 802.1AS & 802.1AS-rev  
 > IEEE 802.1Qci  
 > IEEE 802.1Qbv  
 > IEEE 802.1Qav  
 > IEEE 802.1CB  
 > IEEE 802.1Qcc + Yang  
 > IEEE 802.1Qbu & 802.3br

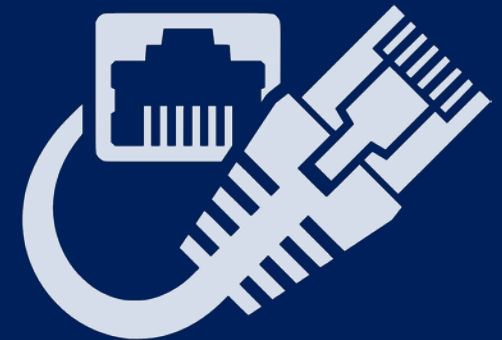
**Not requested:**  
 > IEEE 802.1Qat  
 > IEEE 802.1Qcc  
 > IEEE 802.1Qca

## TSN SPACE PROFILE



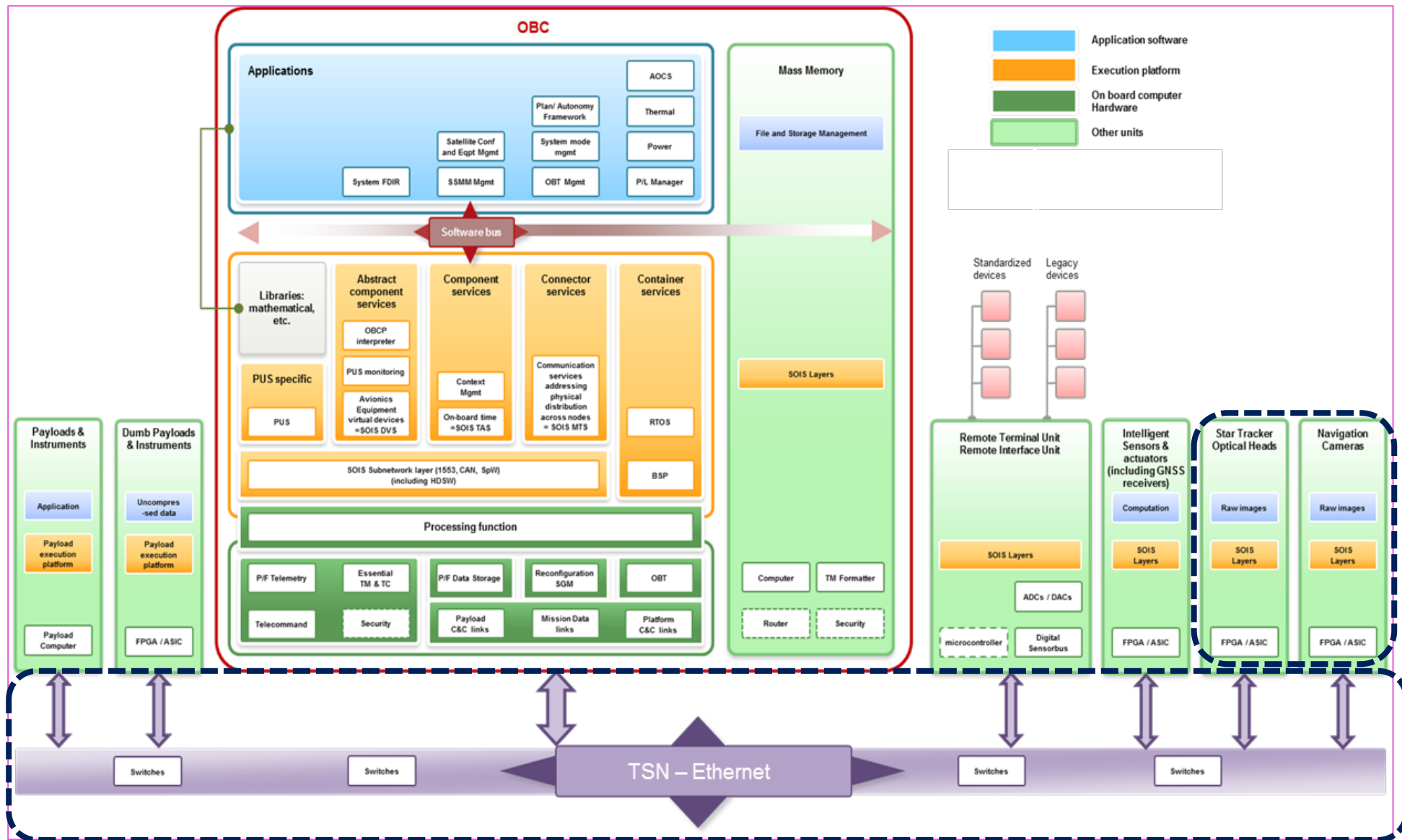
# TSN

## Time Sensitive Networking



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# Modified SAVOIR Reference Architecture



New equipments providing high volume of data (Raw images)

Unified Switched Network (Ethernet/TSN)

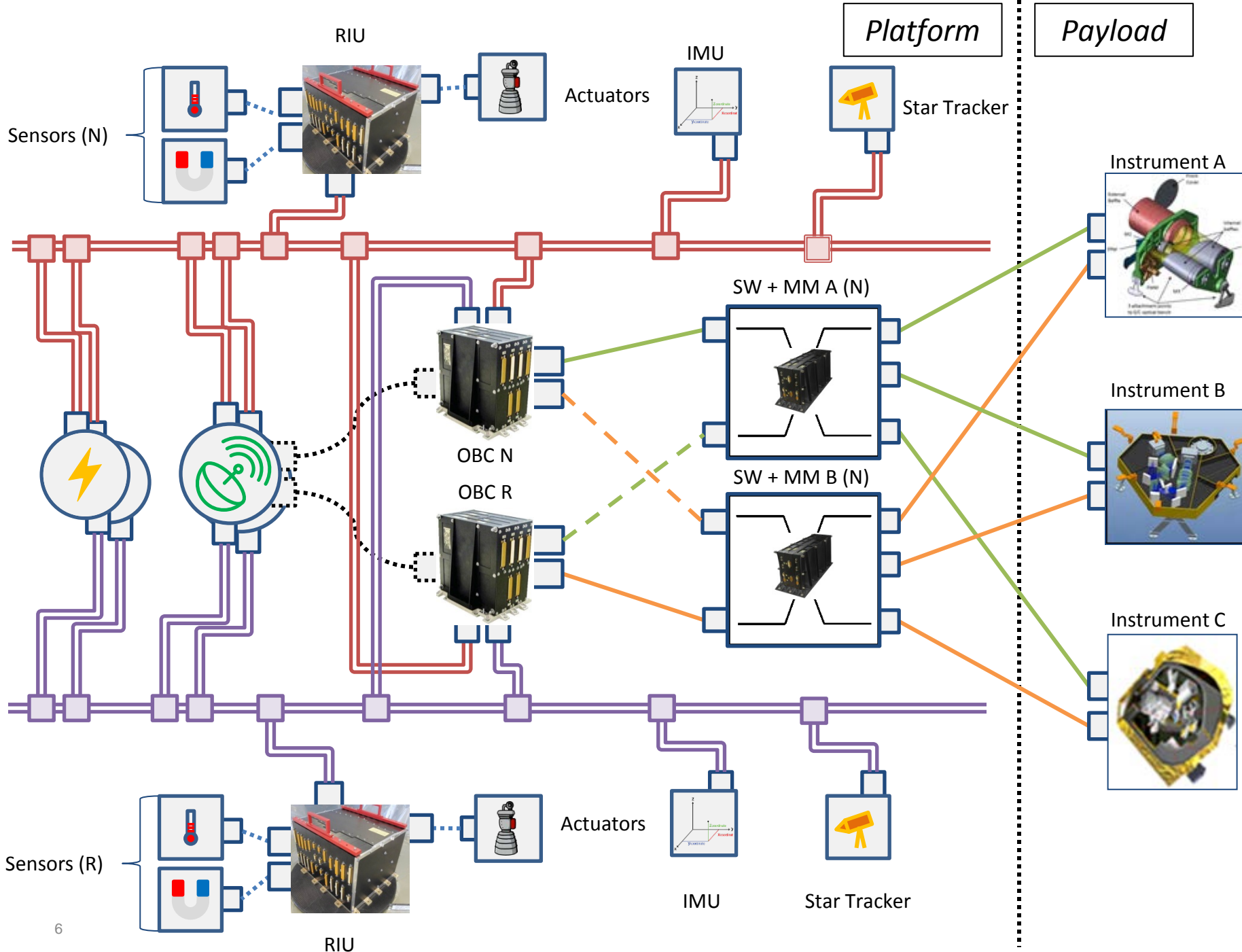
# Current Generic HW architecture

## Platform

- Low Latency, low jitter, guarantee of arrival
- Cold/Hot Redundancy
- 1553, CAN, SpaceWire

## Payload

- High average throughput, guarantee of arrival
- Cold/Hot Redundancy
- SpaceWire, SpaceFibre, Custom P2P



# TSN as unified network ?

## Challenge

Is TSN a superset of 1553 + SpaceWire i.e. is it possible to satisfy both platform and payload requirements using the same technology in a Unified Ethernet/TSN Network ?

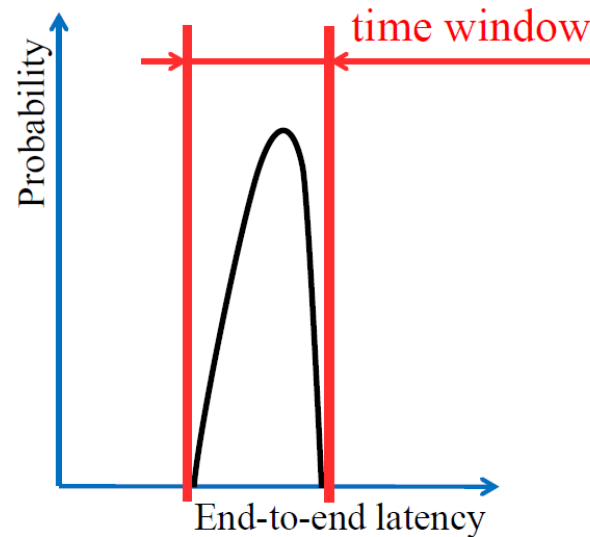
## Organization

In order to answer that question, two aspects have to be analysed:

- ① Which protocols/features should be used ? Which protocols should be avoided ?
  - ① What are the protocols offered by TSN ?
  - ② What are the requirements of the satellite network ?
  - ③ What is the minimum subset of TSN protocols allowing to satisfy these requirements ?
- ② What is a good and valid topology ?

# TSN Promises

- Deterministic data packet delivery =
- Data packet delivery within a **time window** without loss or delay due to congestion or errors



**Determinism = Guaranteed Delivery with Bounded delay and jitter**

*(Standards from IEEE, IETF, 3GPP, and Beyond – TSN/A Conference 2019)*



# TSN QoS

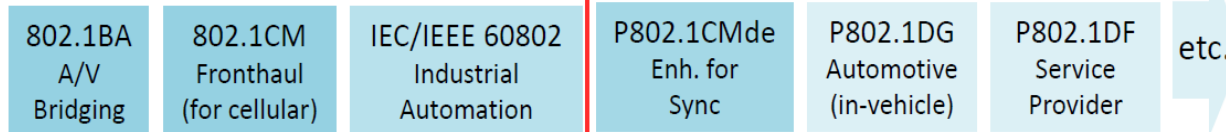
## OSRA-NET Traffic Classes

Class	Freq. scale (Hz)	Data Rate scale	Jitter	Latency	Level of determinism	Timestamp
	Min-Max	Min-Max	ms	ms	Low/Medium/High	Mandatory/Optional
1	0,1-1	100bits/s -10 kbits/s	10	10	Medium	Optional
2-a	8-10	< 1 Mbits/s	5-10	10	High	Optional
2-b	8-10	< 1 Mbits/s	5-10	10	Medium	Mandatory
3	8-10	< 250 kbits/s	10	10	High	Optional
4	0,1-1	> 100 Mbits/s	<100	<100	Low/Medium	Optional
5-a	10-1000	< 3 Mbits/s	0,5-1	0,5	High	Optional
5-b	10-1000	< 3 Mbits/s	0,5-1	0,5	Medium	Mandatory
6	1-10	> 100 Mbits/s	2	10	High	Mandatory
7	1-10	100 bits/s-1 kbits/s	1	2	High	Optional

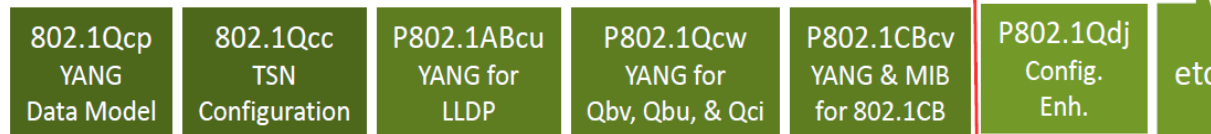
### Determinism with support for Mixed Criticality

# IEEE 802.1 TSN Progress

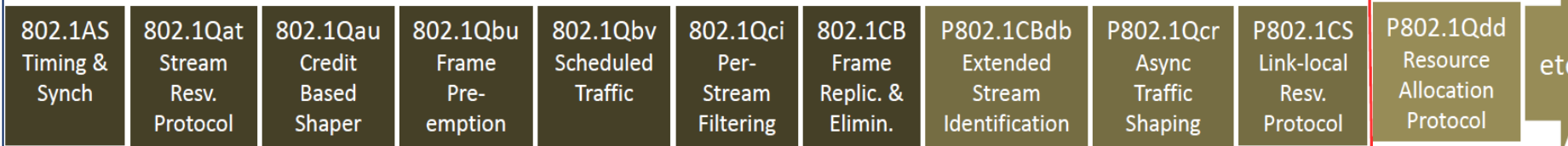
## Profiles:



## Configuration:



## Base technology:

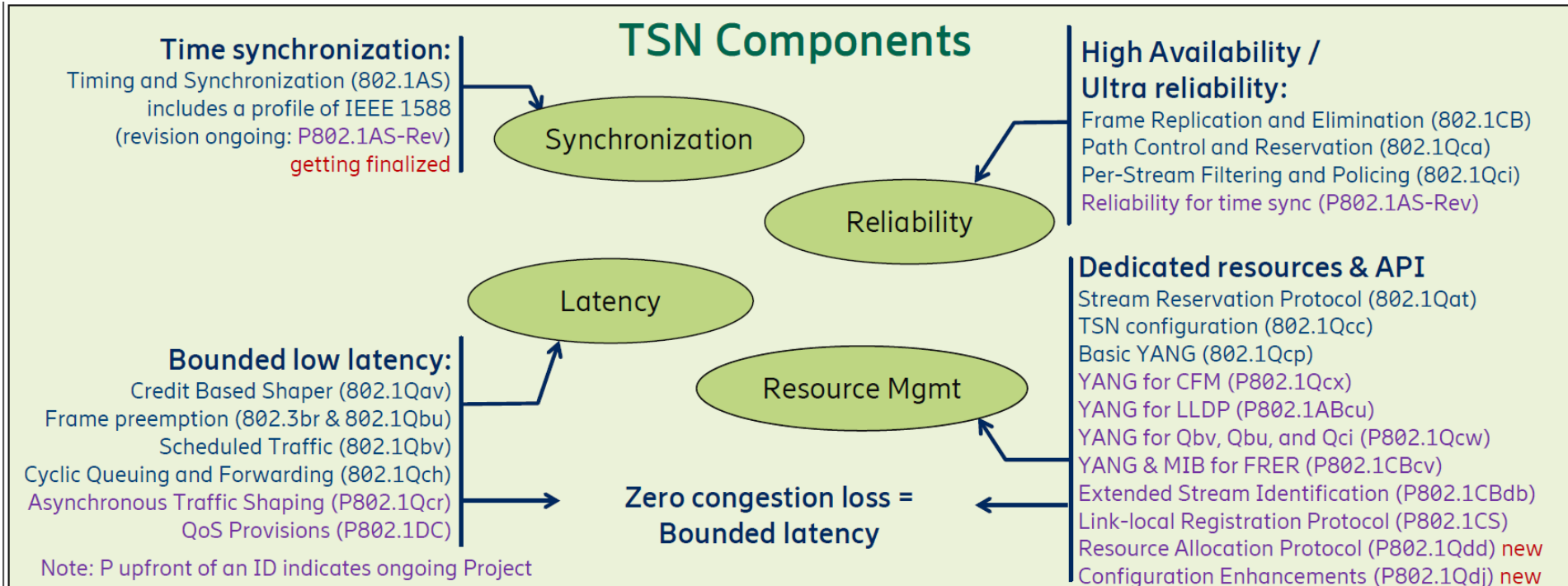


TSN/A 2018 time

# TSN Progress

(Standards from IEEE, IETF, 3GPP, and Beyond – TSN/A Conference 2019)

# TSN Pillars



(Standards from IEEE, IETF, 3GPP, and Beyond – TSN/A Conference 2019)

### Optional

- IEEE 802.1Qch

### Mandatory:

- IEEE 802.1AS & 802.1AS-rev
- IEEE 802.1Qci
- IEEE 802.1Qbv
- IEEE 802.1Qav
- IEEE 802.1CB
- IEEE 802.1Qbu & 802.3br
- IEEE 802.1 Qcc (static)
- YANG Data Models



### Not requested:

- IEEE 802.1Qat
- IEEE 802.1Qcc (dynamic)
- IEEE 802.1Qca

# Time for a Space Profile ?

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# TSN SPACE PROFILE

WIP 2012-01-17

## Aerospace TSN Profile AS6675

Develop a profile of the TSN set of standards that is applicable to Avionics use cases, including AS6509 CAIN

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### Related Info

**Issuing Committee:** [As-1a Avionic Networks Committee](#)

**Rationale:** Separating the TSN profile from the body of the AS6509 allows for its reuse in other avionics applications of the TSN standard with diverging use cases from AS6509 CAIN (E.g.: Civil aircraft use cases)

# AeroSpace Profile ?

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We are not alone !



# Foreseen ADS Demon- strator

Steps from legacy  
to full TSN  
awareness

## Ethernet encapsulation

- 1553 / RMAP frames from *platform* and *payload* are encapsulated into Ethernet 802.1Q-**2012** frames
- Legacy Master/Slave paradigm

## Challenge legacy design

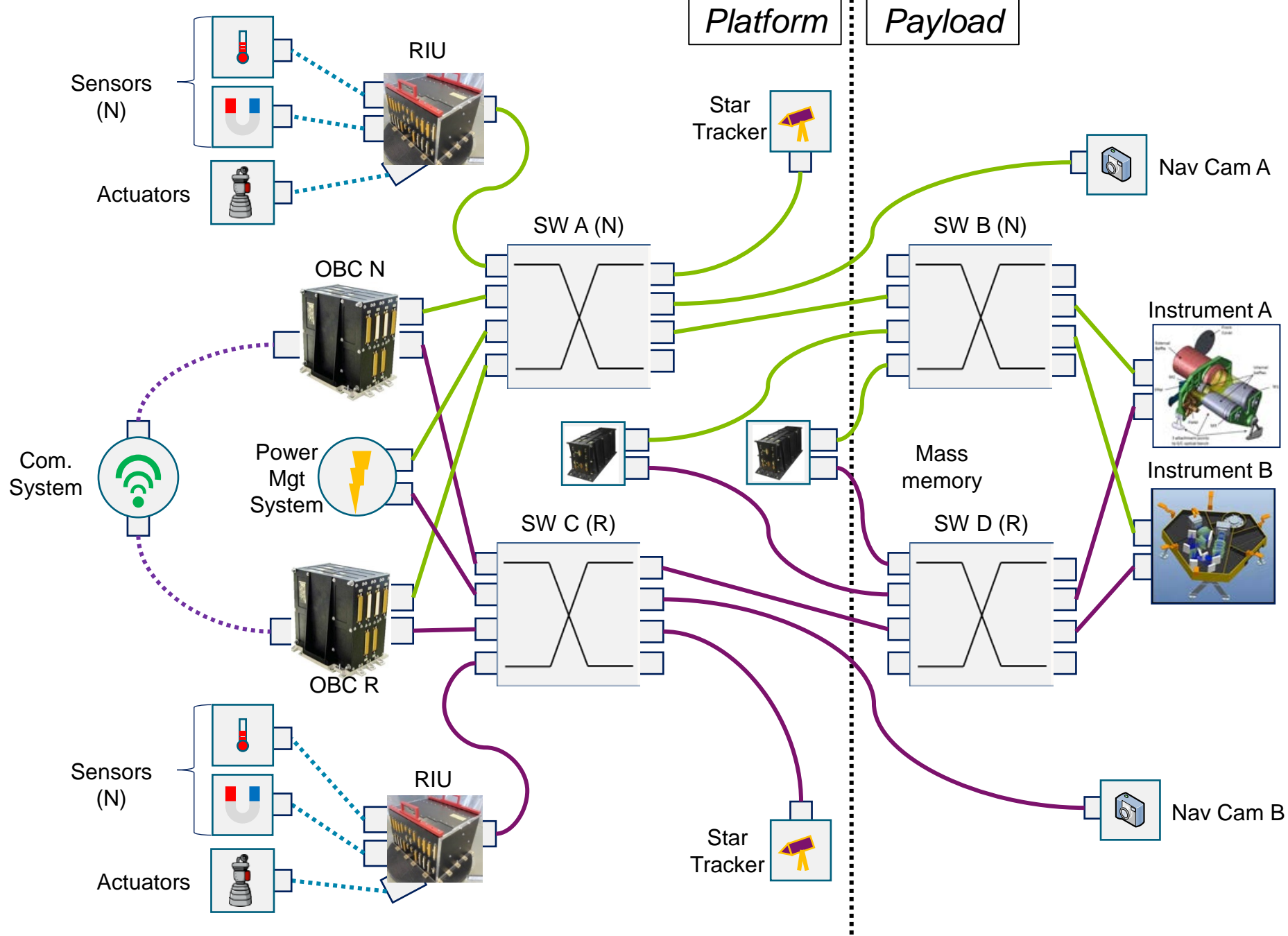
- Move from *pull* to *push* model
- Smart Sensors (timestamped pushed messages)
- Smart actuators (presentation time support)

## TSN for Platform and Payload

- Exploit time distribution, time stamping and traffic shaping/policing
- Keep Master/Slave paradigm

## On-Board Network Req. Analysis

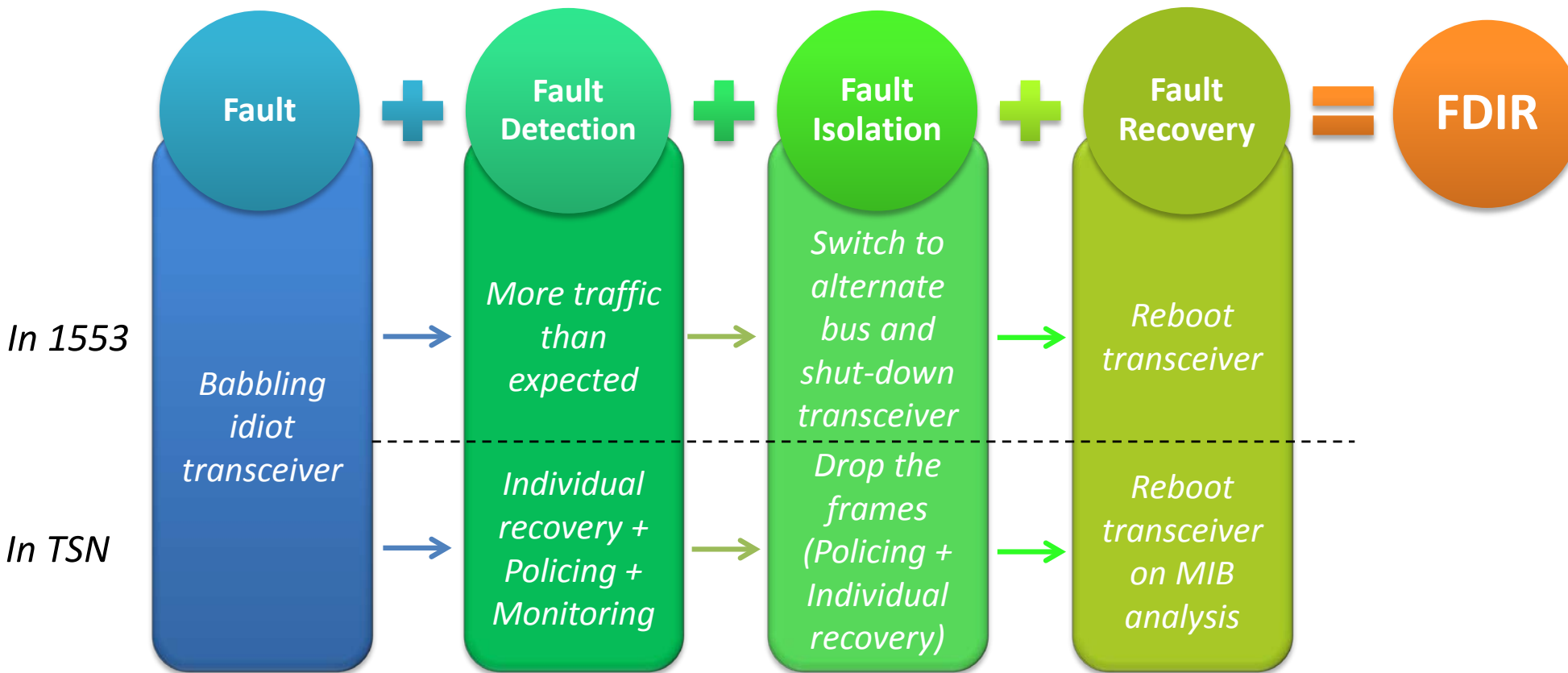
- Identification of actual network constraints i.e. number of streams, throughput, delay and jitter
- Mapping to OSRA traffic classes



# Foreseen ADS Demonstrator

## Topology

# FDIR example with TSN



802.1CB  
(Seamless  
Redundancy)

802.1Qci (Per  
Stream Filtering  
and Policing)

MIB (Management  
Information Base)

## ➤ End Points / Switches

- NXP LS1028A



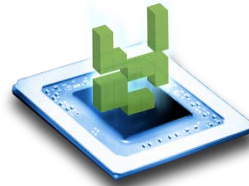
- SoCe MSTN IP + Multiport FMC

<https://soc-e.com/mtsn-multiport-tsn-switch-ip-core>

<https://soc-e.com/products/multiport-fmc-board>



- TTECH EDGE IP + Evaluation PCIe board



<https://www.tttech-industrial.com/products/deterministic-networking/fpga-asic/edge-ip-solution/>

<https://www.tttech-industrial.com/products/deterministic-networking/hardware/evaluation-board>

- Xilinx TSN IP 1GTSN + Ethernet FMC

<https://www.xilinx.com/products/intellectual-property/1gtsn.html>



- MicroChip SAMV71, KZ9477 & LAN937x switches

<https://www.microchip.com/developmenttools/productdetails/atsamv71-xilinx>

<https://www.microchip.com/wwwproducts/en/KSZ9477>



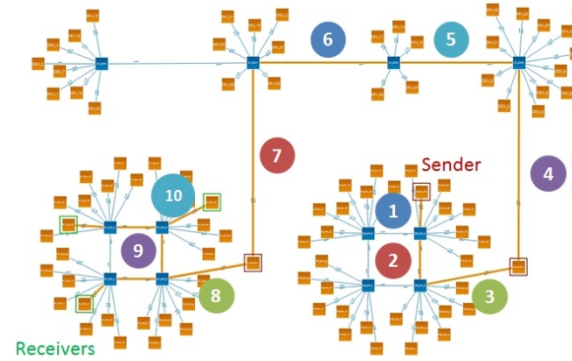
# Hardware Building Blocks

Planned to be integrated in ADS demonstrator

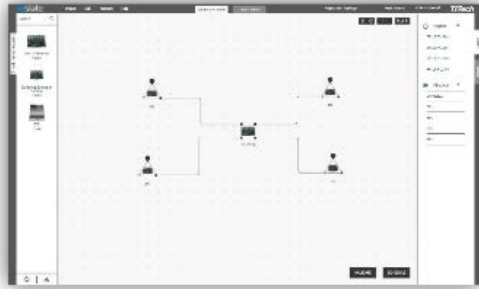
## ➤ Configuration Tools

- RTAW Pegase ZeroConfig-TSN

<http://www.realtimeatwork.com/software/rtaw-pegase>



- TTTech Slate XNS



<https://www.tttech-industrial.com/products/deterministic-networking/network-configuration/slate-xns>

## ➤ Spying Tools

<https://www.profitap.com/profishark-1g-plus>



# Tools Building Blocks

Planned to be  
evaluated in the  
scope of ADS  
demonstrator



## ❑ Airbus Defence and Space

PhD student Pierre-Julien Chaine, Compliance of Ethernet TSN-based solutions with spacecraft industry requirements (PHD 2018-2021)

## ❑ CNES

CCTP DSO/TB/ET/2019-00535: Evaluation of Ethernet TSN as Avionics Network, with THALES ALENIA SPACE and MICROCHIP

## ❑ ESA

Contract “Assessments to Prepare and De-Risk Technology Developments, iSAFT Test Tool for deterministic on-board Ethernet Networks” with TELETEL

# *teletel*



## How To Test TSN ?

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Thank you