Satellite On-board Network Use Case

IEEE P802.1DP/SAE AS6675

DEFENCE AND SPACE

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- **DISCLAIMER**: This presentation should be considered as the personal views of the presenter not as a formal position of AIRBUS DEFENCE AND SPACE
- **CREDITS**: The presentation is exploiting results from ADS internal and ESA/CNES co-funded activities and especially materials from EDEN project currently on-going @ IRT Saint-Exupéry
- EDEN project: https://www.irt-saintexupery.com/wp-content/uploads/2021/03/EDEN-Project.pdf

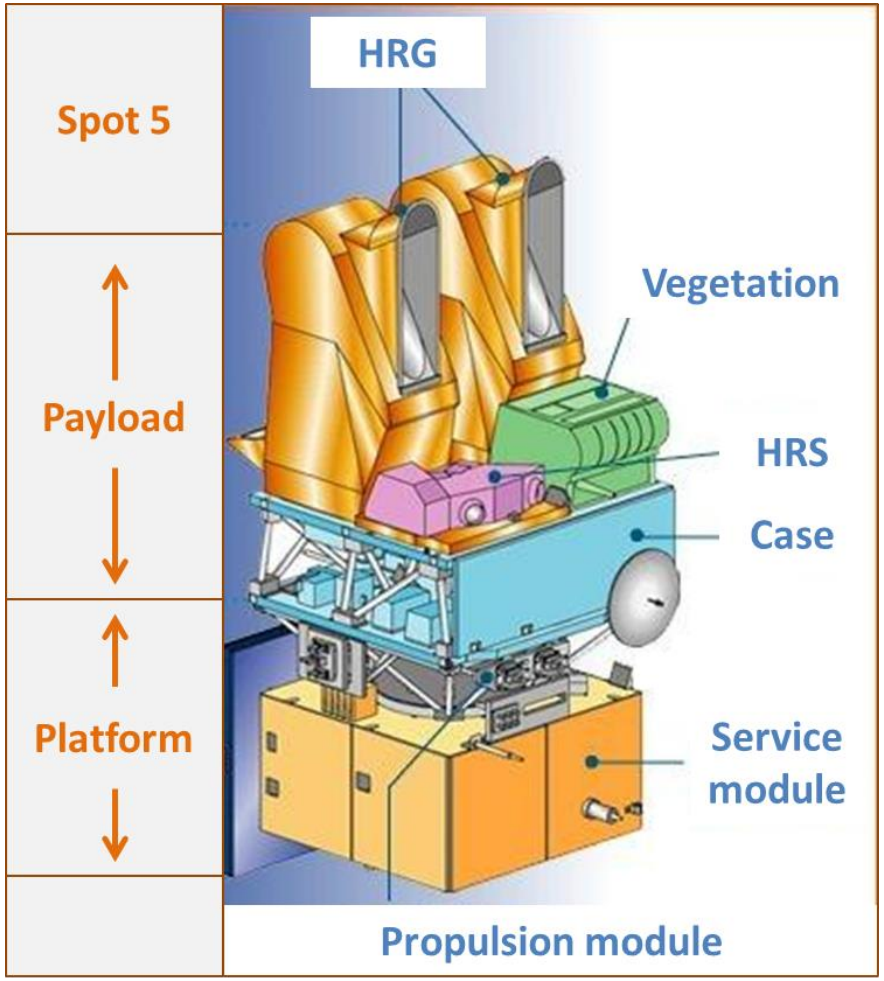
Spacecraft System

- **Payload - *High Performance Domain***
  - Repeaters/Transponders for Telecom satellite
  - Instruments for Scientific Missions
  - Optical Payloads and image processing for Earth Observation

  ⇒ **high data rates / soft real time**

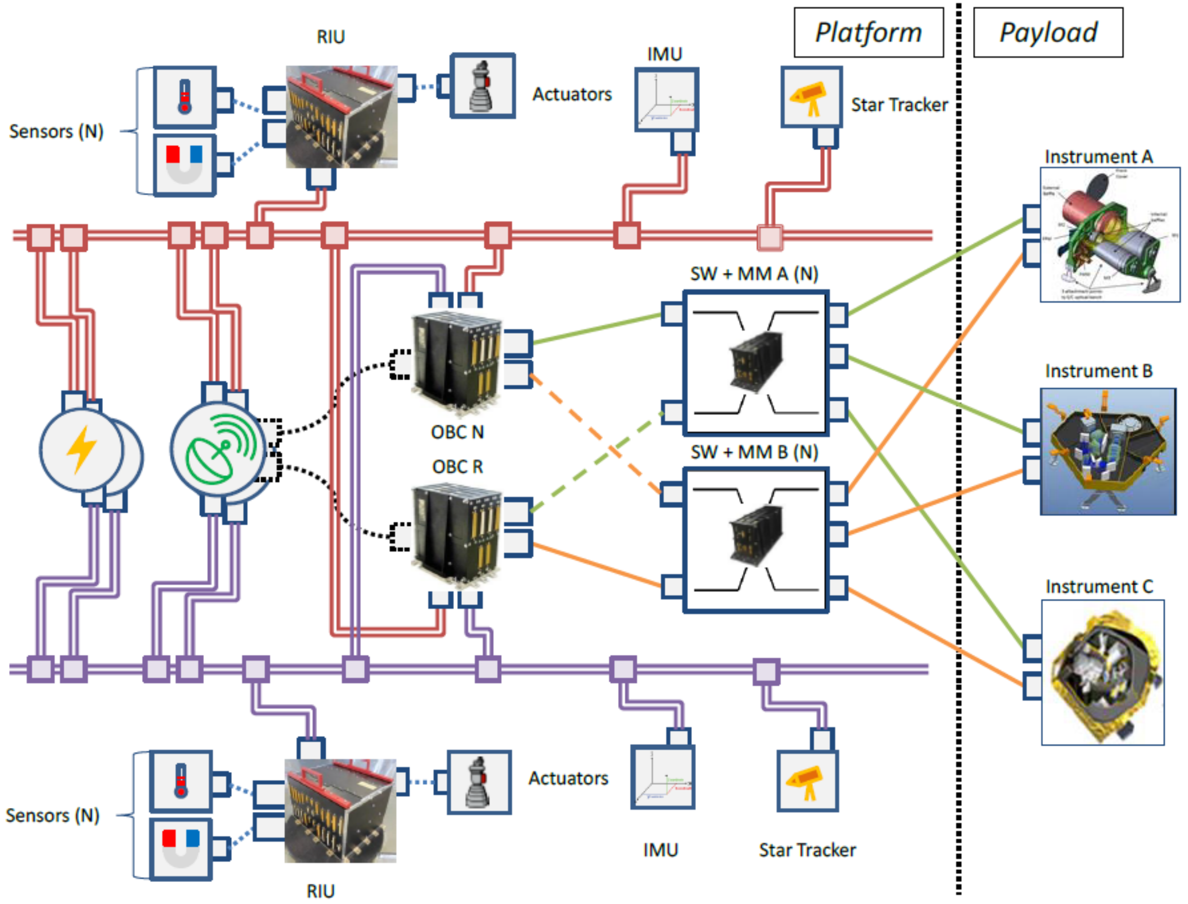
- **Platform - *Time Critical Domain***
  - Attitude Control
  - Power Supply
  - Monitoring and Control of Payload
  - Telecommunication with ground

  ⇒ **low data rates / hard real time**

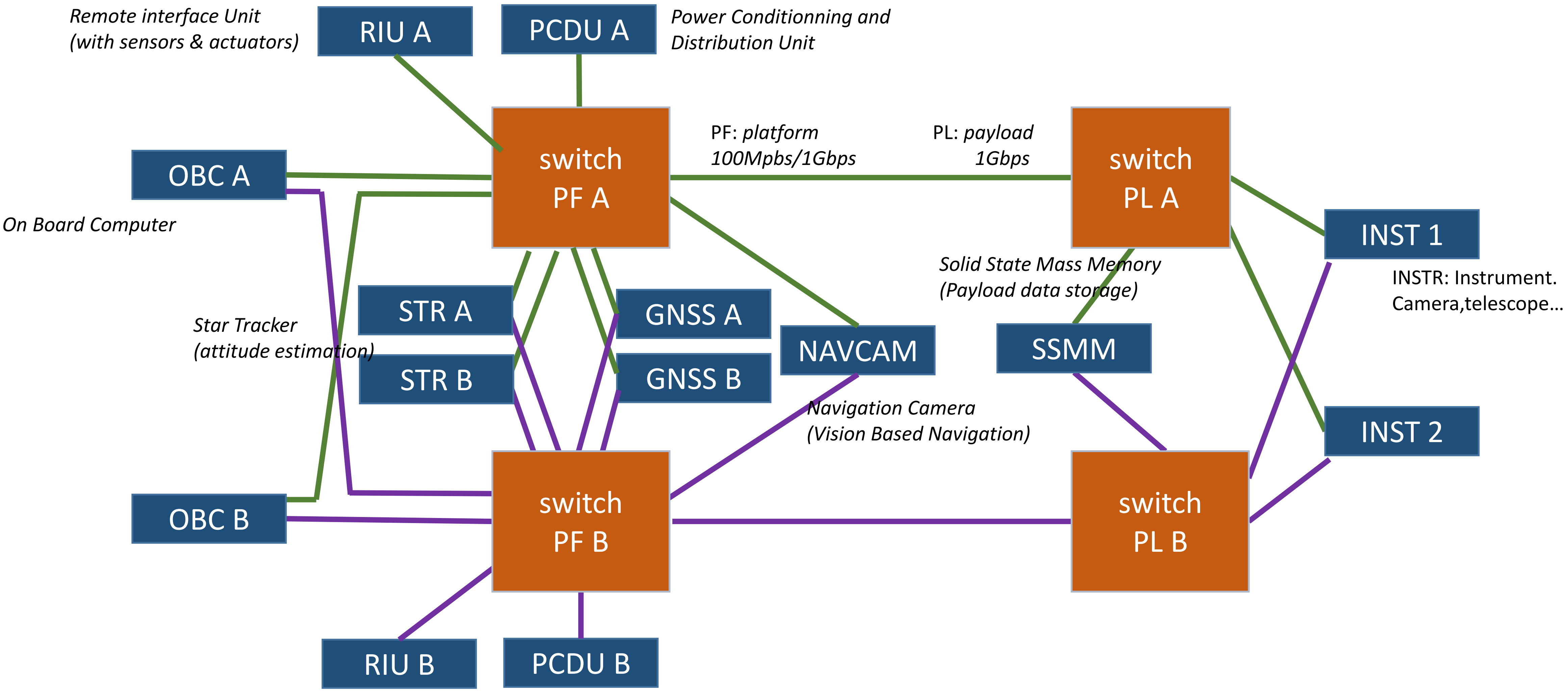


Legacy Networks

	Platform	Payload
MIL-STD-1553 1 Mbps	Command and Control Time synchronisation	Command and Control Time synchronisation
Spacewire 100 Mbps	Data transfer	Data transfer
Dedicated high bw datalink > 1 Gbps	N/A	Data transfer
dedicate discrete wire 1Hz, 8Hz	synchronization	synchronization



Forecasted Representative Topology

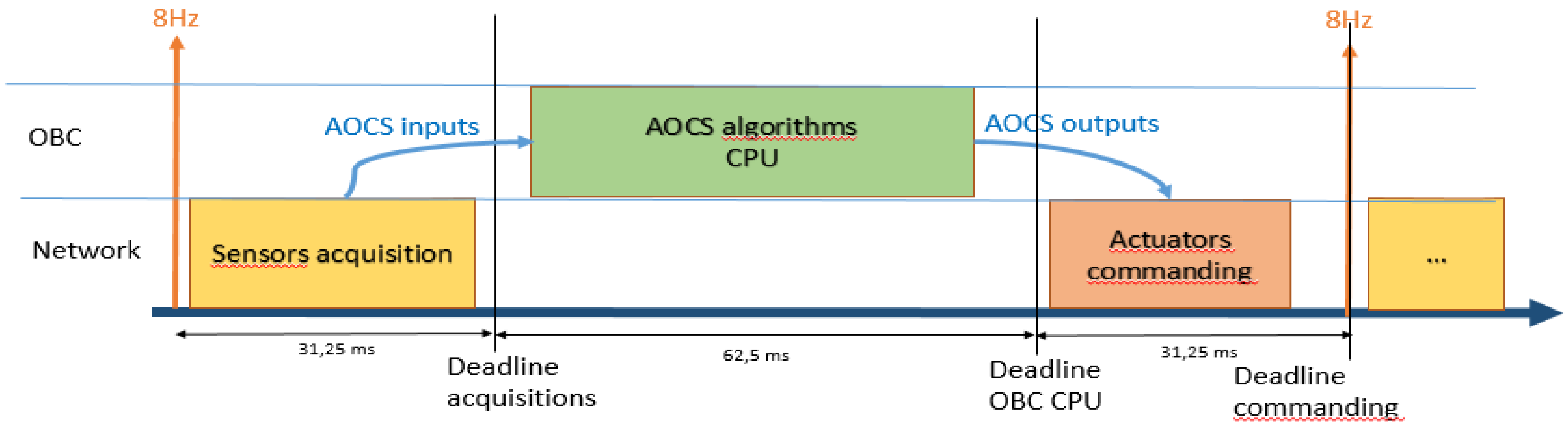


Topology Rationale

- OBC is central, it manages all the network nodes
  - non-intelligent end stations are triggered by incoming commands, including for messages generation (RIU) in a master/slave paradigm where OBC acts as the master
  - intelligent end stations have some autonomy with processing capabilities and are able to generate frames on their own (STR, NAVCAM, GNSS, INST, SSMM)
- Platform and Payload flows are duplicated and follow disjoint paths (excepted RIU, PCDU for use case simplification purpose) to make the system tolerant to
  - loss of a frame,
  - failure of a link,
  - failure of a switch,
  - failure of an end station network interface.
- All the PLAFTORM end stations are duplicated (A/B) to have redundancy for failure tolerance purpose. They are usually in cold redundancy
- PLATFORM OBCs are in cold redundancy
- Switches are in hot redundancy, nominally always ON

GNC/AOCS software control loop

- The GNC (Guidance, Navigation and Control) or AOCS (Attitude and Orbit Control System) is the part of the OBC software that is responsible for the satellite flight management.
- This software processing is executed cyclically with sensors acquisitions done at the start of the cycle, in order to produce actuator commands that must be received before the end of the cycle.



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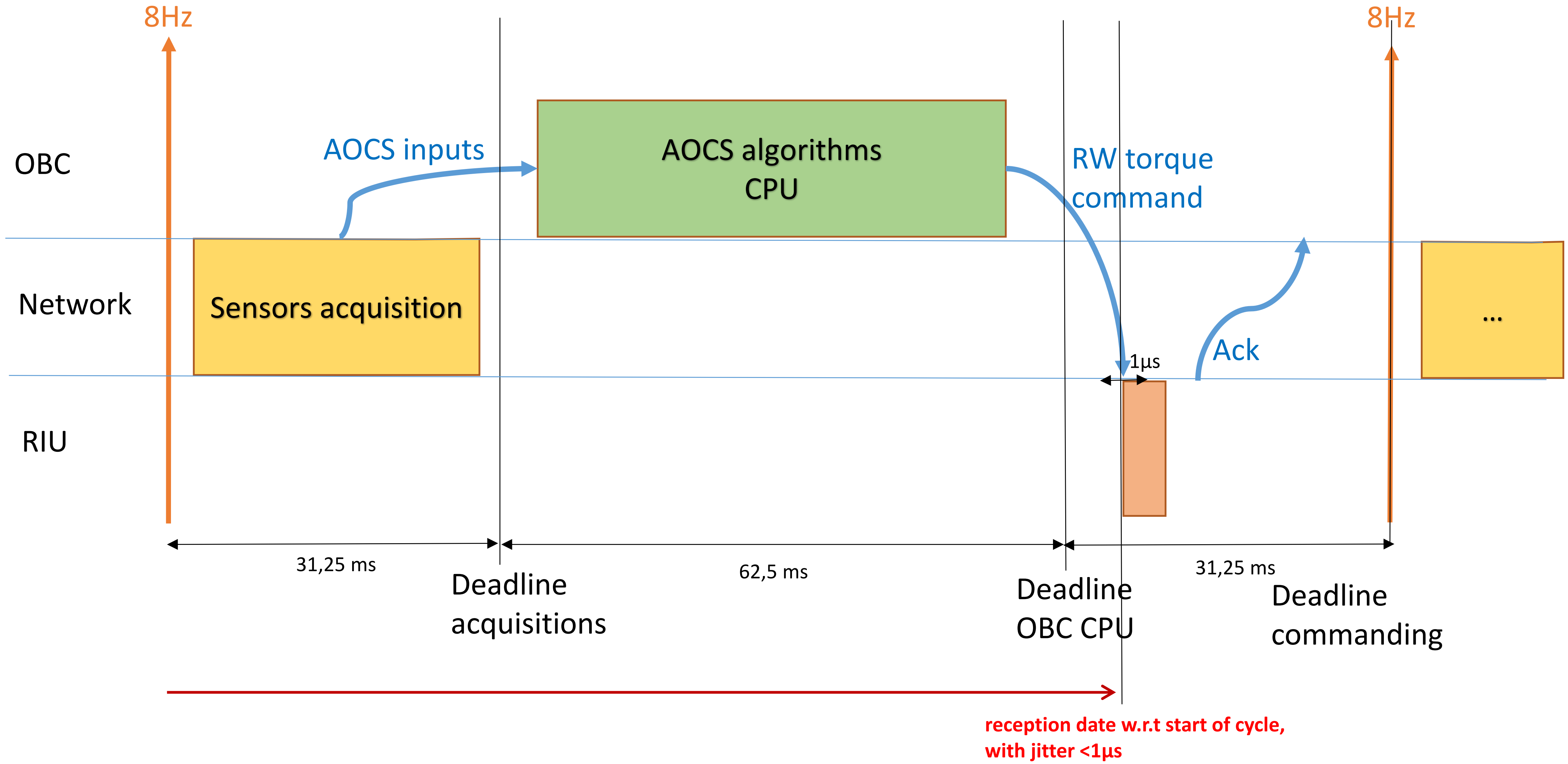
Ultra Low (1µs) & Low (500µs) Jitter definition



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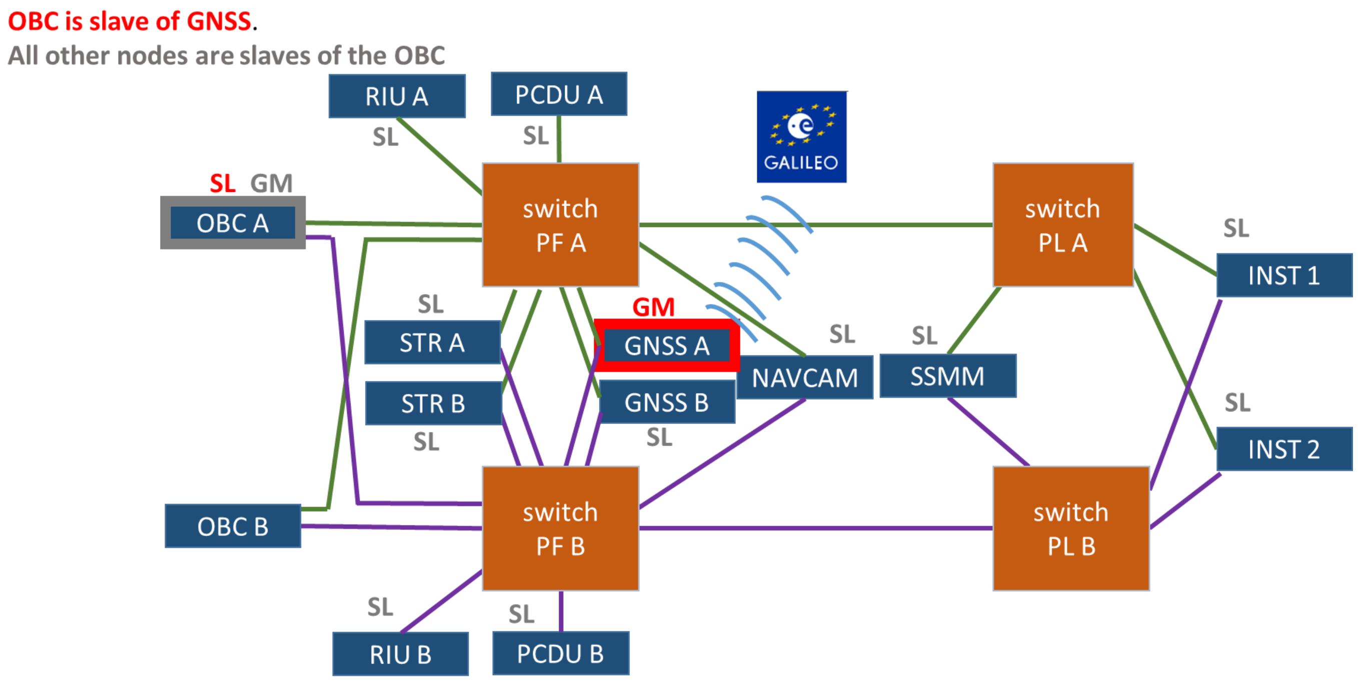
Synchronization



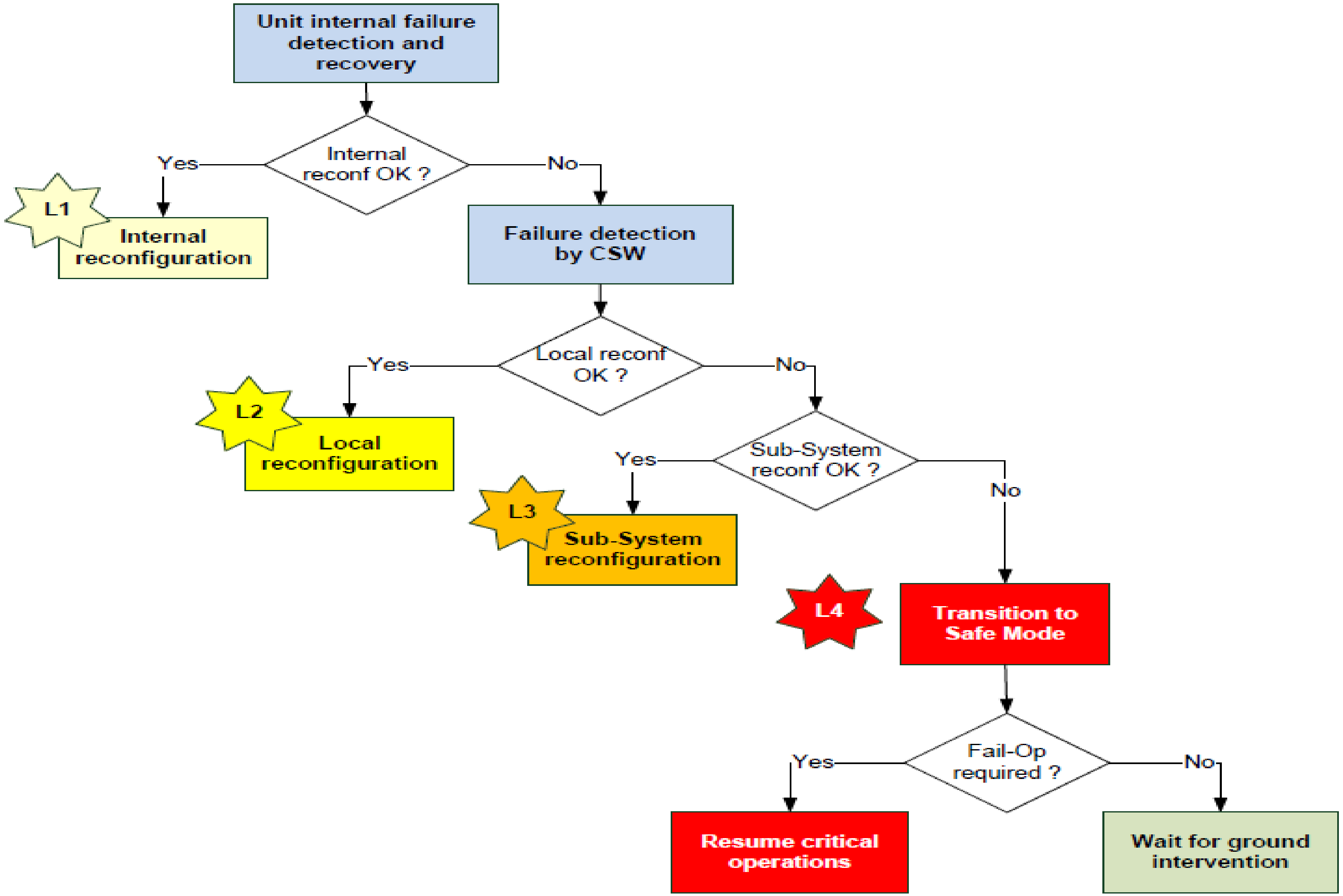
In addition to providing the PVT acquisition to the OBC, the GNSS offers a synchronization service to the network. Failure and reconfiguration to the redundant GNSS would lead to a synchronization loss. Indeed, GNSS takes one minute (order of magnitude) after switch-on to be able to provide the synchronization service.

To ensure the continuity of the network synchronization, the following solution is proposed:
the OBC is the only slave of GNSS,
the OBC is master for the rest of the network

Traffic Classes

	Description	Period	Application Synchronized to Network	Data Delivery Guarantee Mode	Delivery Guarantee Value	Tolerable Jitter Value	Application payload size variability	Payload (Bytes)
C&C ultra low jitter	high frequency (8 Hz), time window, ultra low jitter	62,5 - 125ms	Yes	Deadline	Same period	1us	Fixed	64
C&C low jitter	high frequency (8 Hz), time window, low jitter	62,5-125ms	Yes	Deadline	Same period	500µs	Fixed	64
C&C Time window	high frequency (8 Hz), time window	62,5-125ms	Yes	Deadline	Same period	N/A	Fixed	64
Acquisition list	time window, bounded delay between messages delivery	62,5-125ms	Yes	Deadline	Same period	N/A	Fixed	64-1100
Acquisition	deadline to the message delivery: end of cycle or before end of cycle	62,5ms-1s	Yes	Deadline	Same or different period	N/A	Fixed	64
MEO	min delay between messages delivery	62,5-125ms	Yes	Deadline	Same period	N/A	Fixed	64
VBN	high data rate, deadline to the message delivery	33,3ms	Yes	Deadline	Same period	N/A	Fixed	1048576
Instrument	high data rate	1ms - 3ms	No	Bandwidth		N/A	Fixed	4096

FDIR


Unit internal failure detection and recovery
Internal reconf OK ?
Yes
No
L1
Internal reconfiguration
Failure detection by CSW
Local reconf OK ?
Yes
No
L2
Local reconfiguration
Sub-System reconf OK ?
Yes
No
L3
Sub-System reconfiguration
L4
Transition to Safe Mode
Fail-Op required ?
Yes
No
Resume critical operations
Wait for ground intervention

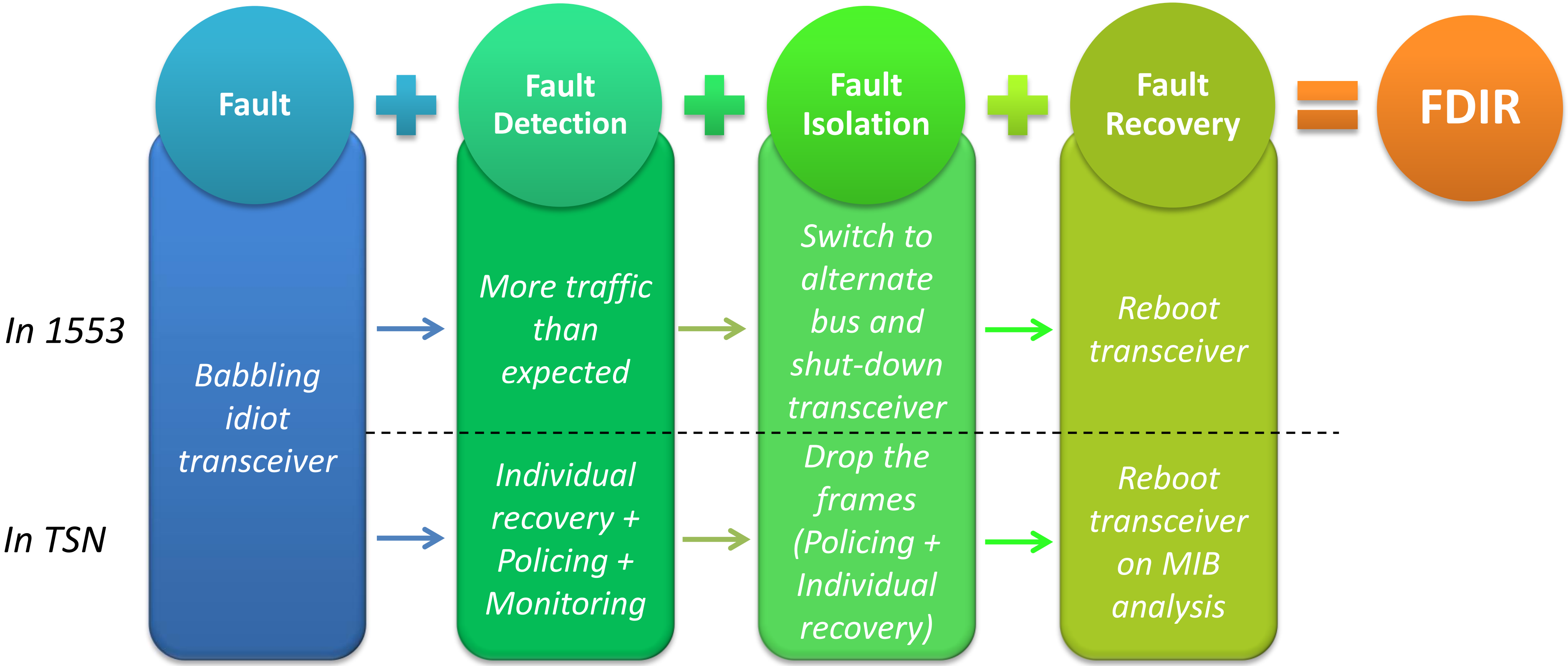
FDIR @ Network level

- To support management of cold/warm/hot redundancy at unit/interface level
- To prevent “babbling idiot” behavior from an instrument, causing an excessive packet rate to the Processor Module. Measures can be implemented at E/S and switch level
- To provide to the Processor Module report of every error detected (and potentially recovered) locally at network E/S and switch level.
- To provide requirements on E/S failure groups, i.e. for terminals that are not cross-strapped to the switch, which combinations of those terminals may be reconfigured in case of a switch single-point failure affecting interface to those terminals.
- To provide failure recovery strategy at switch level
- To provide protection against network communications against packet loss, at least for critical data.

- The detection mechanism must cover the local OBC scope up to the complete system involving remote equipments connected to this OBC. Each of these failures may be transient or permanent. It is in charge of the system to select the recovery actions.

- In case of failure the reporting mode can be either through:
  - an immediate failure status dispatch mechanism
  - a continuous monitoring based on confirmation, thresholds, and predefined metrics and statistics computation (MIBs)

FDIR Example



Foreseen mandatory features (in line with current Synchronous Profile B)

Ref.	Name	Rationale
IEEE 802.1AS	Timing and Synchronization	Time Distribution
IEEE 802.1Qci	Per-Stream Filtering and Policing	Policing (FDIR) + QoS management at Layer 2
IEEE 802.1CB	Frame Replication and Elimination (FRER)	Availability and FDIR
IEEE 802.1 Qbv	Scheduled Traffic	Ultra low jitter tenure
IEEE 802.1Qav	Credit Based Shaper	Quality of Service
IEEE 802.1 Qcc	Time Sensitive Network Configuration	Static configuration part
IEEE 802.1Qbu & IEEE 802.3br	Frame Pre-emption	Might be required for ultra low jitter tenure on for 100 Mbps, TBC vs exclusive gating

Thank you !