Open architecture (IIOT) subsea Control System

Perth October 29th 2024

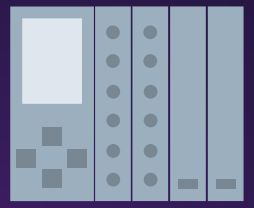
IIOT and subsea Control System

Subsea => Location of some devices.

Control System => manages, commands, directs or regulates the behavior of other devices or systems using control loops.
wikipedia.org

IIOT => Industrial Internet of Things.

Internet



Process Node

Surface

Subsea

PT/TT Sensor

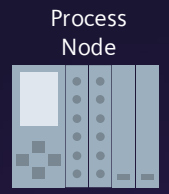
Picture from
Saipem.com

Picture from
advanced-mechatronics.de

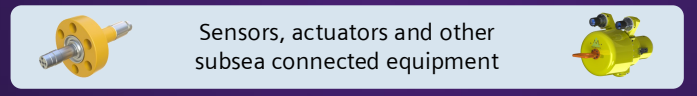
Electric
Actuator

Open architecture (IIOT) subsea control system

Process Node located on the surface.



Sensor(s) and actuator(s) located subsea.

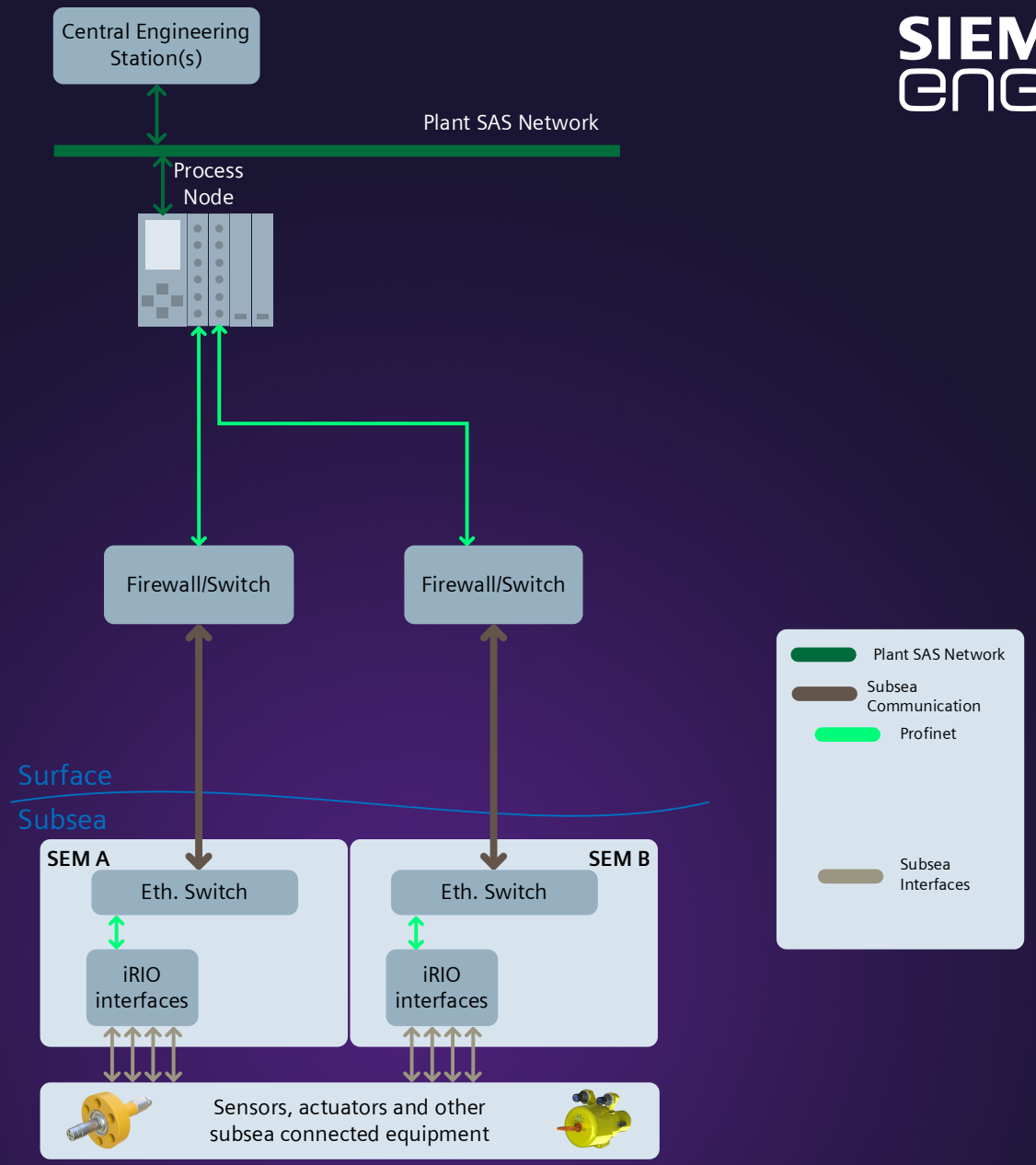


Open architecture (IIOT) subsea control system

Process Node on the surface is connected to Plant SAS Network and equipped with Central Engineering Station(s).

Communication between Subsea and Surface are Ethernet based and Profinet protocol is used in the interface with the Process Node.

Subsea located equipment is connected to iRIO (Intelligent Remote I/O devices) in redundant SEM's (Subsea Electronic Module).

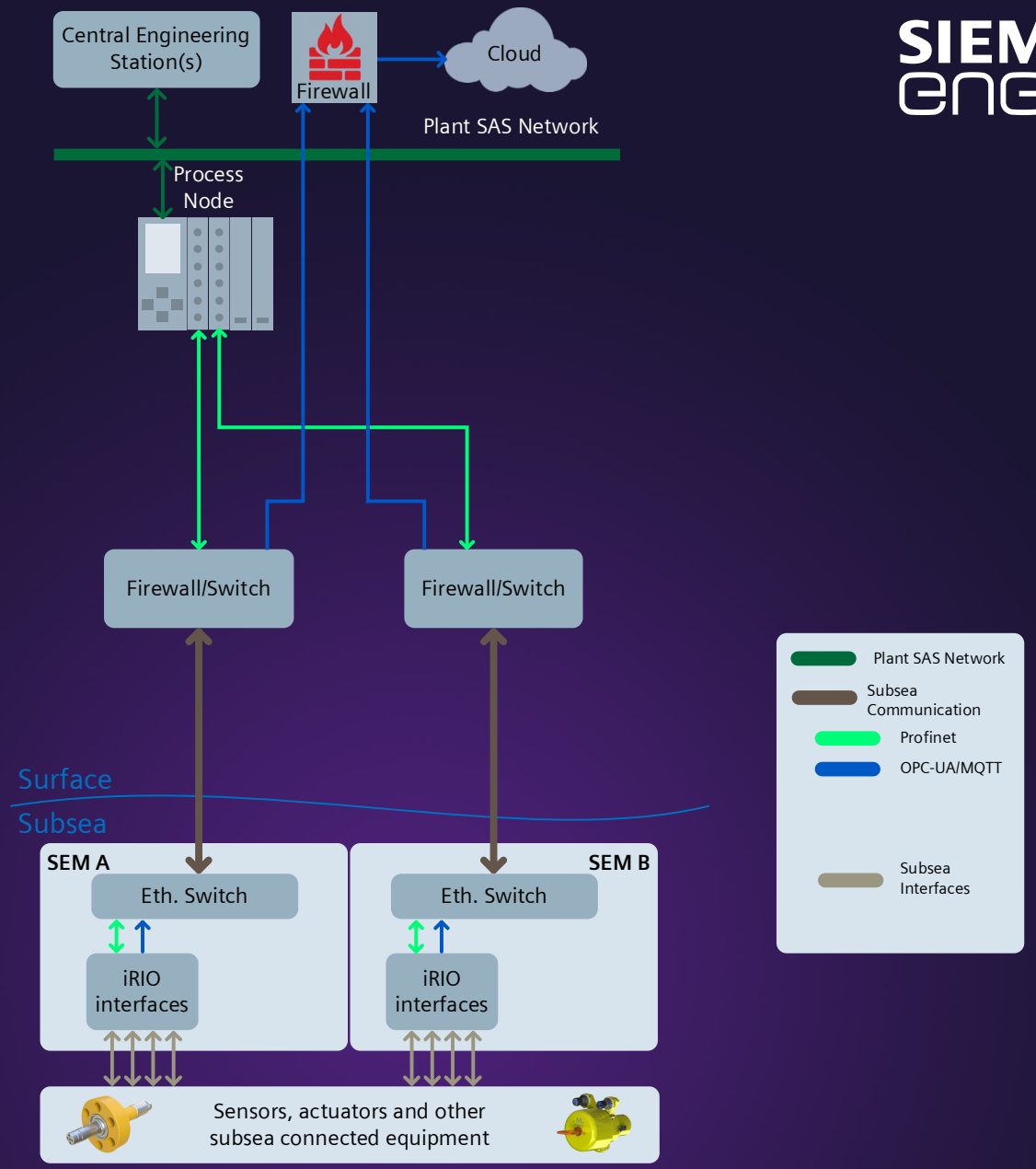


Open architecture (IIOT) subsea control system

Noncritical (historical) data for the process is feed from the subsea connected equipment through the iRIO devices and to the surface in OPC-UA or MQTT packages.

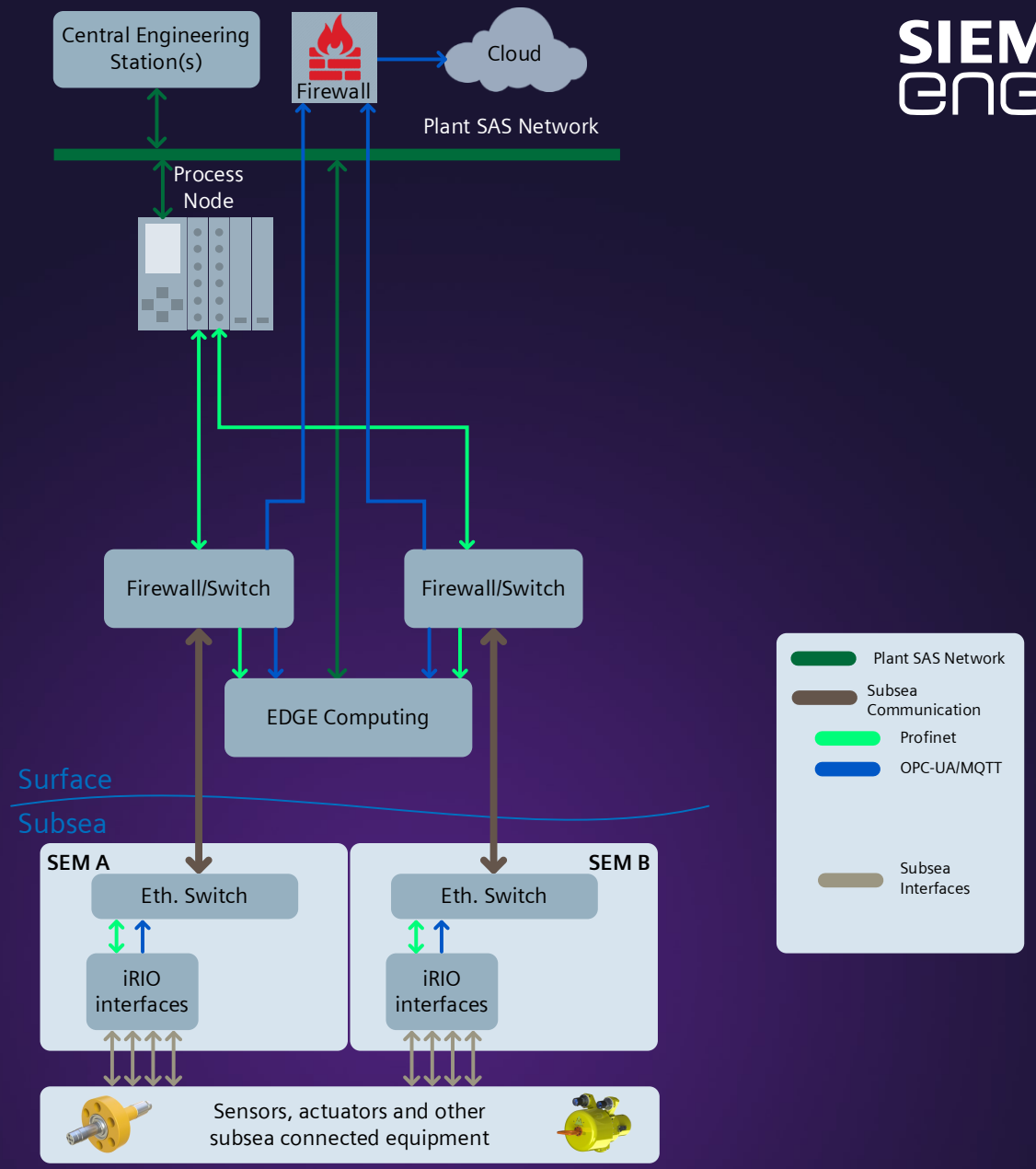
The historical data could be used either locally on the surface or stored in any cloud.

Managed Ethernet switches routes the process data to the process node and historical data to local historian and/or cloud(s).



Open architecture (IIOT) subsea control system

Edge computer(s) could be connected directly on to the nonproprietary communicating standards available on the surface.



Open architecture (IIOT) subsea control system

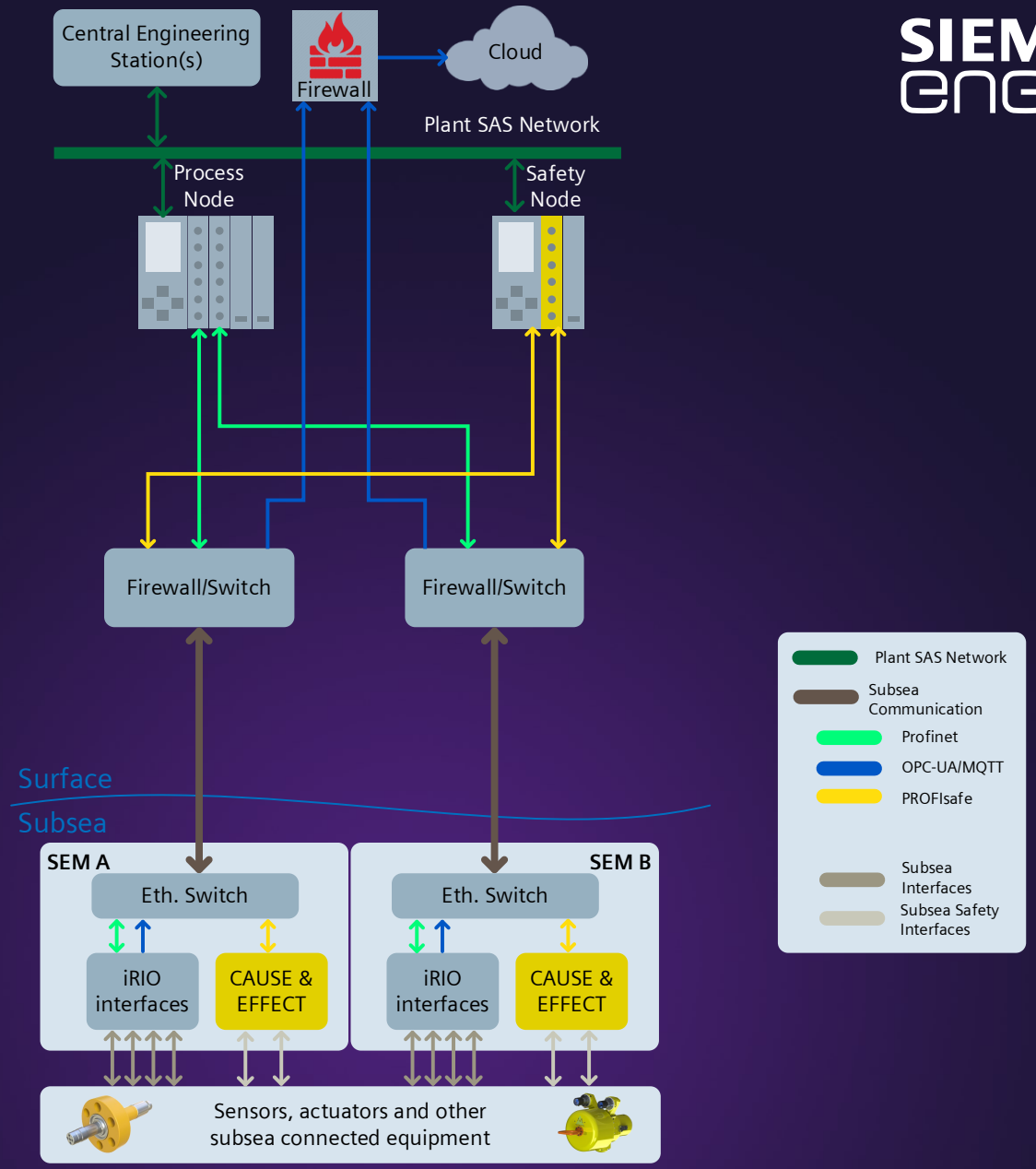
SIL 3 safety could be included with:

CAUSE (4-20ma Inputs) and,

EFFECT (Digital outputs) on the seabed.

LOGIC SOLVER in a typical Safety Node located on the Surface.

Communication between Subsea and Surface would be based on **Black Channel PROFIsafe** communication.



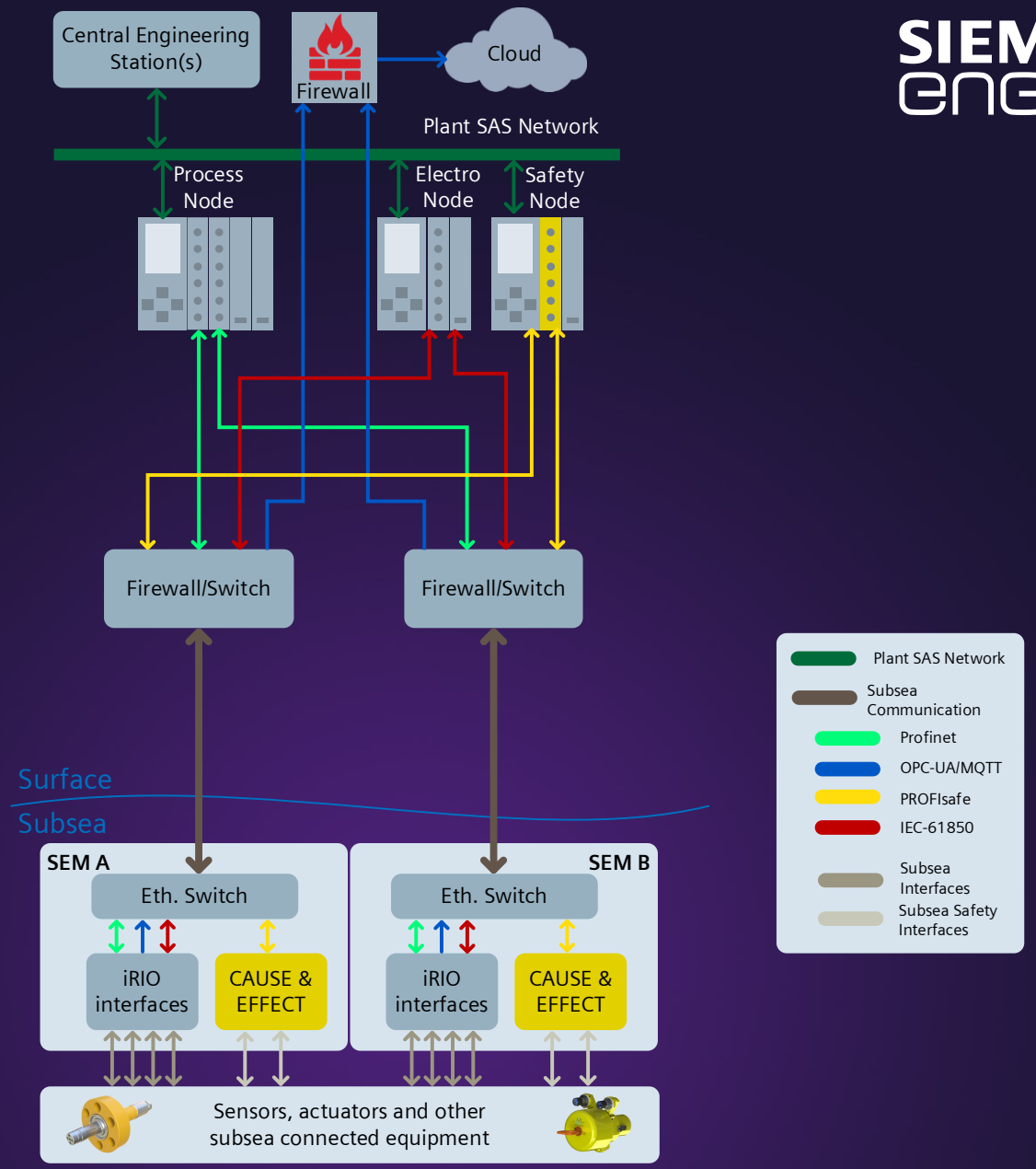
Open architecture (IIOT) subsea control system

IEC-61850 (Goose) is used in management and control of power grids and distribution.

Could be extended to control large power devices on the seabed.

Uses logical segregation on Ethernet and could exist on the same communication medium as:
CONTROL (Profinet)
CLOUD (OPC-UA/MQTT)
SAFETY (PROFIsafe)
POWER CONTROL (IEC-61850)

or separate mediums

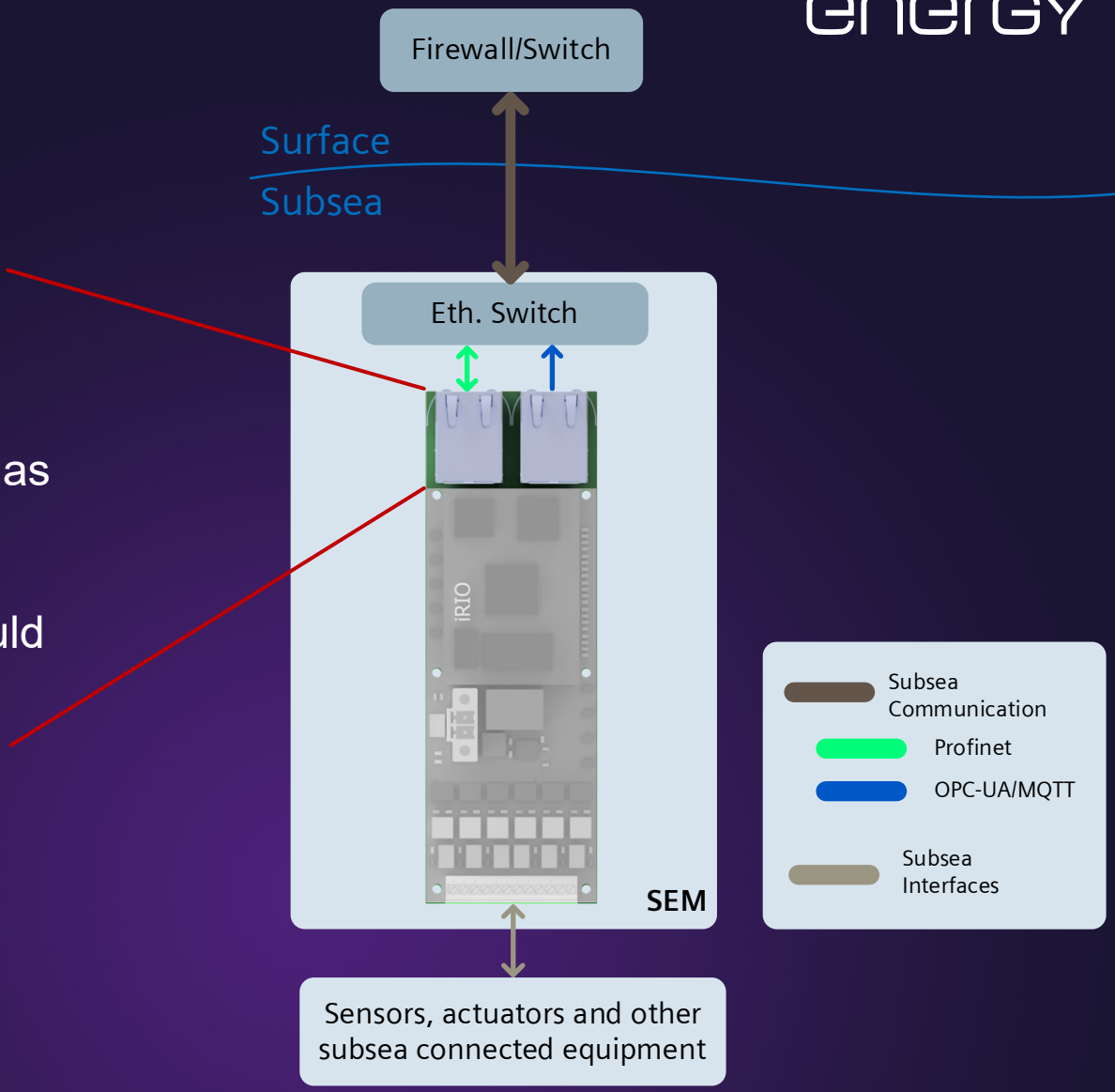


Subsea Interface cards (iRIO Cards)
Connections towards the surface

All communication towards surface would be Ethernet based.

iRIO cards needs to be equipped with Ethernet port(s) as defined in IEEE 802.3u (10/100M b/s).

Different open industrial communication protocols should be available to use, pending on purpose.



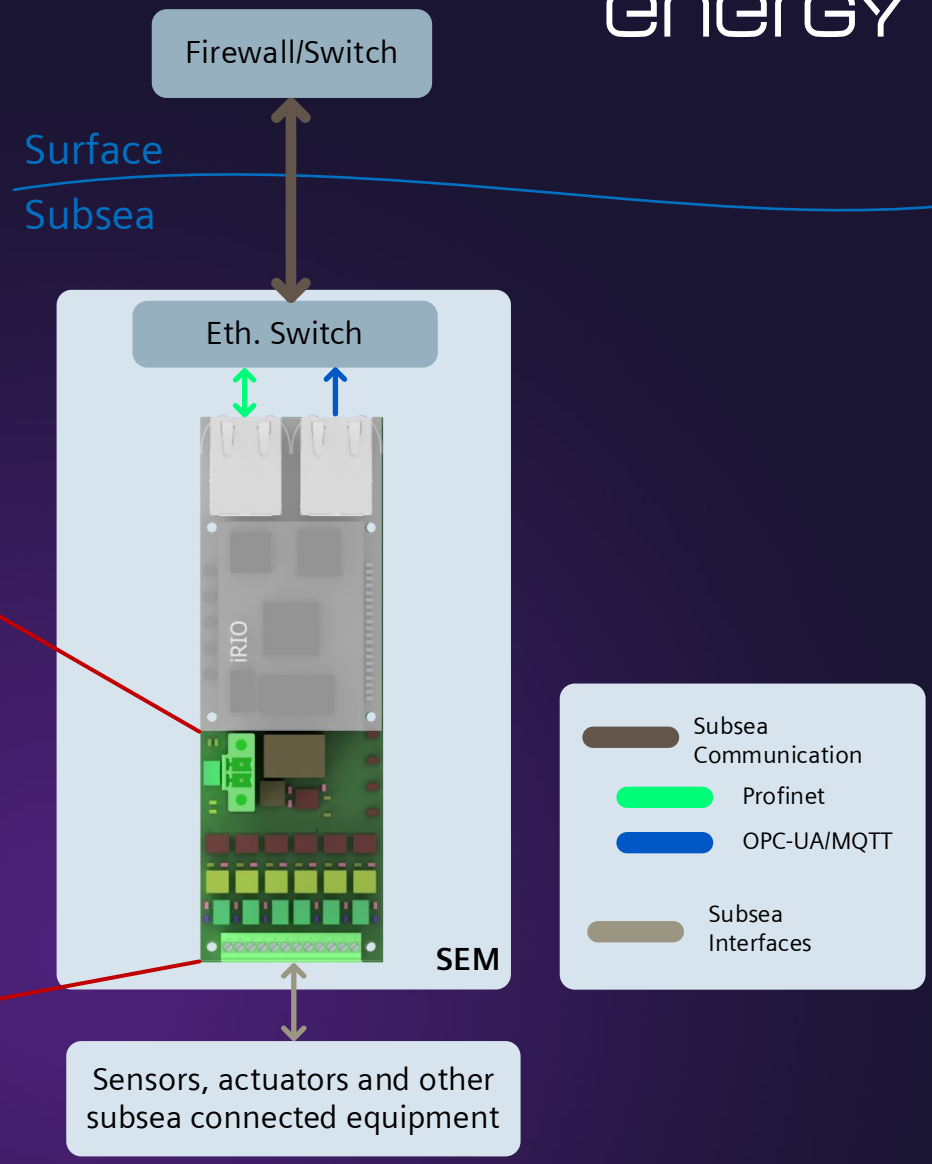
Subsea Interface cards (iRIO Cards)
Connections towards subsea equipment

<u>Electrical interfaces required</u>
Analog and Digital – Inputs and Outputs
SIIS Level 1 – 4-20mA Interfaces

Serial ports – RS-422 & RS-485 (2 and 4 wire)
SIIS Level 2
Fault Tolerant CAN (ISO 11898-3)
High-Speed CAN (ISO 11898-2)

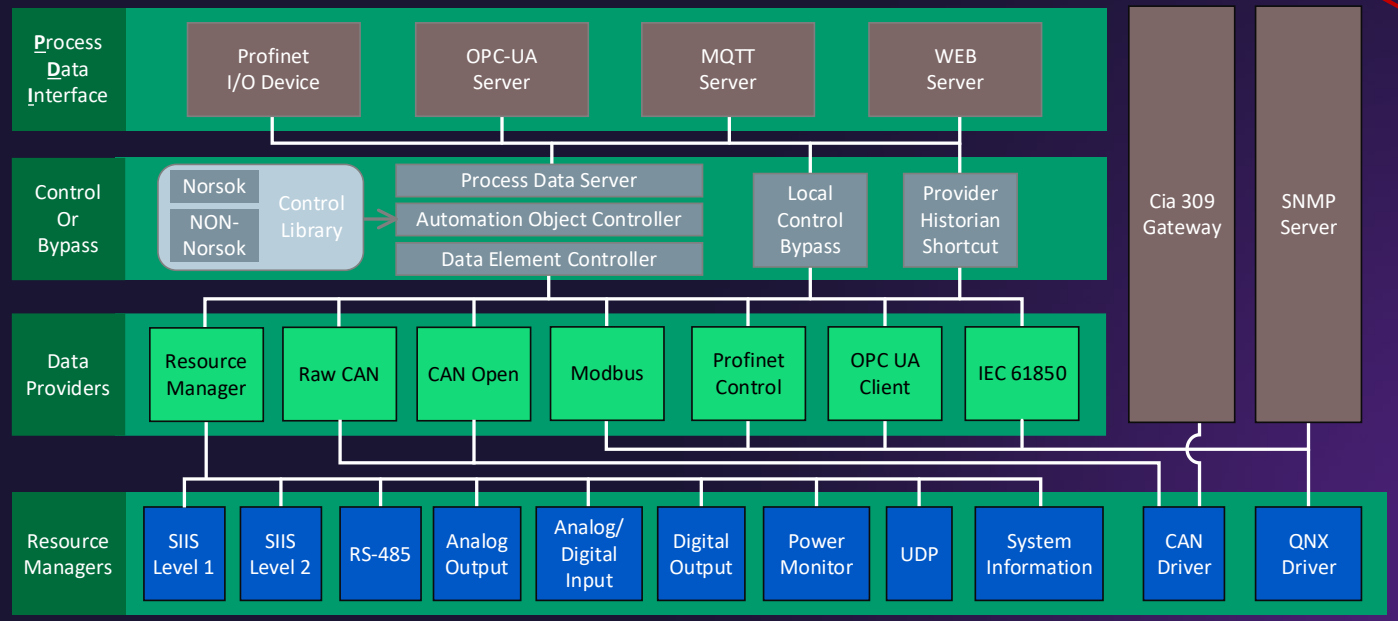
SIIS Level 3 – Ethernet IEEE 802.3u (10/100Mb/s)

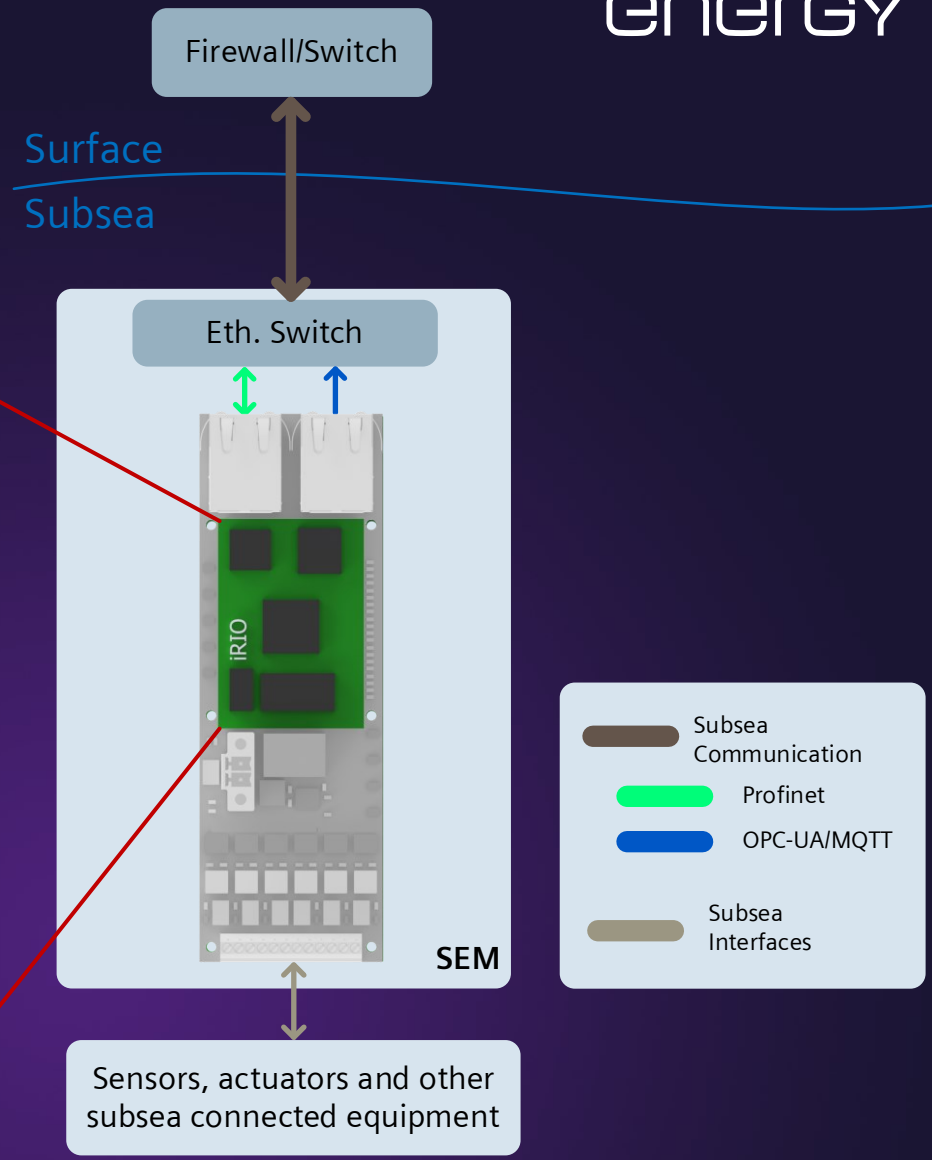
<u>Communication protocols required</u>
SIIS Level 2 – CAN-Open on CAN bus
SIIS Level 3 – TCP/IP



Subsea Interface cards (iRIO Cards)
Software architecture

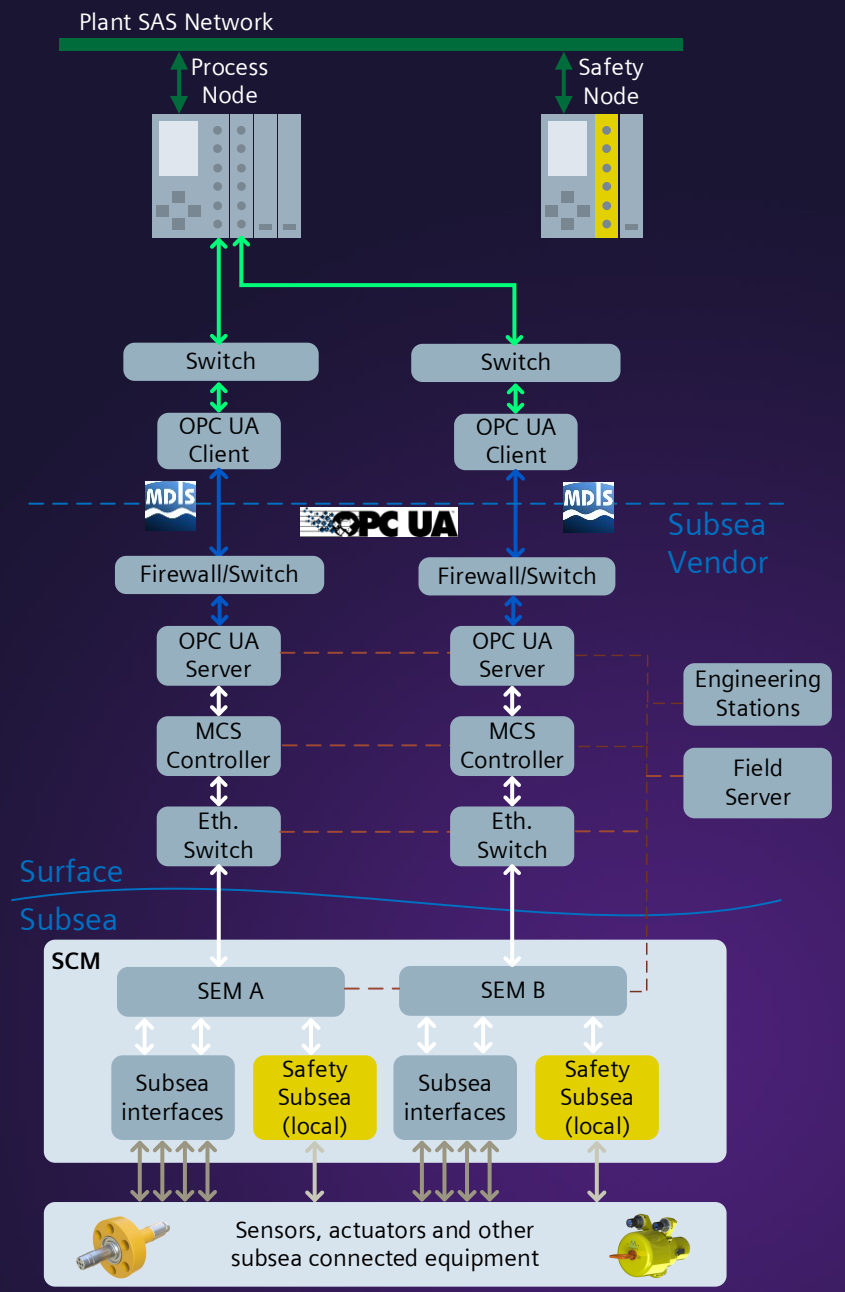
Save a LOT of work by using the same CPU Module on all iRIO cards, with the same Real Time Operating System and common software modules.





Remember to penetration test all **P**rocess **D**ata **I**nterfaces according to IEC-62443-2-4 (Cybersecurity)

MDIS – Topology and performance



- Complex Engineering
- Space demanding
- Extended Maintenance – SW/HW
- None Deterministic / real time performance
- High latency
- No safety features
- Complex cyber security regime

∑ Data quality

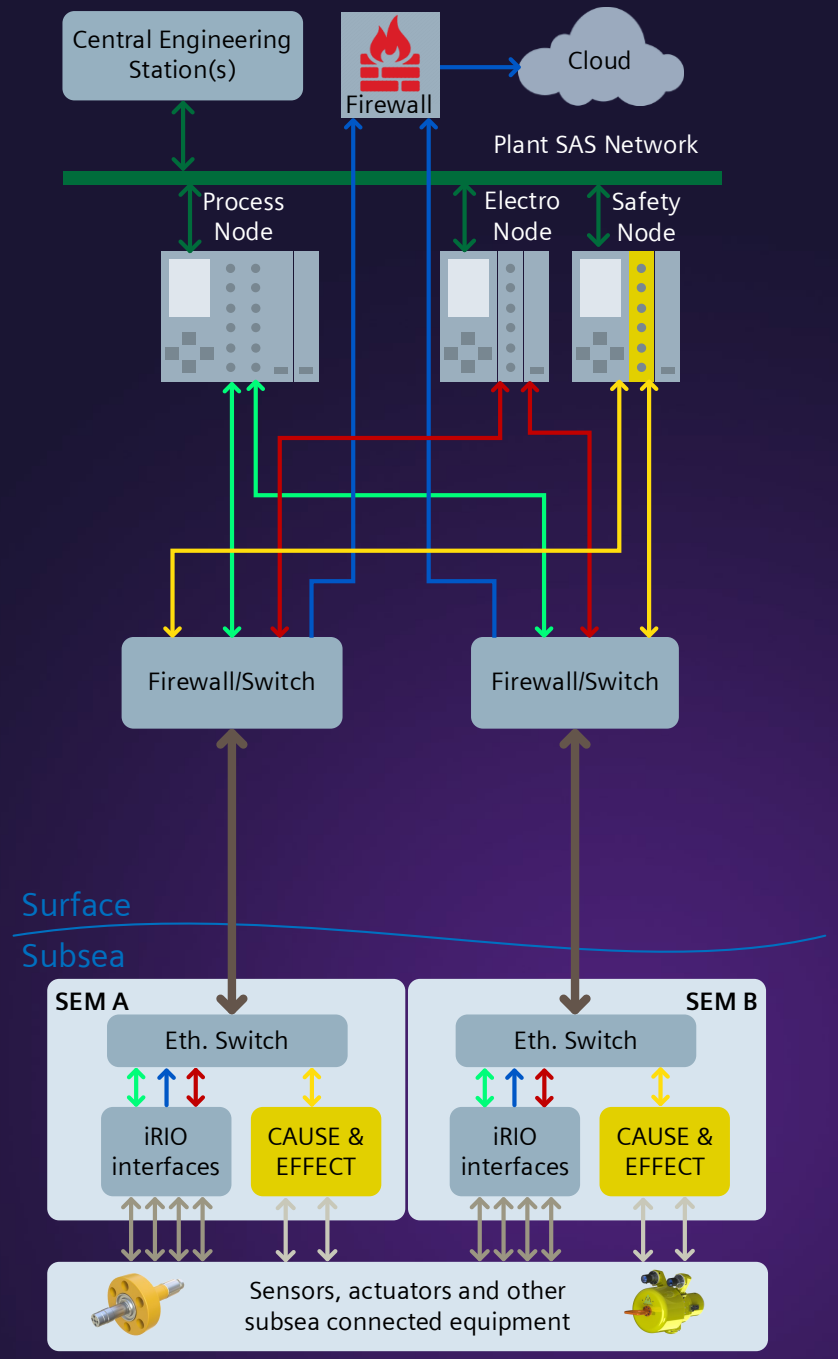
∑ Fault

∑ Latency

?

IIOT – Topology and performance

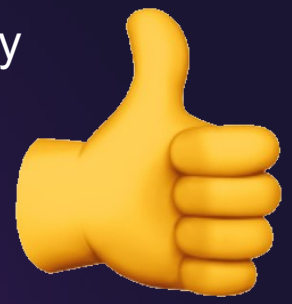
- Simple Engineering
- Optimized maintenance – SW/HW
- Easy scalable / expansion
- Deterministic / real time – low latency
- Simplified cybersecurity regime
- Space saving - IOT device (SCU/MCS not needed on the surface)



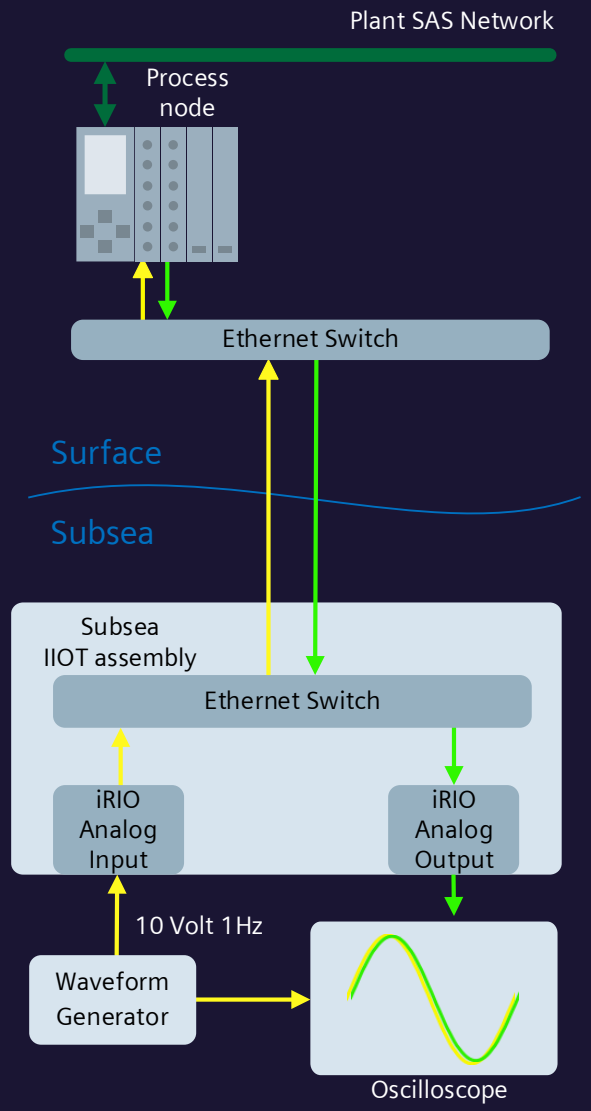
∑ Data quality

∑ Fault

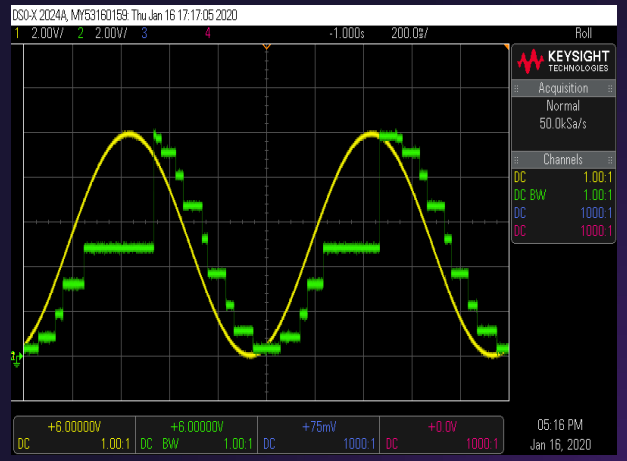
∑ Latency

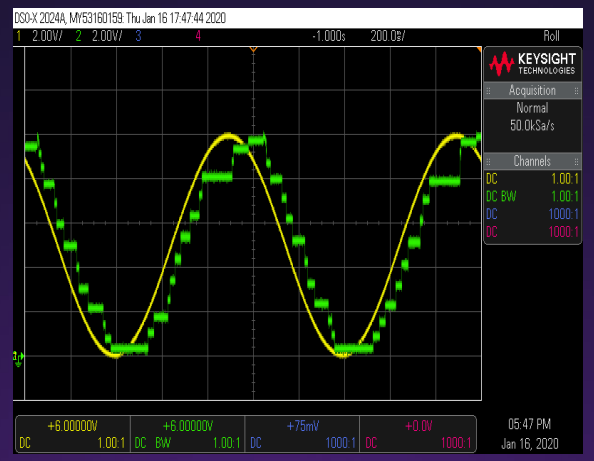


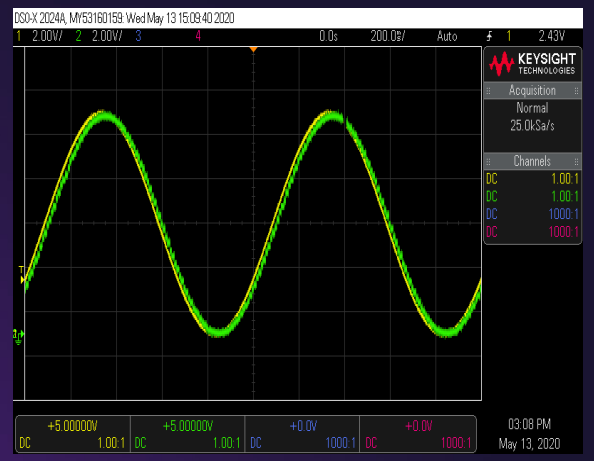
Realtime Performance of Process Control



Project progress



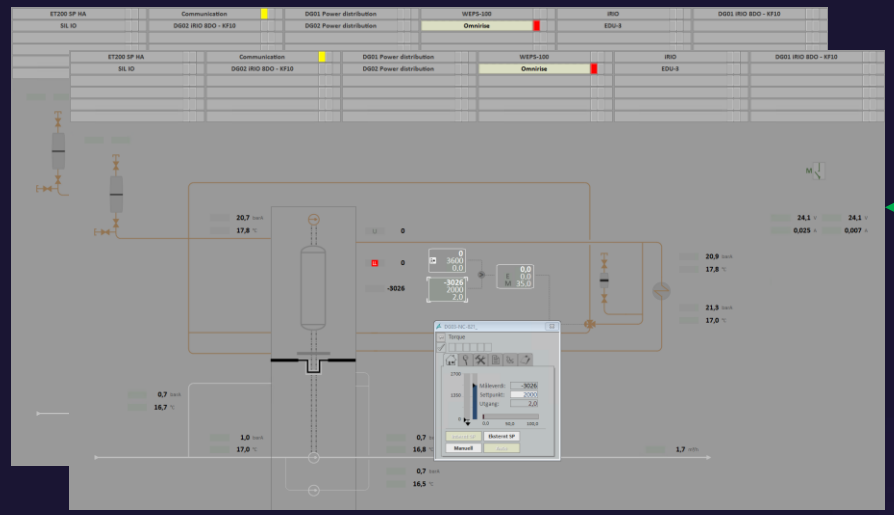




- Input-Output read cycle and Profinet cycle synchronized to minimize latency and jitter
- 4 milli second Profinet cycle
- Enables control loops down to 50ms closed topside, running on redundant topside node

FSubsea Omnirise™ with IIOT setup and HIL simulator

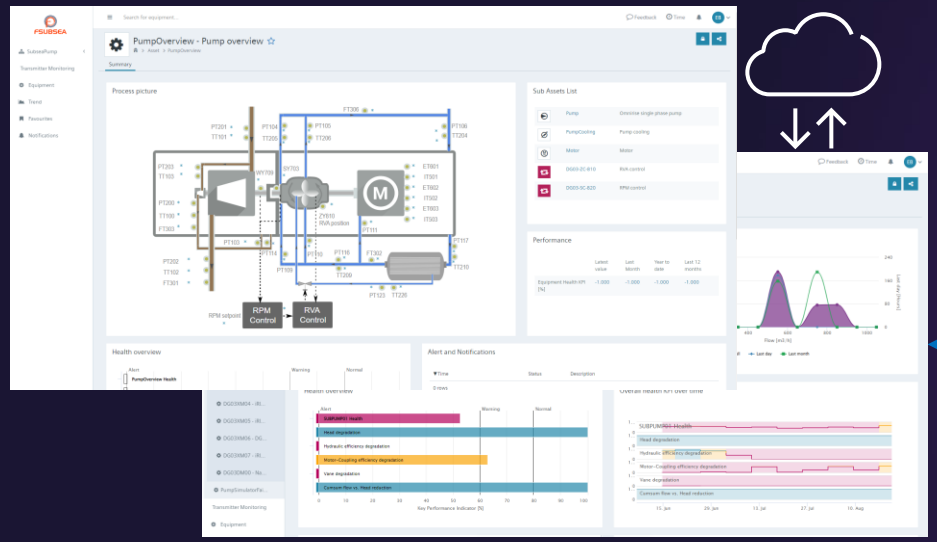
Operator screens (Simatic PcS7 or other)



Control logics (Simatic PcS7 or other)

Omnirise™ in pit test

Digital Twin - dashboards and data analytics



MQTT

PROFINET

Subsea IIOT setup

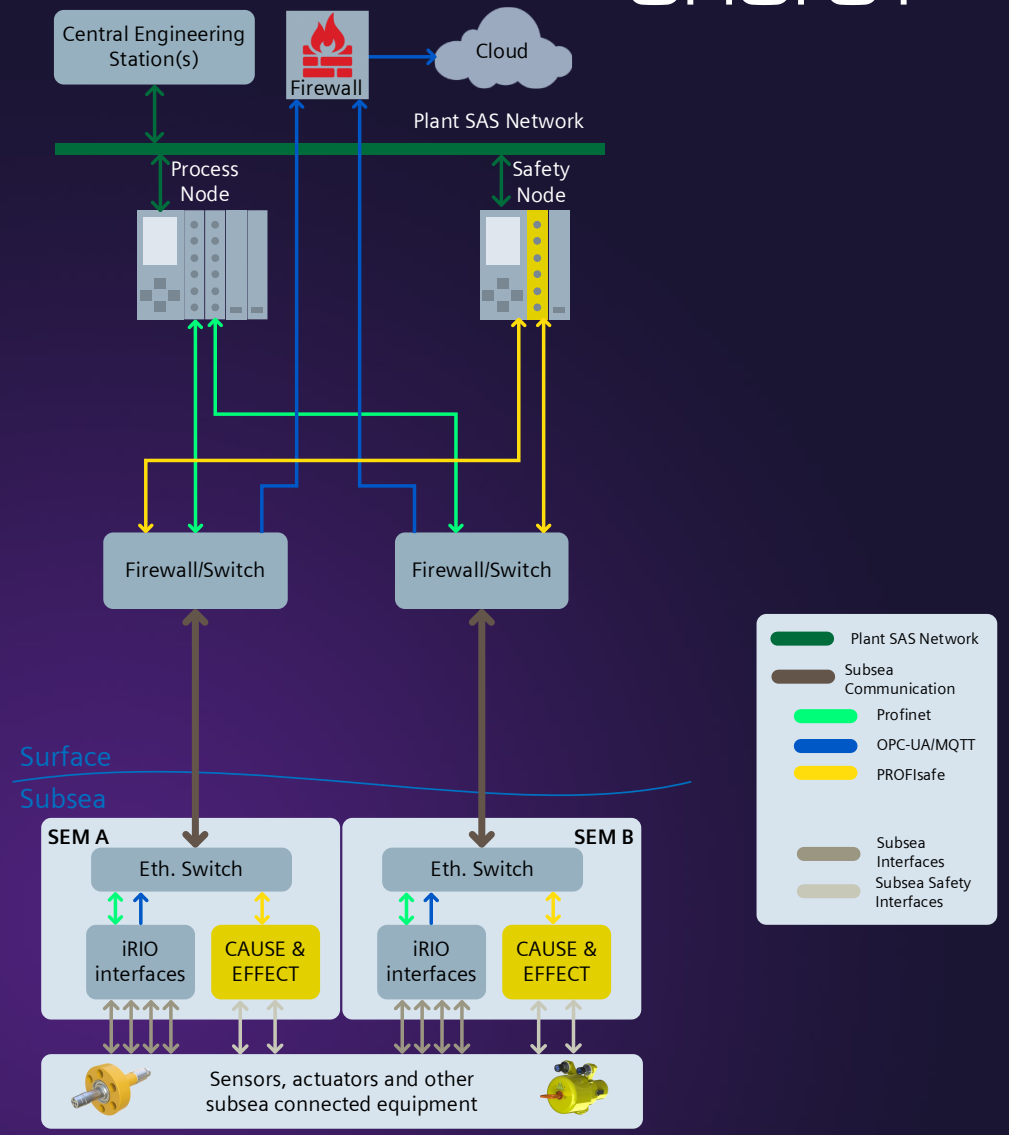
Fast acting control loop, RIO and CM data

SIIS Subsea Instrumentation Interface Standardisation

Summary – Design tips

Open architecture (IIOT) subsea control system

- Avoid closed systems and black boxes. Design holostic and flexible systems
- Use open standards and interfaces, **don't** reinvent the wheel
- Give each type of requirement (Process, Cloud, and Safety only the required data for that type of setup
- Reuse as much software as possible for different I/O types
- Penetrate test all parts according to IEC-62433-2-4 - Cyber Security
- Timestamp with syncronized clocks as close to the source as possible



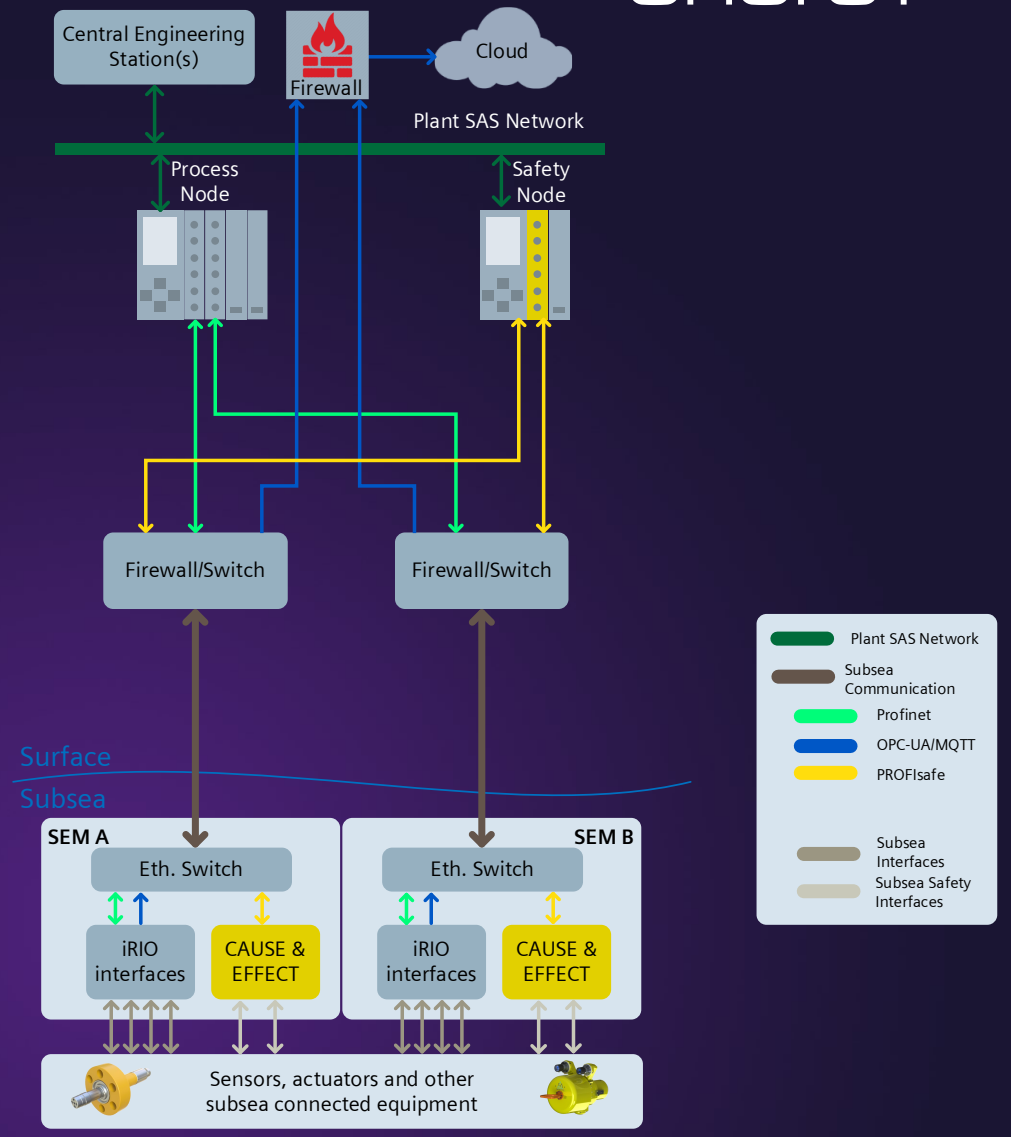
Summary – Financial benefits

Open architecture (IIOT) subsea control system

CAPEX Savings:

- Reduced surface integration costs, only one system
- Simplified testing, only one system
- Prepared for digitalization, cloud data storage, digital twins
- All toolboxes and defined logic available for surface located equipment could be used on similar subsea located devices

- **OPEX** Savings:
  - One expert group due to only one system to maintain
  - Open aftermarket



Thank you for your attention

Published by Siemens Energy at SUT-2024 Perth October 29th

Karstein Berge Kristiansen

karstein.kristiansen@siemens-energy.com