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# How may cybersecurity impact the design of safety instrumented systems?

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# About me

- Professor at Engineering Cybernetics department
- Master in Engineering Cybernetics, PhD in safety and reliability
- Focus:
  - Instrumentation systems, including industry 4.0
  - Safety-instrumented systems and functional safety
  - Cybersecurity of operational technology (OT) systems
- Mix of industrial and academic experience

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**Role in SFI NORCICS:**
Part of supervisor team for new 2-years postdoc (researcher) on cybersecurity and safety-instrumented systems (SIS).

# Content of presentation

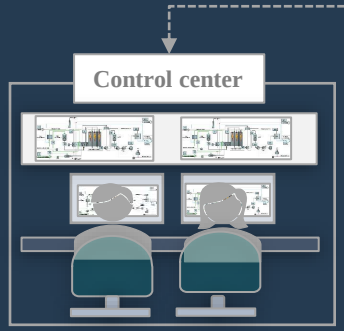
Safety instrumented systems

Cybersecurity vs safety

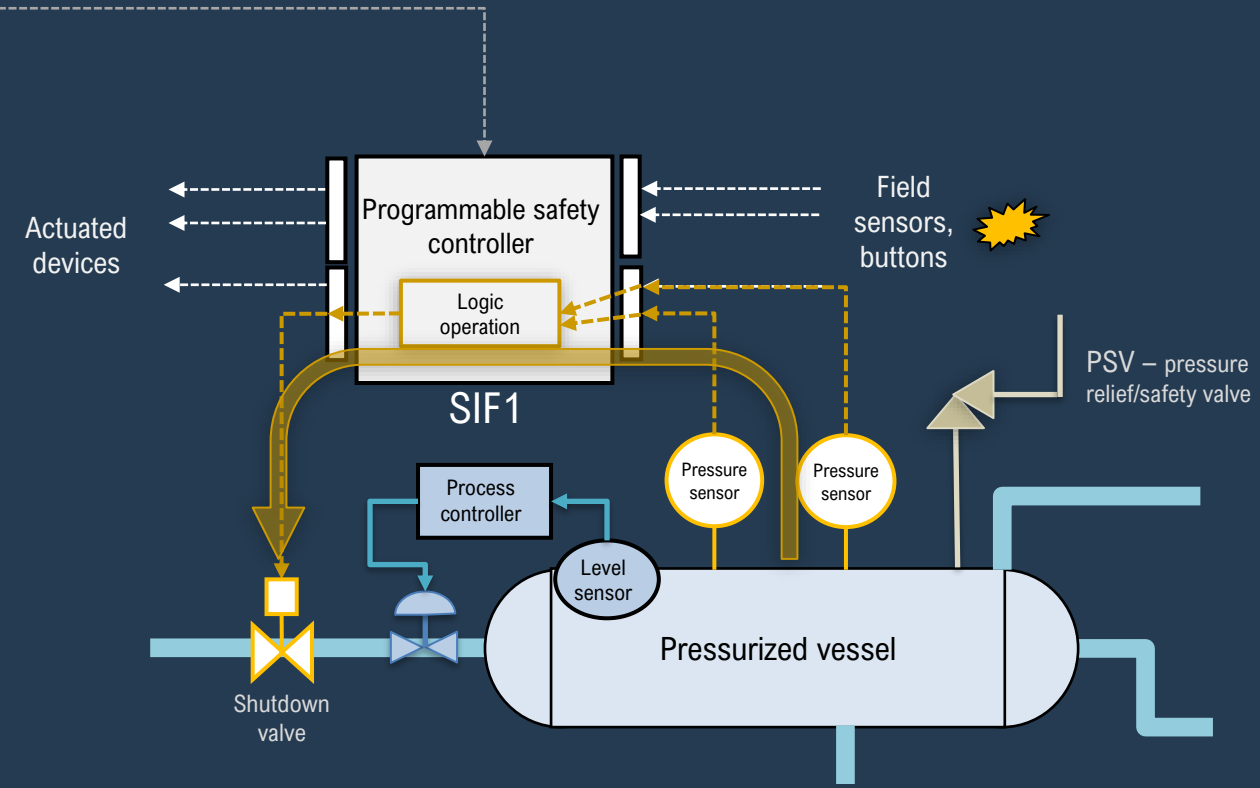
Impacts of attacks

About managing both

# Safety instrumented system (SIS)

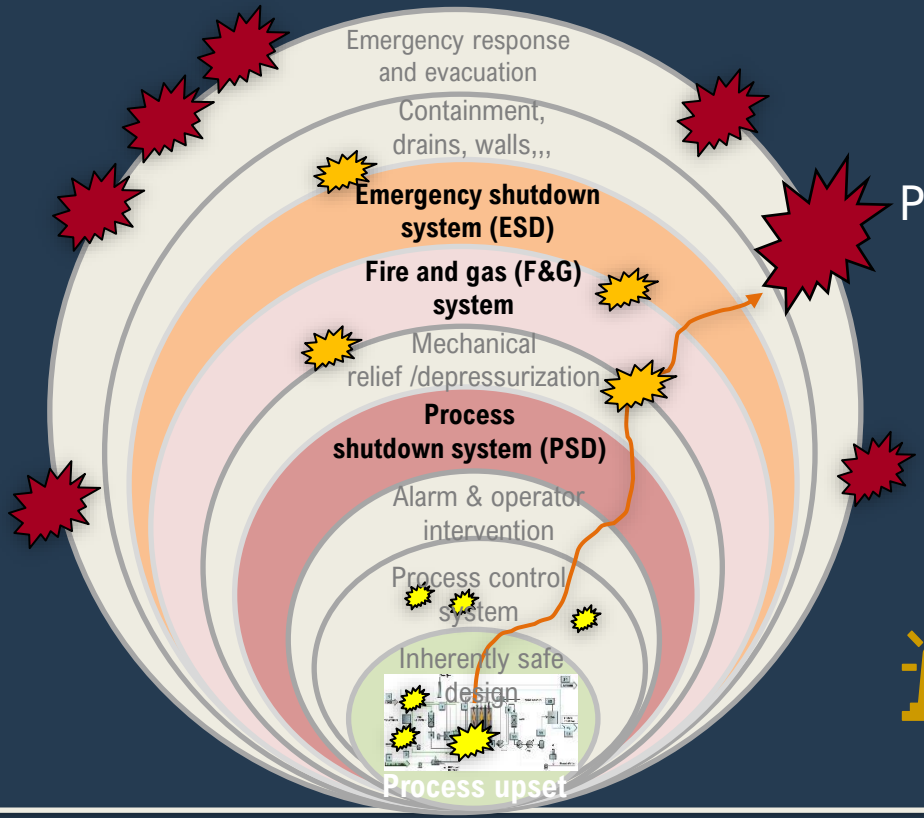



- Regulatory requirements
- Risk based approach
- SIL implications for design and operation




SIF: Safety instrumented function
SIL: Safety integrity requirements

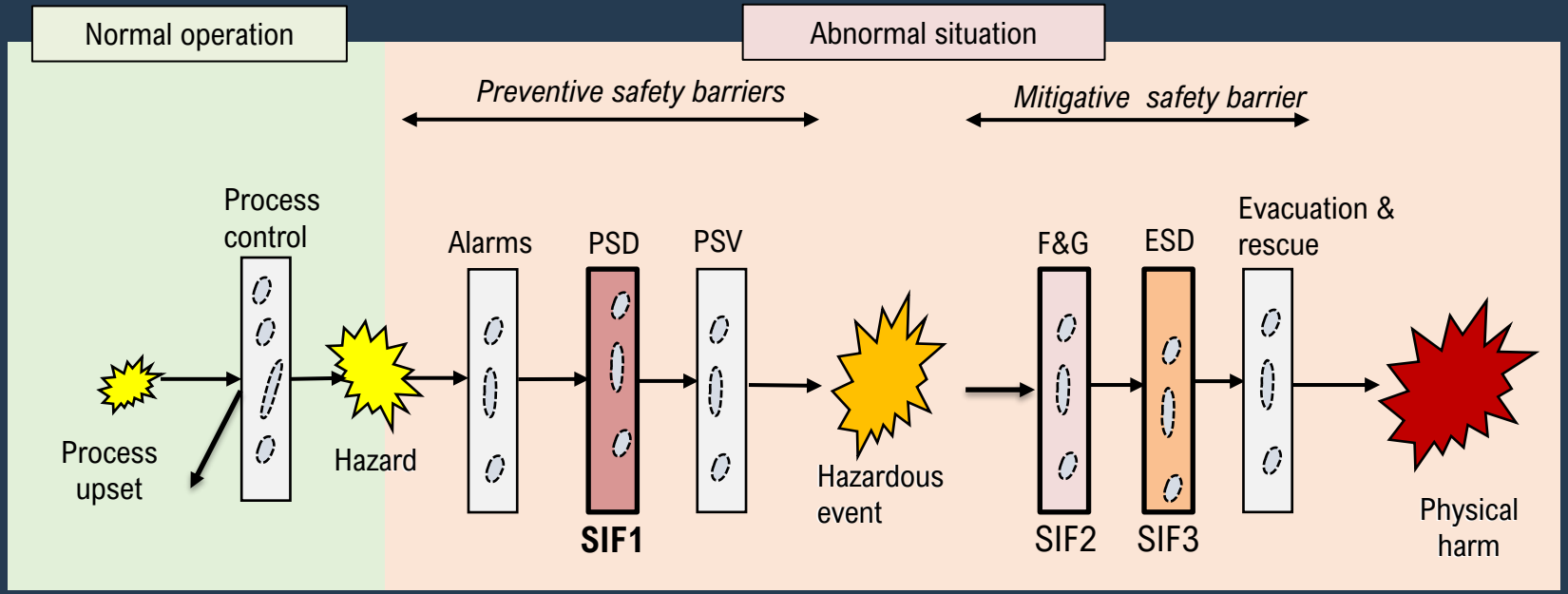
# SIS contribution to layers of protection




Physical harm

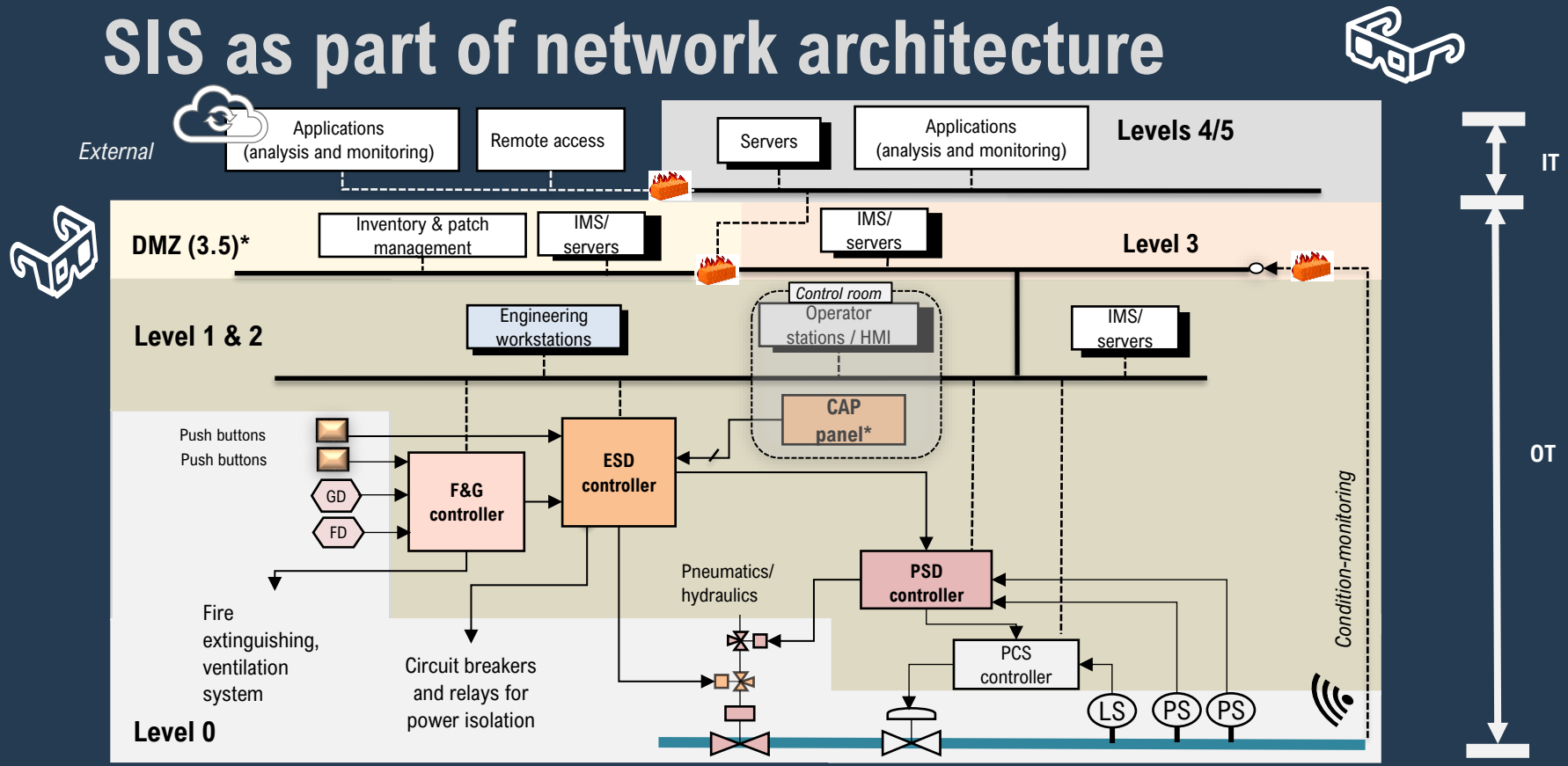
Each layer (or barrier) MUST be independent er to be effective!

# Safety barriers: Specific roles of protection layers




SIS: Safety instrumented system. ESD: Emergency shutdown, PSD: Process shutdown, PCS: Process control system. F&G: Fire and gas system. PSV: Pressure safety (relief) valve

# SIS as part of network architecture

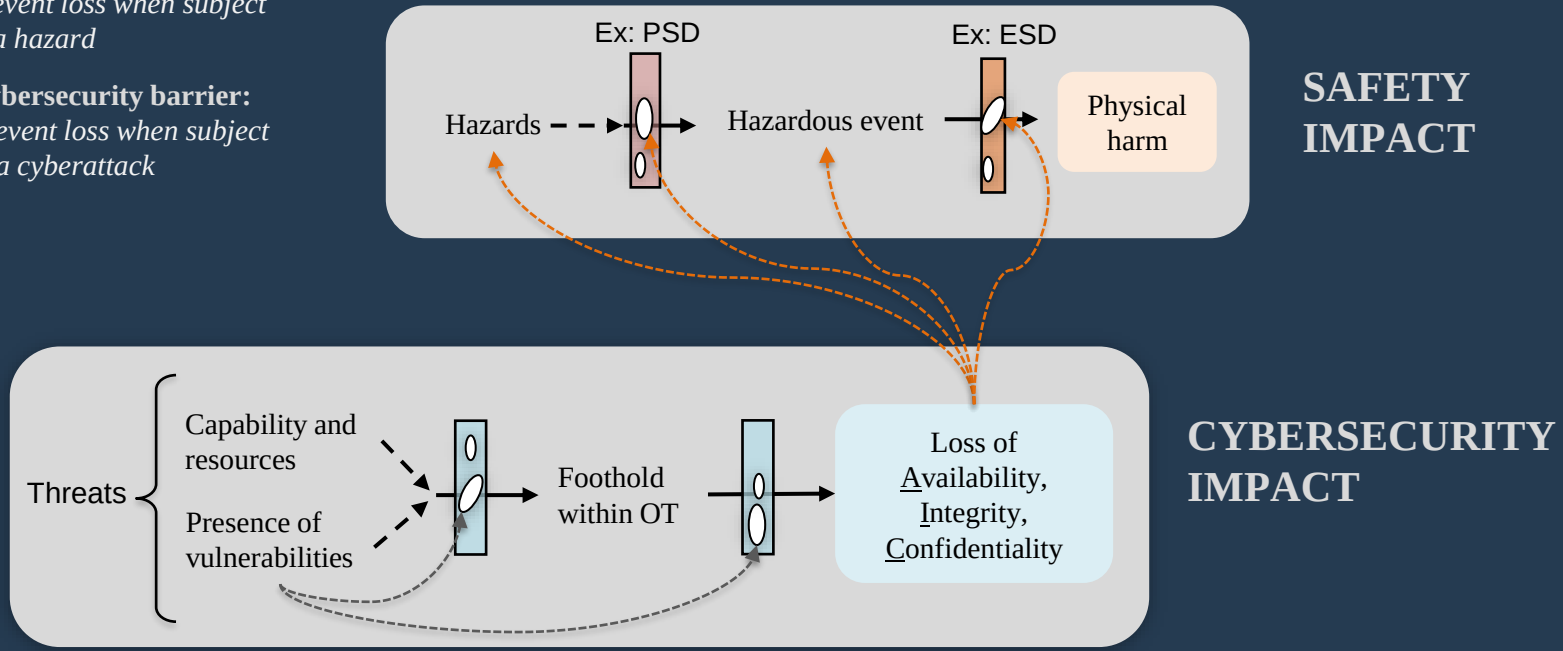



OT: Operational technology. ESD: Emergency shutdown, PSD: Process shutdown, PCS: Process control system. CAP: Critical action panel (*Offshore facilities only)
LS: Level sensor. PS: Pressure sensor. GD: Gas detector. FD: Fire detector. IMS: Information management system.

# Cybersecurity impact on safety

**Safety barrier:**
*Prevent loss when subject to a hazard*

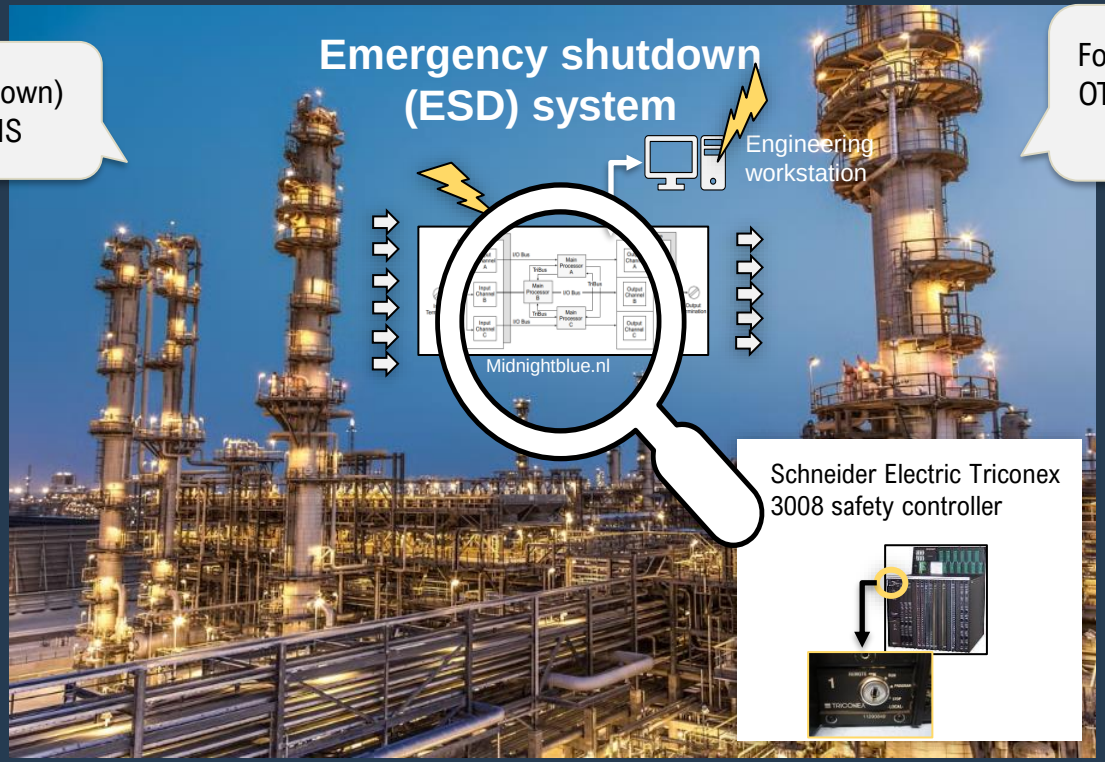
**Cybersecurity barrier:**
*Prevent loss when subject to a cyberattack*




ESD: Emergency shutdown, PSD: Process shutdown

# Example: Attack on SIS in Saudi-Arabia (2017)

First (publicly known) attack on a SIS




Foothold inside OT for a longer period

TRISIS
TRITON
HATMAN

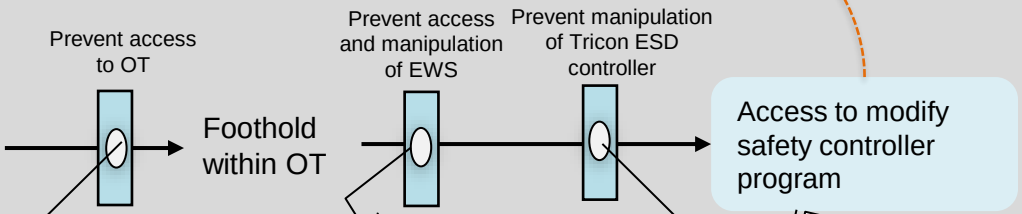
SIS: Safety instrumented system. ESD: Emergency shutdown

# The attack explained


The ESD controller functions (almost) affected:
- Manipulated code could create unsafe state
- Fortunately, validation check error among the tripled processing units
- SIS controller entered fail-safe state

**SAFETY IMPACT**

- Capabilities and motivation of TsNIIKhM
- Triton* malware: remote access Trojan
- Zero-day in Triconex safety controller firmware




- Exploited a mis-configured firewall in DMZ
- Access via unpatched flaw in windows or intercepting employee login
- Deployed malware for accessing controller named as a legitime file
- Key switch initially left in program mode
- Reverse-engineered TriStation protocol
- Exploited zero-day vulnerability to write/read/.. in memory regardless of key switch position

**CYBER-SECURITY IMPACT**

ESD: Emergency shutdown system. EWS: Engineering workstation.
DMZ: Demilitarized zone (layer 3.5)

# Standards framing SIS and cybersecurity

### Functional safety

- **IEC 61508** – generic (2010)
- **IEC 61511** – process industry (2016)
- **IEC 62061/ ISO 13849** – Machinery
- ….
- Offshore Norge GL 070 – petroleum (2024)

Framing SIS design and operation

### Functional safety & cyber security

- IEC **TS** 63069 – generic (2019)
- ISA **TR** 84.00.09 – process industry (2017)
- IEC **TR** 63074 – machinery (2023)

Related:

- Cyber-informed engineering

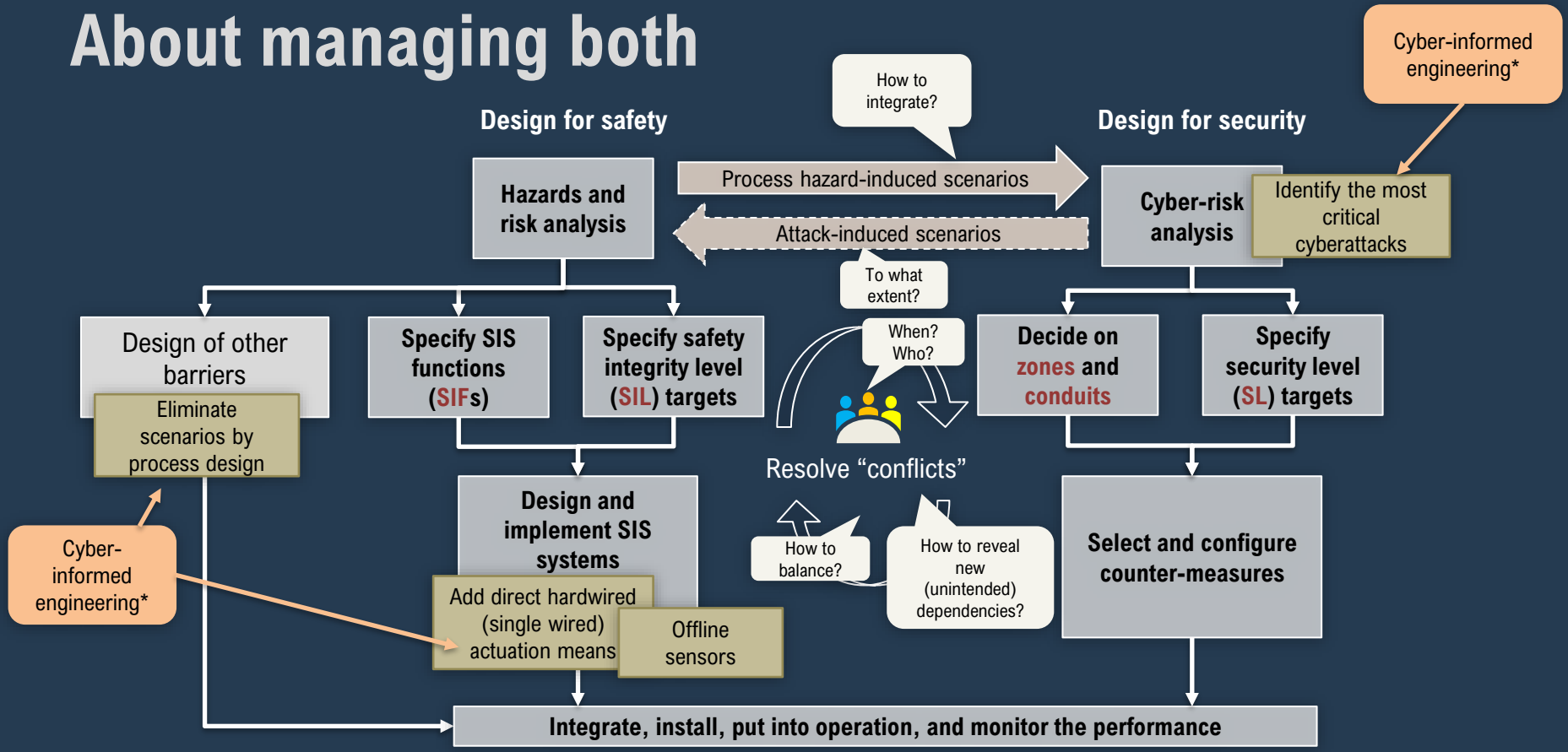
Initiatives to manage both

### Cybersecurity

- **IEC 62443** OT cybersecurity (201x/202x)
- DNV GL G108 – use of IEC 62443 (2020)
- NIST Cybersecurity framework (2024)
- NIST SP 800-82 OT cybersecurity guideline (2023)
- Offshore Norge GL 114 (2014)

Framing OT cybersecurity

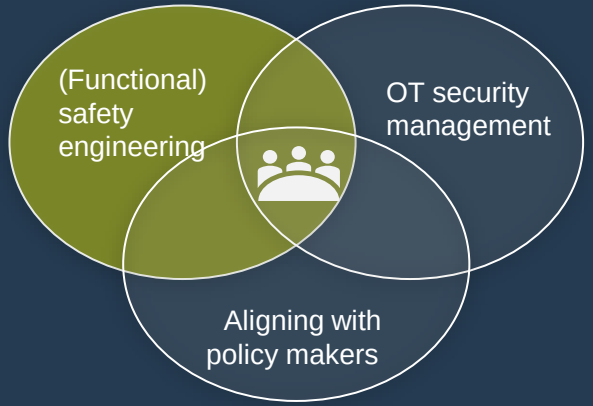
# About managing both




*Example: Consequence-driven cyber-informed Engineering (CCE™).

# SFI NORCICS is recruiting now!

## 2-year full-time Postdoc position on Cybersecurity of safety-instrumented systems (SIS)




**Supervision team NTNU:** Sokratis Katsikas, Vasileios Gkioulos, Mary Ann Lundteigen

**Research topics:**

- **SIS attack scenarios:** Identification of new and learning from the past
- **Understand SIS vulnerabilities:** Existing commercial systems and new smart instrumentation and IIoT
- **Compare practices and identify gaps:** With basis in current standards and guidelines
- **Provide new contributions:** To existing frameworks and as new guideline

Partners involved in the project: **Yara, Hydro, Equinor**

# Thank you for the attention! Any questions?

**Selected references (beyond standards):**


- Makrakis, G. M. et al (2021). Industrial and Critical Infrastructure Security: Technical Analysis of Real-Life Security Incidents. IEEE Access.
- Guzman, N., Kozine, I., Lundteigen, M.A. (2021) An integrated safety and security analysis for cyber-physical harm scenarios. Safety Science.
- Cyber-informed engineering: https://inl.gov/national-security/cie/
- Publications through the CDS forum, including cyberbarrier management project, see https://cds-forum.com/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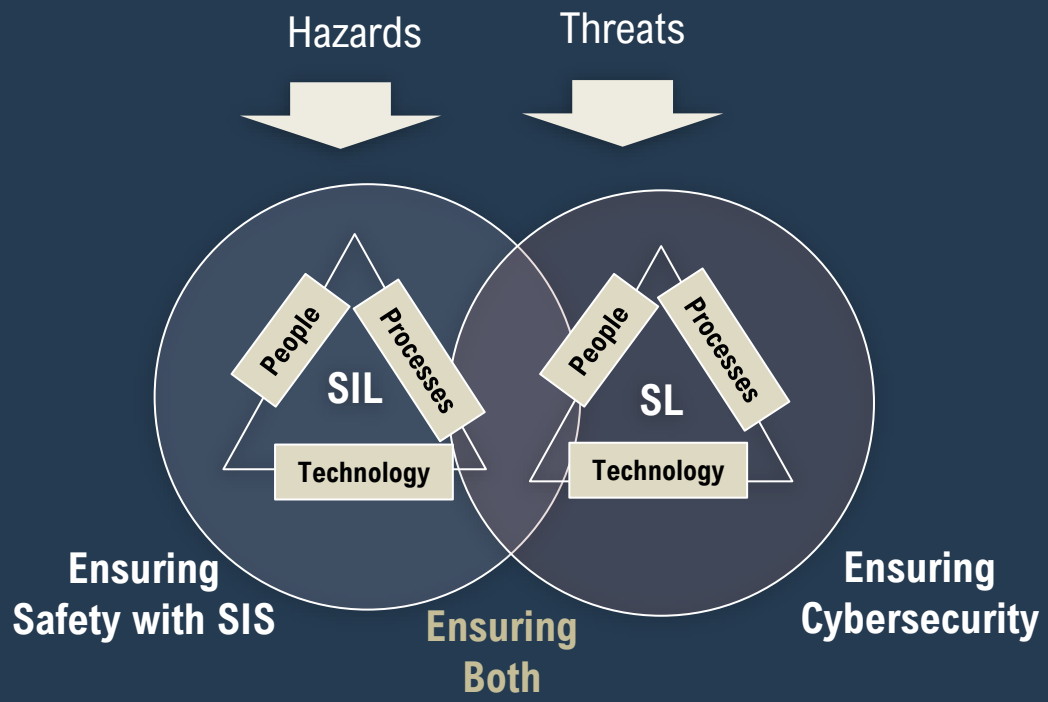


SIL: Safety integrity level. SL: Security level