MIRION
TECHNOLOGIES

I&C Systems Engineering

Diverse Instrumentation & Control Systems for Design Extension Conditions

I&C Systems for DEC

From R&D labs, to critical nuclear facilities, and on the front lines, Mirion Technologies provides proven radiation safety technologies that operate at the highest levels of precision, and deliver trusted expertise that empowers our customers to solve problems and enable breakthrough innovation.

- **60+ years of industry experience**
- **Highly qualified solutions**
- **An international presence in all types of nuclear reactors**

REACTOR SAFETY & CONTROL

Mirion is proud to support nuclear power operators across the entire lifecycle of the plant, from new construction, to operations, outages, and decommissioning.

A nuclear reactor is monitored using a combination of specialized instruments and control systems to ensure its safe and efficient operation. This monitoring is crucial for maintaining safety margins, optimizing reactor performance, and preventing accidents.

We can provide solutions to give operators key information to allow the safe and efficient operation of nuclear facilities. Our Reactor Instrumentation and Radiation Monitoring Systems help nuclear operators maintain reactor safety and peak operational performance.

STAND-ALONE SAFETY I&C SYSTEMS

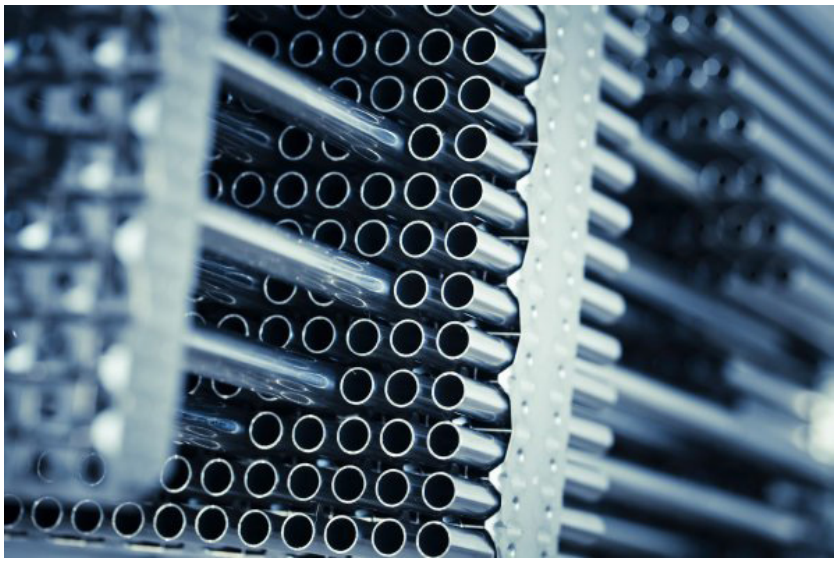
CHALLENGES

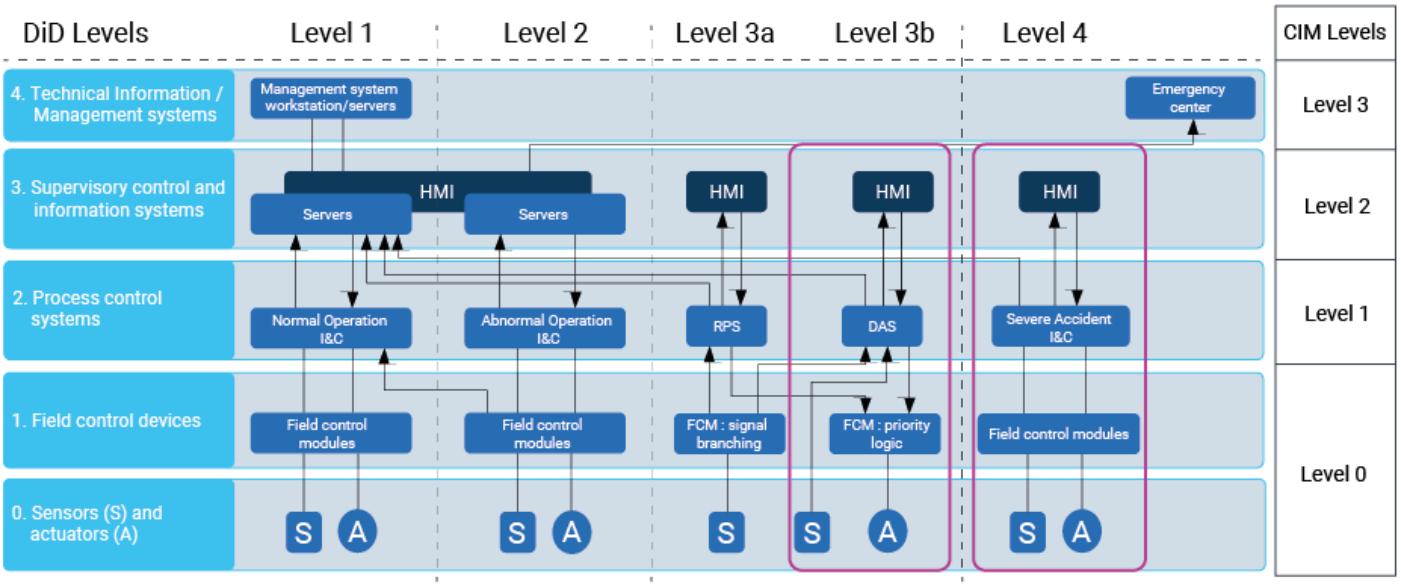
The need to install dedicated systems for Defense in Depth (DiD) Level 3b and Level 4 for Design Extension Conditions is fairly recent and the existing requirements for those I&C systems differ between codes, standards and regulatory bodies.

One of the main and frequent requirements for these I&C systems is the necessary level of independence they shall maintain with other I&C systems of the nuclear facility.

The requirements for an I&C system in DiD Level 3b are mostly based on the discussion of the postulated Common Cause Failure of the I&C system in DiD Level 3a realized by a digital I&C system platform. Consequently, a so-called Diverse Actuation System (DAS) is required for the DiD Level 3b.

Depending on the implemented Defense in Depth principle in the installation, a certain diversity may also be requested for the I&C system in DiD Level 4, so-called Severe Accident I&C (SA I&C).





FUNCTIONS

The scope of functions and the design of the DAS and SA I&C within the plant I&C architecture depend mainly on the safety regulations that are in force in the country of the nuclear facility.

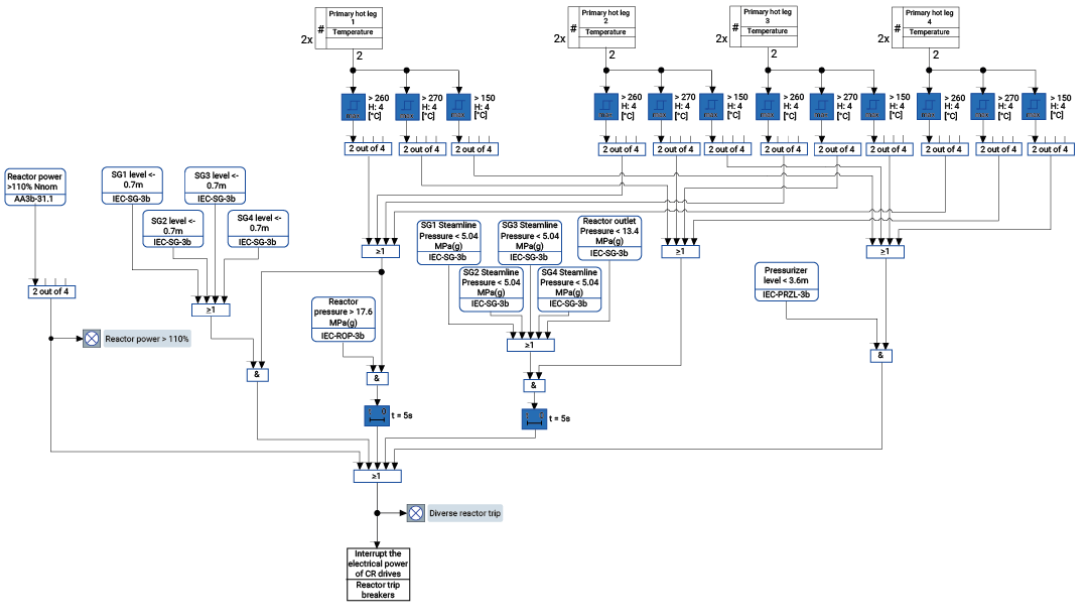
Most of the time, the following functions shall be performed for DAS:

- Short-term functions such as Reactor Trip on High Reactor Power (using NFMS) and control of containment isolation valves
- Long-term functions such as ventilation system, start and stop or monitoring of Primary Hot Leg Temperature or Containment Pressure
- Volumetric activity (for example, aerosol, iodine, RNG)

For SA I&C, mainly long-term functions must be performed, such as:

- Diesel start-up
- Control of ventilation system in the control room
- Dose-rate of gamma radiation
- H2 monitoring
- Air flow and volumetric activity of RNG in ventilation stack

Additionally, Mirion can provide SPND measurements thanks to existing SPND detectors and associated safety processing units in the Mirion Technologies catalog.



SOLUTIONS

The proposed solution to address the field and automation levels is based on existing and qualified Mirion Technologies platform and products to build a fully integrated I&C system:

proTK™ Platform

- Various detector assemblies (scintillation, proportional counters, ionization chambers, fission counters/chambers, SPND)
- Digital processing units for performing full I&C functions
- Protected software, efficient self-monitoring
- Local HMI
- Set of I/O boards allowing to acquire different types of input and to generate orders to actuators (0-24 V, 4 to 20 mA)
- Cables and connectors
- Cabinets and mechanical parts
- Engineering and maintenance tools

RAMSYS™ Product Line

- Various detector assemblies (ionization chambers, large area silicon, Geiger Muller tubes, silicon, NaI scintillators, proportional counters) associated with powerful qualified algorithms and processing units (for alpha, beta, gamma, radon, neutron)
- Efficient self-tests
- Local HMI
- Mechanical parts
- Cables and connectors
- Interfacing capabilities (0/24 V, 4 to 20 mA, RS485)
- Maintenance tools

Thermodynamic measurements (e.g.: temperature, pressure, level, flowrate) are addressed mainly by existing sensors in the Mirion Technologies catalog or other Safety COTS supplier.

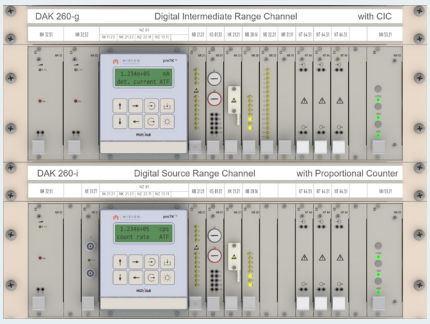
Supervision

The supervision level for these two I&C systems commonly consists of hardwired panels (based on galvanometers, lamps, push buttons) and is not addressed in this brochure. Nevertheless, Mirion Technologies is able to specify and design this HMI according to dedicated Nuclear Facility rules and HFE requirements.

With its own technology for detectors and the qualified proTK platform for automation level, Mirion Technologies can cover all functions for DiD 3b and 4 levels and to propose a full stand-alone, independent and diverse solution for both DAS and SA I&C systems, from the field level to supervision.

By using Mirion Technologies solutions, the diversity is addressed in three ways:

- Design diversity using different technology and different architecture;
- Signal diversity using different sensors and possibly different algorithms;
- Equipment diversity relying on CPU types of different design, different manufacturer and different design process.



Digital Processing Unit

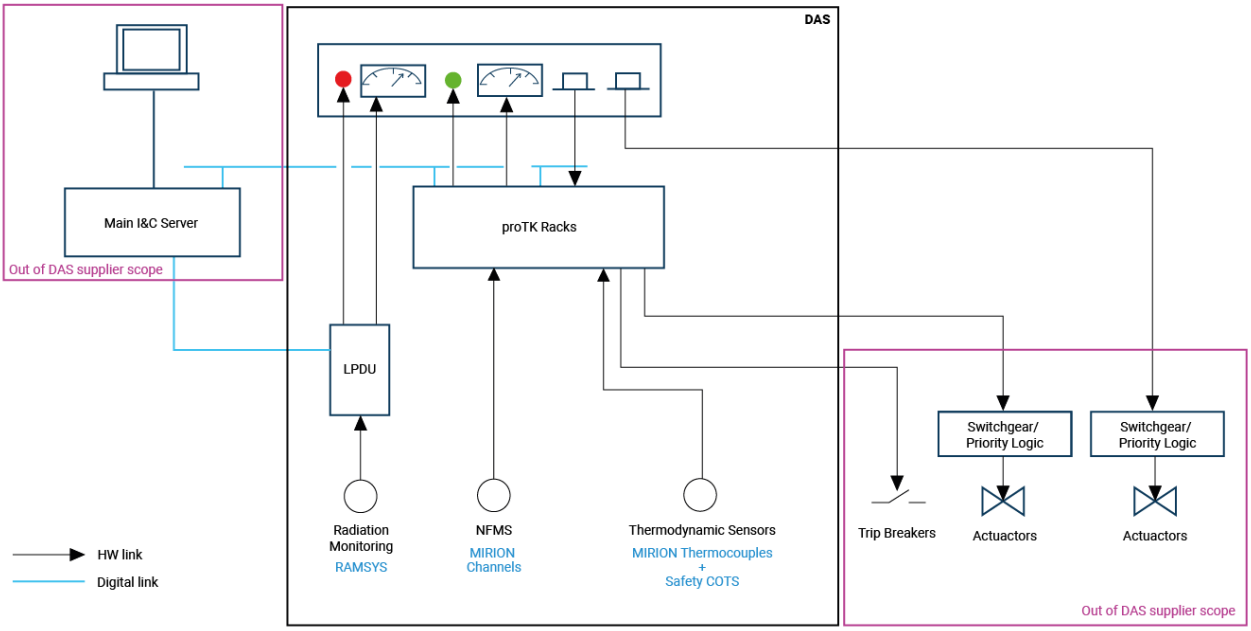
Detector

Preamplifier

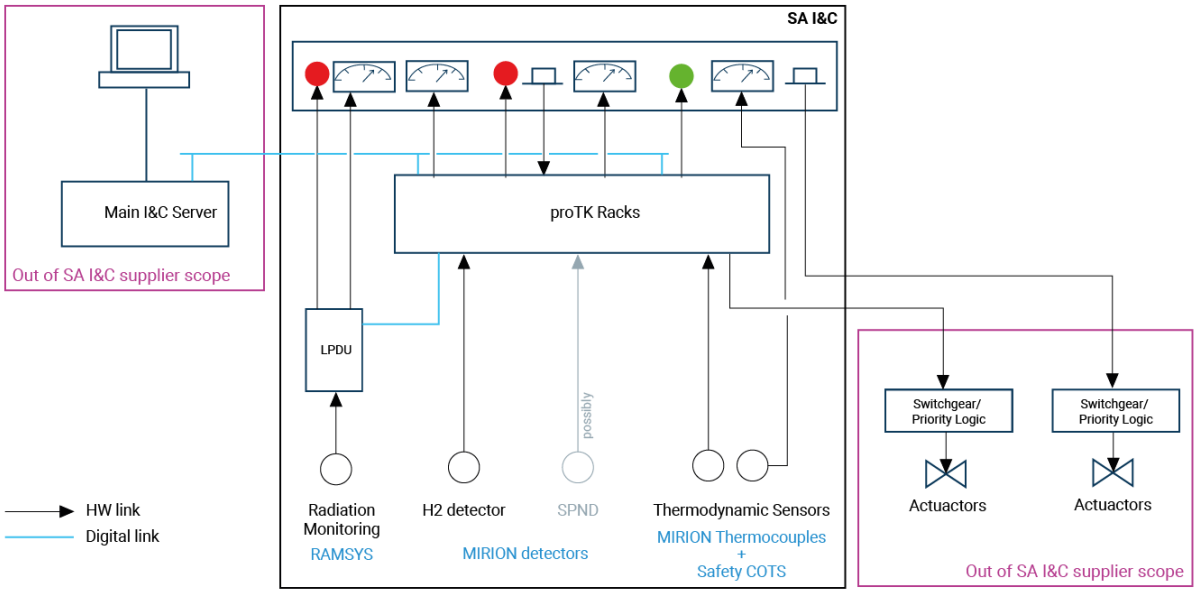
ARCHITECTURE

The following preliminary architectures can be considered:

For DAS:



For SA I&C:



BENEFITS

One existing approach for DAS in new nuclear power plants is to propose an analog I&C system which is fully diverse from digital solutions implemented in DiD Level 3a but which is very complex to design, to maintain and evolve.

The hardwired technology implementation often requires a huge number of cabinets, implying dedicated space for them (this point can be a critical issue for all modernization projects where requirement for DAS is new).

We can provide a diverse, compact solution for DAS at an attractive cost thanks to the advantages of digital technology over analog technology, and possibly a reduction of the intermediate I&C system.

Because NFMS channels are needed for DAS and proTK processing units can implement dedicated I&C functions, the proposed solution avoids intermediate equipment between the NFMS and Trip Breaker (as is the case with DAS I&C implanted in recent NPPs).

The most important and specific measurements of SA I&C such as, SPND channels, H2 monitoring, and radiation measurements in severe conditions are the core of our business, ideally suited to propose a stand-alone diverse SA I&C system for a nuclear power plant.

The use of such stand-alone I&C systems would also reduce the number of external interfaces to be managed by the overall I&C responsible, i.e. the customer.

Lastly, the independence and diversity requirements should be handled at the overall I&C level, where it's better to consider and to assess a full I&C system covering all the I&C levels to correctly address these requirements with the other I&C Systems.

EXPERIENCE

RAMSYS Product Line

More than 30,000 radiation monitoring systems (RMS) measurement channels are in operation today.

RMS systems operate in more than half of the world's nuclear power plants.

Mirion Technologies is the RMS system supplier for all types of nuclear power plants, in particular the latest 2nd or 3rd generation, and the only one for the EPR fleet.

proTK Product Line

More than 1,400 signal processing units are operating around the world.

Over 750 NFMS are in operation across the globe.

Lastest references:

- Radiation Monitoring Systems at nuclear power plants in Belgium;
- Ex-core Nuclear Instrumentation System at nuclear power plants in Belgium;
- Neutron flux and Gamma power instrumentation for a new research reactor in the Middle East;
- Neutron Flux Instrumentation at several Research Reactors in the US;
- Neutron Flux Instrumentation for a new research reactor in South America;
- Radiation Monitoring Systems for Brazilian nuclear power plant;
- Complete and stand-alone I&C systems (Belgium nuclear power plant).

QUALIFICATION

RAMSYS Product Line

RAMSYS complies with the most demanding standards requested for nuclear power plant safety related applications:

- 10CFR50B
- 10CFR21
- NQA-1
- IEC 61513
- IEC 61226
- IEC 62138
- ANSI/IEEE std 7-4.3.2
- IEC 60987
- HAF 604

The RAMSYS product line is 1E qualified according to the IEEE 323 and IEC 60780 standards, which rely on the specific following norms:

- **EMI/RFI tests:**
  - IEC 61000-6-2
  - IEC 61000-6-4
  - EPRI TR 102323
  - RG1.180
  - MIL STD 461E
- **Seismic tests:**
  - IEEE 344
  - IEC 60980
  - IEC 60068-3-3
- **Other tests:**
  - TID: IEC 60544-2

proTK Product Line

The standards applied for equipment qualifications (e.g., measurement channels, detectors, monitors) are:

- KTA 3501/ KTA 3503 / KTA 3505 / KTA 3507 (German nuclear regulatory guides for safety systems and systems that provide signals for the reactor protection system)
- KTA 1501/ KTA 1502/1503 / KTA 1505 (German nuclear regulatory guides for radiation monitoring systems in nuclear power plants)
- IEC 60780/ IEC 61513 / IEEE 323 (international nuclear standards for equipment qualification and system requirements; applicable to equipment importance to safety)

The software life-cycle fulfills the requirements for Cat. A or Cat. B/C monitors (acc. IEC 61226). IEC 60880, for systems performing Cat. A functions (important to safety). EMC/EMI tests have been performed according to the series of standards: IEC 61000-6-2/4. Seismic qualification has been performed according to the IEEE 344, IEC 60980, KTA 3503 / KTA 3505.

Abbreviations

AOO	*Anticipated Operational Occurrences*
COTS	*Component Off The Shelves*
DAS	*Diverse Actuation System*
DEC	*Design Extension Conditions*
DiD	*Defense in Depth*
HMI	*Human Machine Interface*
HFE	*Human Factors Engineering*
I&C	*Instrumentation & Control*
NFMS	*Neutron Flux Monitoring System*
NO	*Normal Operation*
RNG	*Rare Noble Gas*
RPS	*Reactor Protection System*
SA	*Severe Accident I&C*
SPND	*Self-Powered Neutron Detector*

Protect What's Next™

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