I&C Challenges, Architecture and Lessons Learned, Status on EPR projects

Nuclear Industry Localization Conference

Cape Town 1-3 June 2011

Summary

- **General Features of EPR™ :**
  - **Recent Trends,**
  - **Design Basis and Defense in Depth,**
  - **Diversity,**
  - **Architecture.**
- **Technologies.**
- **Human-Machine Interface System.**

General Features of EPR

- **EPR originally targets worldwide markets with a design compliant with internationally recognized rules and standards ; it can be adapted where necessary.**
- **The I&C system is designed consistent with the plant design based on 4 trains of safeguard systems (4X100 %) : sufficient even with one train failed, one train in maintenance or test and one train incapacitated by the accident.**
- **European Utilities Requirements (EURs) are first considered together with the IEC standards : the EURs take into account the lessons learned from the N4 digital I&C and H/MI systems .**
- **Adapted designs are available and comply with other standards : in particular USA(IEEE, Regulatory Guides, NUREGs and URDs).**

Recent Trends Highlights

I&C architecture robustness

- **Implementation of Successive Lines of Defence in Depth with increased independence.**
- **Extended consideration for Common Mode Failures (Prevention and Mitigation)**

Design Basis and Defence in Depth

IAEA	EPR C&I
Control the main plant parameters within their expected operating range. Detect and mitigate deviations from normal op. range, in order to prevent escalation to incident or accident	Main Control Function Limitations, LCO
Trip the reactor and starts ESFs up to bring the plant to Controlled State, and subsequently Safe Shutdown State, while maintaining at least 1 barrier for the confinement of radioactivity	RT/ESFAS
Address the Complex Sequences (incident or accident coincident with multiple failures) and Severe Accidents (B) in which the design basis may be exceeded and keep radioactive releases as low as possible.	RRC-Mitigating Systems

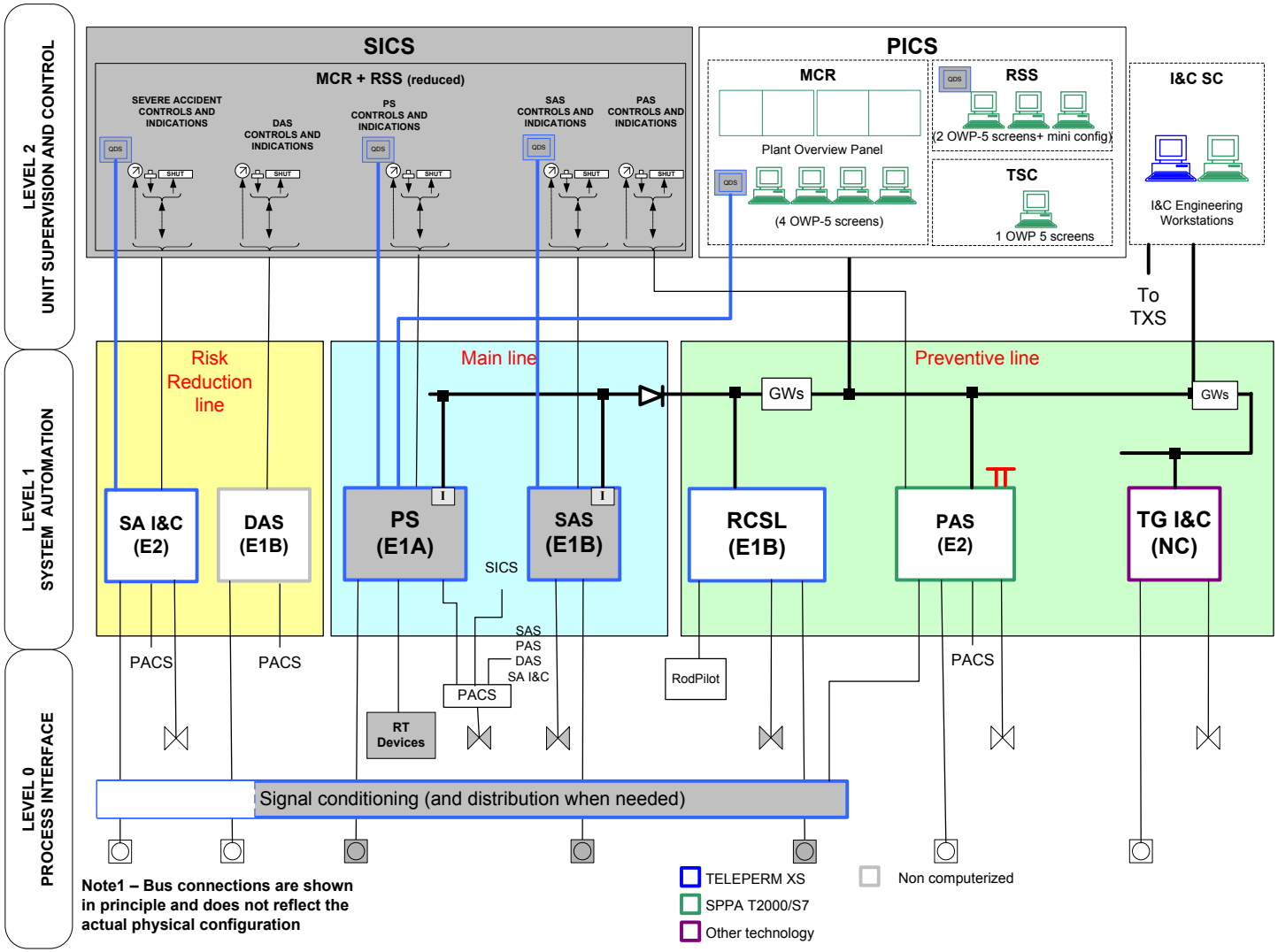
Diversity

- **Diversity provides resistance to Common Mode Failures : diverse equipment packages provide backup to each other.**
- **Teleperm XS™ and SPPA-T2000™ (or other off the shelf technology) are diverse from each other:**
  - **Teleperm XS™ is an AREVA product line, T2000™ is a SIEMENS product line.**
  - **Diverse hardware and software (I/O boards, local area networks, CPUs, busses, etc…).**
  - **Diverse computer-aided design tools.**
  - **Manufactured in different factories (Teleperm XS™ in Karlsruhe, T2000™ in Erlangen).**
- **Hardwired technology provides diversity with respect to both Teleperm XS™ and T2000™ when it is required to cope with digital I&C common mode failure.**

Functions and Equipment Classes According to EURs

EUR Function Class		Min Equipment Class
F1A	Functions required in case of an accident to bring the reactor to controlled state	E1A
F1B	Functions required in case of an accident to bring the reactor to safe shutdown state Functions that prevent the risk of radioactive releases	E1B
F2	**Other functions contributing to plant safety** **(e.g. respect of limiting condition of operation, safety system availability monitoring, protection against internal hazards effects, residual risk reduction, detection and control of radioactivity releases …)**	E2
NC	Non classified functions	NC

Standard EPR I&C Architecture



Summary

- General Features of EPR™ :
  - Recent Trends,
  - Design Basis and Defense in Depth,
  - Diversity,
  - Architecture.
- **Technologies.**
- Human-Machine Interface System.

Technologies

- **I&C systems for EPR™ as well as for renovation of plants already in operation take advantage of a substantial experience feed-back :**
  - Digital I&C in various types of nuclear power plants ,
  - Computerized man-machine interface (N4).

- **Modern I&C systems largely based on digital technologies:**
  - TELEPERM XS ™ manufactured by AREVA.
  - SPPA T2000 ™ manufactured by SIEMENS.
  - Video displays units used for graphical interfaces and mimics,
  - Communication with external systems (site management, remote monitoring…),
  - Flexible architecture,
  - Integrated engineering and design tools.

- **Hardwired Technology is retained for specific functions.**

AREVA Digital Safety I&C TELEPERM XS ™

- Complies with international standards for class 1E (F1A) application: IEEE, RGs, NUREGs, IEC (specifically IEC60880 and 60880-2), European Standards and Rules.
- Modern microprocessors (AMD K6-2E) provide high computational capabilities.
- Class 1E network (L2) provides safe data transmission (deterministic).
- Gateways provide connection to other technologies.
- Wide range of I/O boards available.
- Efficient safety-oriented computer-aided design tools: FunBase, SPACE and SIVAT.
- Permanent self monitoring and diagnostic stations.

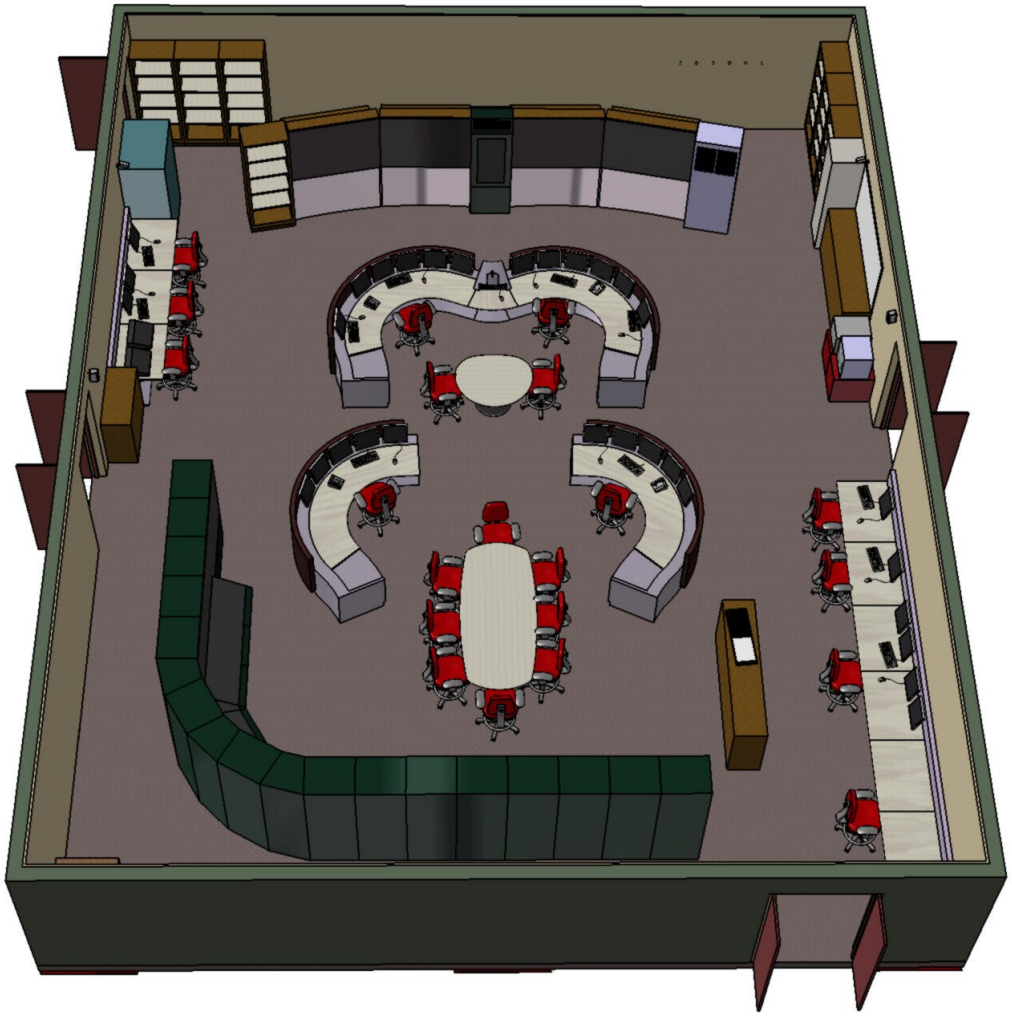
Summary

- General Features of EPR™ :
  - Recent Trends,
  - Design Basis and Defense in Depth,
  - Diversity,
  - Architecture.
- Technologies.
- **Human-Machine Interface System.**

Control Centers

- **Operation from Main Control Room (MCR), as long as it is inhabitable.**
- **Remote Shutdown Station (RSS), should MCR become uninhabitable (fire, smoke, etc.).**
- **Technical Support Center (TSC) for experts called for support following an accident.**
- **The various control stations exhibit homogeneous ergonomics.**
- **No fire or other incident can simultaneously impact MCR and RSS.**

Main Control Room Operation Area



Main Control Room
Safety Information and Control System

Notice

Any reproduction, alteration, transmission to any third party or publication in whole or in part of this document and/or its content is prohibited unless AREVA has provided its prior and written consent. This prohibition concerns notably any editorial elements, verbal and figurative marks and images included herein.
This document and any information it contains shall not be used for any other purpose than the one for which they were provided. In particular, no patent application and/or registered design may be applied for on the basis of the information contained herein.