Steps towards a large-scale I&C modernization at the Paks NPP to support the planned plant service time extension

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Presentation overview

- Introduction to Paks NPP
- Completed modernization projects: RPS, plant computers, radiation monitoring
- I&C modifications for power uprating: core monitoring, pressure control
- Preparations to replace traditional I&C
- Scope, schedule of I&C reconstruction
Paks NPP in brief

- Four VVER-440/213 units (1982-1987)
- Present total capacity = 1890 MWe
- Production in 2006 = 13.5 TWh (≈37.6%)
- Safety enhancements (1996-2002)
- Power uprating to 108% (2006-2009)
- Plant service time extension (30 ⇒ 50 y)
Safety system refurbishment

- Motivation and functional improvements:
  - Compliance with requirements (single-failure, fault tolerance, fail-safe features, seismic qualification)
  - Higher level of automation, less operator actions
  - Full-scope diversity, testability and self-diagnostics

- Full reconstruction between 1999-2002
- Result: triple-redundant, fully digital RPS
- Tools: Teleperm XS, Space, ProfiSim
- Extensive use of simulator for V&V tests
Architecture of the new safety system
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Animated RPS logic diagram as displayed in the window of the ProfiSim tool
Process computer system (PCS) I.

- **Most important Paks PCS functions:**
  - Data acquisition from the technology (+ RPS GW)
  - Signal processing & display, data storage
  - Serving other plant systems with processed data
  - No active control functions, only monitoring

- **Full reconstruction between 1998-2003**
- **Parallel work with RPS modernization**
- **Unit 1-4, simulator + Plant Info Centre**
- **New items: CSF monitoring + EOP display**
Process computer system (PCS) II.

- **Architecture of the unified PCS:**
  - Redundant 100 Mbps network (Fast Ethernet)
  - Redundant Scada servers, distributed processing
  - Supervisor syst. (self-diagnostics + reconfiguration)
  - Unified HMI for the CR operators and O&M personnel
  - HTML-based (WEB) services for external PCS users

- **Unified hardware and software tools:**
  - Professional, PC-compatible servers (rack mounted)
  - Win-NT 4.0, iFIX Scada shell, MS SQL Server 2000
  - Multi-level access control and data protection
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Architecture of the new process computer at Unit 1
Main display format of the new PCS
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Paks NPP I&C modernization
Radiation monitoring systems

- **1st step: environmental monitoring system**
  - Full system reconstruction between 2000-2004
  - 9 monitoring stations ($\gamma$, aerosol, noble gas, iodine) renewed + 11 new $\gamma$ monitoring stations installed
  - 3 water monitoring posts + 2 ventilation stacks
  - Industrial field network + central Scada processing

- **2nd step: internal radiation monitoring**
  - Full system reconstruction between 2006-2010
  - New dosimetry control room with large display panel
  - Scada components with limited soft-control
Power uprating project

- **Most important plant modifications:**
  - New fuel (3.82% enrichment, profiled, 12.3 mm lattice pitch)
  - Decreased hydroaccumulator pressure (59 → 35 bar)
  - New, more stable primary pressure control
  - New HP turbine inlet nozzle, modified turbine control
  - Replacement of high-pressure preheaters
  - Several minor enhancements on the secondary side
  - Modernized generator cooling
  - New, reconstructed core monitoring system
VERONA core surveillance system

- **Main objectives and improvements**
  - Increase system capacity to support power uprating
  - Replacement of the obsolete hardware and network
  - Full SW modernization and porting to Windows
  - New, more accurate reactor physics calculations
  - Integration of the standard Paks core design code
  - Modernization of the human-machine interface
  - Modern SW tools: SQL, OPC, Scada-based HMI

- **Full reconstruction between 2005-2008**
- **Status:** U1,3,4 + simulator = O.K. U2 = **2008**
Architecture of the new VERONA system

Operative displays (iFix View Client)
Remote displays (Remote Desktop Connection)

RPH1 server
RPH2 server

VDP1 server
VDP2 server

EXD server (iFix Client + Terminal Services)

VERONA Expert System

Fast Ethernet network

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Main display format of the new system
History of reaching first 104% then 108% power at Unit 4 (2006)

Paks NPP I&C modernization
Primary pressure controller

- Problems with old controller:
  - Insufficient long-term stability
  - Rough discrete characteristics for heaters and spray
  - Power uprating required a more precise control

- Solution = installation of a new controller:
  - Built from functionally + spatially distributed PLCs
  - Industrial Ethernet for communication + field buses
  - Continuous analogue control (122.75-123.25 bar)
  - Highly stable primary pressure control ensured
Scheme of the new pressure controller
Characteristic of the new controller

Paks NPP I&C modernization
Comparison of the behaviour of the old and new pressure controllers
Present I&C situation

- **Safety I&C systems:**
  - Fully reconstructed, present state is satisfactory

- **Traditional (non-safety) I&C systems:**
  - Approaching their expected service time
  - Modernization is needed for service time extension

- **Plant information & supervision systems:**
  - Most of them was (or will be) reconstructed
  - Their present state is (or will be) satisfactory
Preparations and studies

- Development of the I&C functional model
  - Definition of appropriate I&C functional groups
  - Elaboration of a formal methodology to describe I&C
  - Development of a plant I&C database (U1 completed)

- I&C pilot project = “tasting the pudding”
  - Complete re-engineering of a system (make-up wtr)
  - Testing “the I&C engineer is the programmer” idea
  - Using, testing various tools (ProfiSim, Space etc.)
  - Selection of the final design and implementation approach and applicable tools
Scope and schedule of the I&C works

- Paks-specific guide (based on IEC TR 62096)
- Major steps identified for the Paks case:
  - Establishment of the I&C project framework
  - Preparative activity (e.g. requirements specification)
  - Design phase
  - Manufacturing phase
  - Installation phase

- Proposed time schedule
  - Preparations and project launch: between 2007-2011
  - Site installations at the units: between 2012-2015