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Fukushima effect on SAM requirements and regulatory oversight in Hungary

Dr. Gábor Petőfi
Hungarian Atomic Energy Authority

International Experts' Meeting on Severe Accident Management in the Light of the Accident at the Fukushima Daiichi Nuclear Power Plant

March 17-20, 2014, IAEA, Vienna, Austria,

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Outline of presentation

- Hungarian nuclear programme
- SAM History
- SAM modifications before Fukushima
- Implementation
- Post-Fukushima SAM measures
- Post-Fukushima changes of requirements
- Lessons for consideration

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Hungarian nuclear programme

- Paks NPP
  - 4 VVER-440/213 reactors commissioned in 1983-87
  - 40% of electricity prod.
  - Service life extension 30 + 20 years
  - Two new VVER reactors (2023-26)
- Interim spent fuel storage facility
- Budapest research Reactor
- 100 kW training reactor
- Low and intermediate radwaste disposal facility

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SAM history

- Requirements 1993-1997
  - Periodic Safety Review, PSA, severe accident management
- Implementation
  - First PSR for finalized in Paks NPP in 1999
  - Living PSA Level 1
  - SAM needs were identified
- In 2001: Paks NPP intention for service life extension
- In 2005: new set of nuclear safety requirements
  - SAM is a clear pre-condition for service life extension
  - Full-scope Level 2 PSA shall be completed

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SAM basis – PSA Level 2

- Select AM strategies
- Identity back-fit measures
- Risk reduction options
- Basis for regulatory decisions

- Internal PIEs and hazards
- Seismic PIEs
- SFP events

Containment failure mode	Main reason of the failure	Relevant SAM measure
High pressure vessel failure	Failure of primary depressurisation	more reliable and separate electrical source for SVs
Containment by-pass	SG tube or collector rupture	redirect the coolant from the secondary side into the confinement in case of PRISE
Early containment failure	Hydrogen burn; reactor cavity failure	Installing hydrogen recombiners; IVMR with external cooling
Late containment failure	Containment slow overpressurisation; Base-mat errosion	IVMR with external cooling; Containment heat removal
Late containment enhanced leak	Cavity door seal failure	IVMR with external cooling

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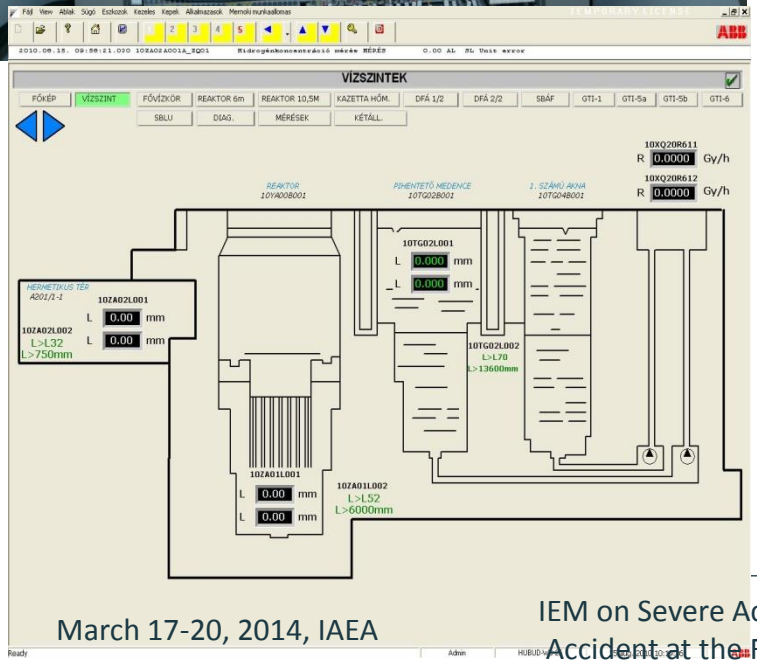
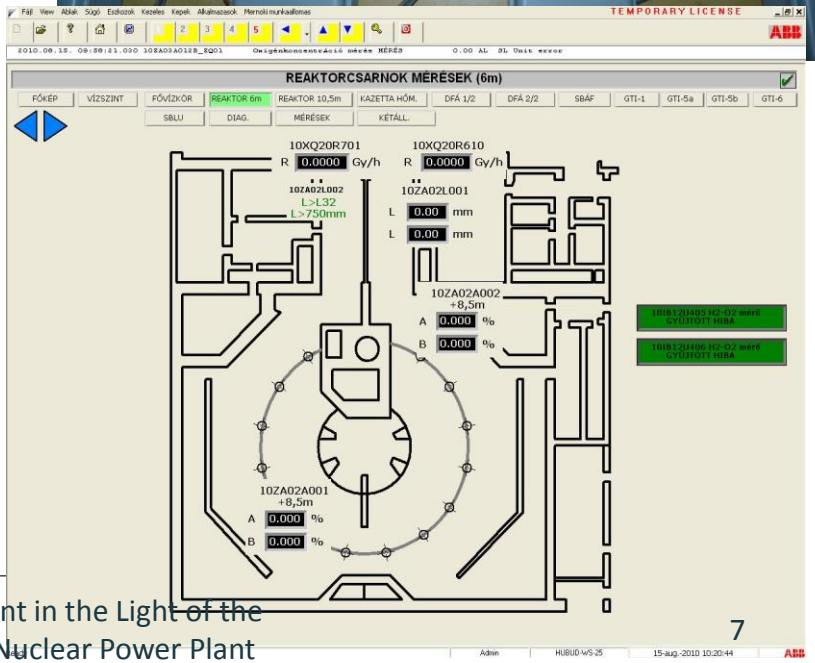
Concluded SAM measures before Fukushima

- Installation of SA instrumentation and monitoring
- Construction of reactor cavity flooding system
- Construction of autonomous power supply to designated consumers
- Installation of passive hydrogen recombiners
- Reinforcement of cooling circuit of spent fuel pool against loss of coolant
- Introduction of severe accident management guidelines
- SAMGs and Technical Support Centre

SA instrumentation and monitoring





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SA instrumentation and monitoring

- Independent power supply
- SA environmental conditions
  - Pressure above the core
  - Core outlet temperatures
  - Water level in the confinement
  - Water level in the cavity of the reactor vessel
  - SG water levels
  - Pressure in the confinement
  - Temperature in the confinement
  - H and O concentration in the confinement
  - Water level in the cooling pond
  - Dose rates in the reactor hall and the confinement
  - Environmental measurement system

Reactor cavity flooding

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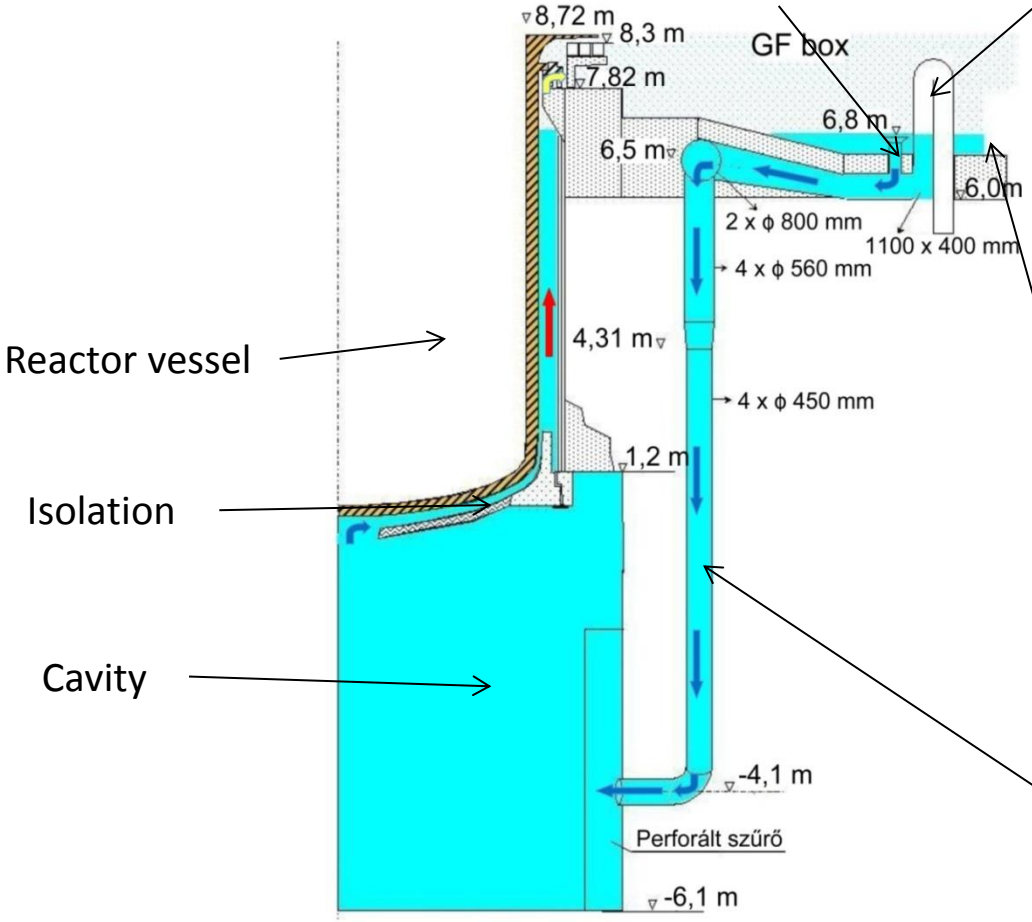
Modification of the ventillation system

(valve) (U-profile)



Water comes to the floor of the SG-box from the trays of the bubble condenser

Ventillating system of the cavity

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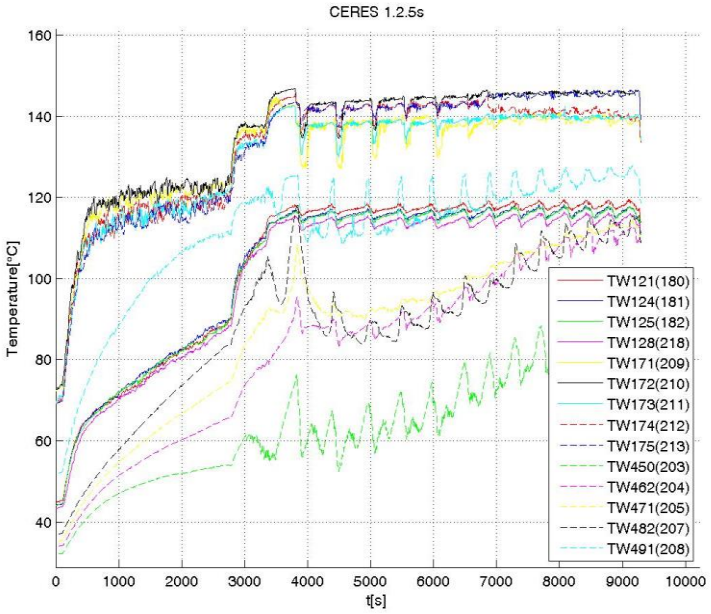
Reactor cavity flooding: CERES experiment

- Efficiency of the cooling loop: proven experimentally by AEKI on CERES test facility
- An integral model of the vessel external cooling loop
- 1/40 slice of reactor vessel surface
- Wall heating (>500 kW/m^2) provides the driving force for natural circulation in the 8 m channel.



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Autonomous power supply

- 4xSA diesels /100 kW: for minimum SA I&C
  - Stored at the site in a separate building
  - SA measurements, valve opening, emergency lighting
  - Charge batteries
- > 24hours
- In operation in 90 min
- Connected as EOP action (before SAMG initiation)

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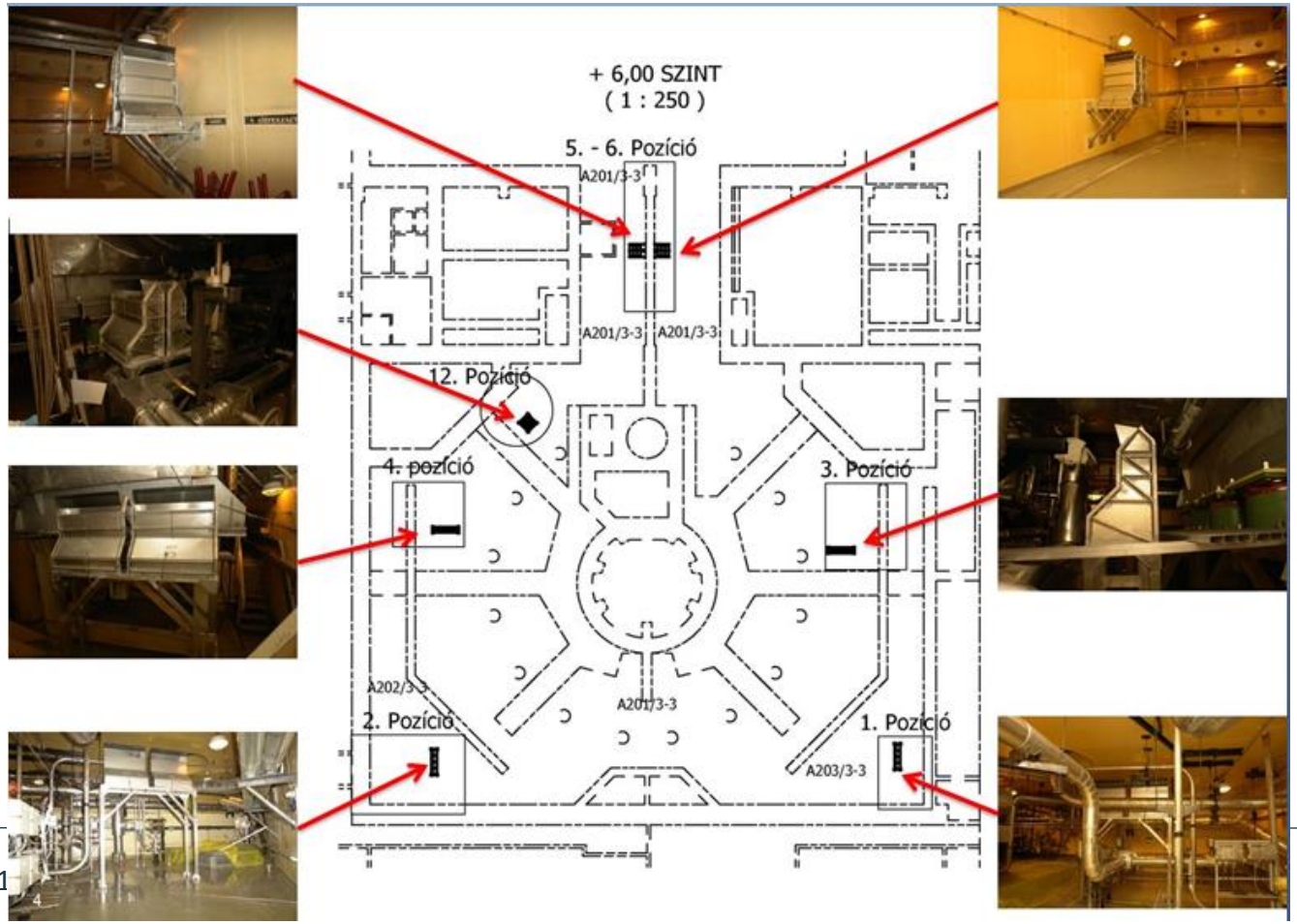
Passive hydrogen recombiners

- 60 H-recombiners at each unit
- Optimal positions: H-distribution analysis by MAAP4/WWER



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SAMGs

- Westinghouse-type SAMGs for all states and SFP
- Entry to SAMG from EOPs according to $T_{core\ outlet}$
- SAMGs executed at TSC
- Training and validation exercise was pre-condition

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Training and validation

- Validation
  - Emergency exercise with 4 scenarios incl. 1 for SFP
  - Under realistic circumstances
  - To test the guidelines, TSC, interface with CR and ERO, time needs, provide feedback
- Training
  - To provide knowledge, improve skills and efficiency of implementing SAMGs
  - Class room, SAMG implementation, drills

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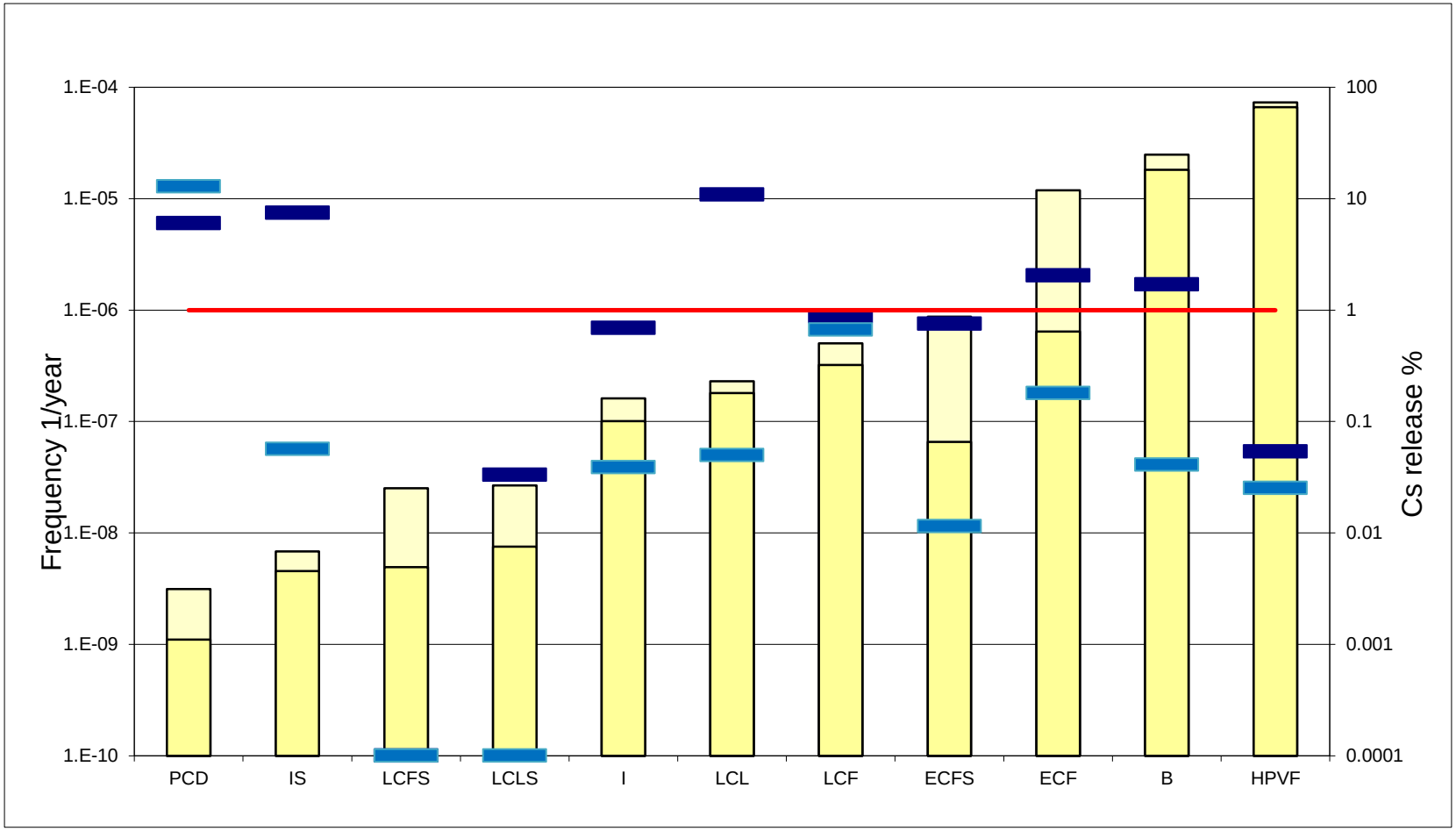
Results of Level 2 PSA 2004 vs 2012



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Post Fukushima SAM

- Outcomes of the Stress Test of Paks NPP
- Decided actions:
  - Long term containment cooling
  - Alternative water supply
  - SAMGs to cover multi-unit accidents
  - New Backup Emergency Centre
  - Independent power supply for the climate system of EC
  - Revision of radio connection
  - Shielded transport vehicle
  - Creating a computer based SA simulator
  - Upgrading computer systems of the centers
  - Organizational and documentation matters
  - SA liquid waste management

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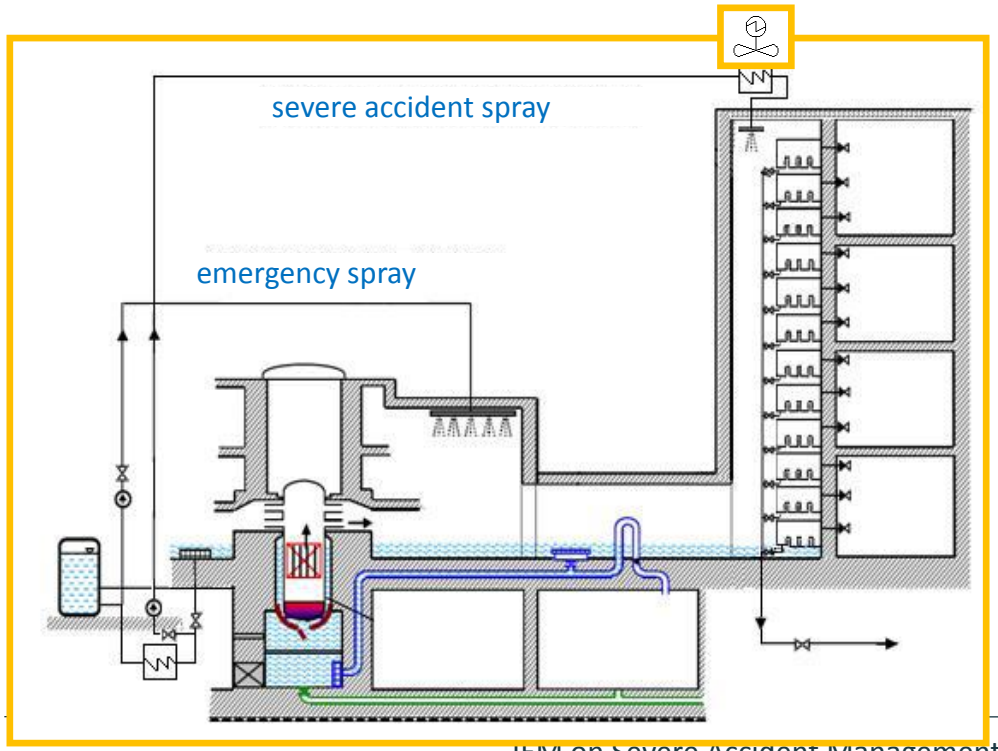
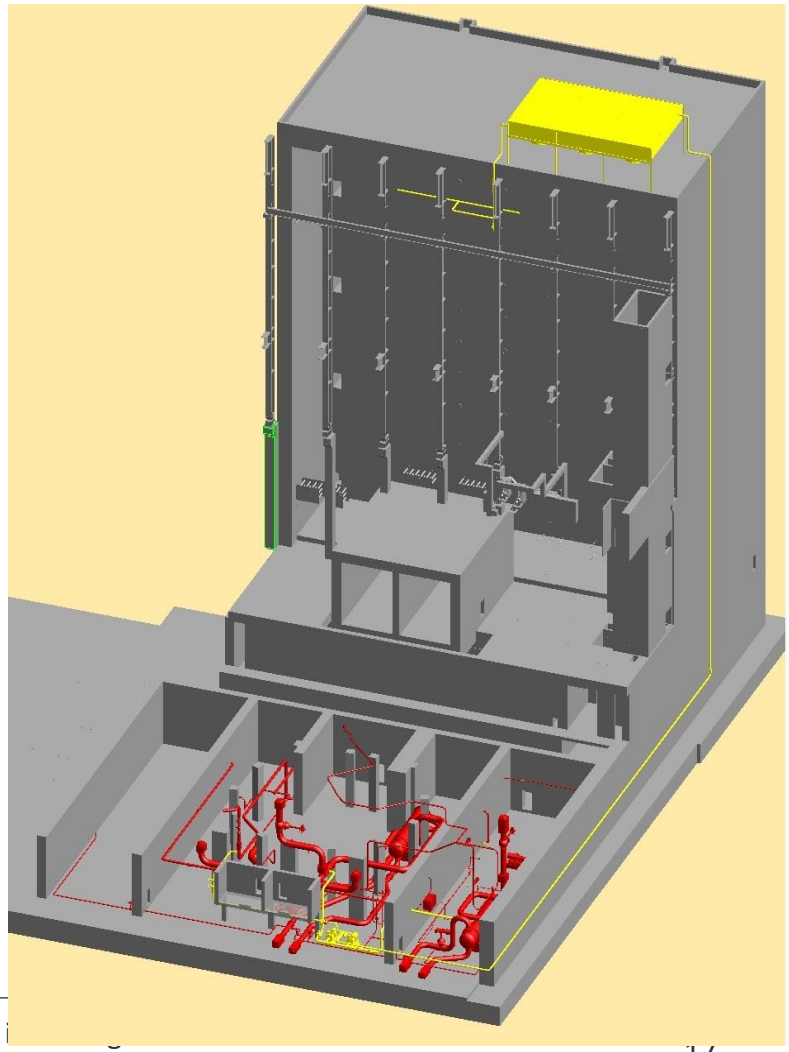
Containment cooling system - concept

- Active SA spray system (2 pumps)
- Air-cooled towers (3 modules)
- Power supply by bunkered SA DGs





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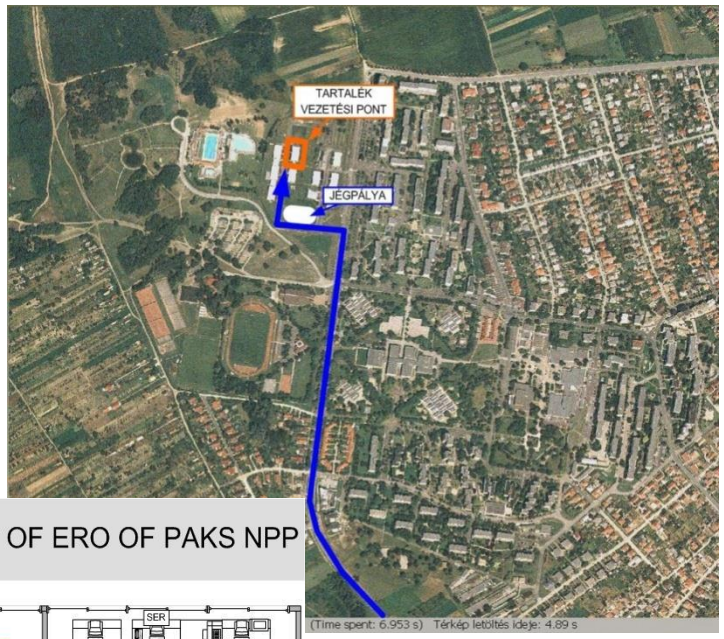
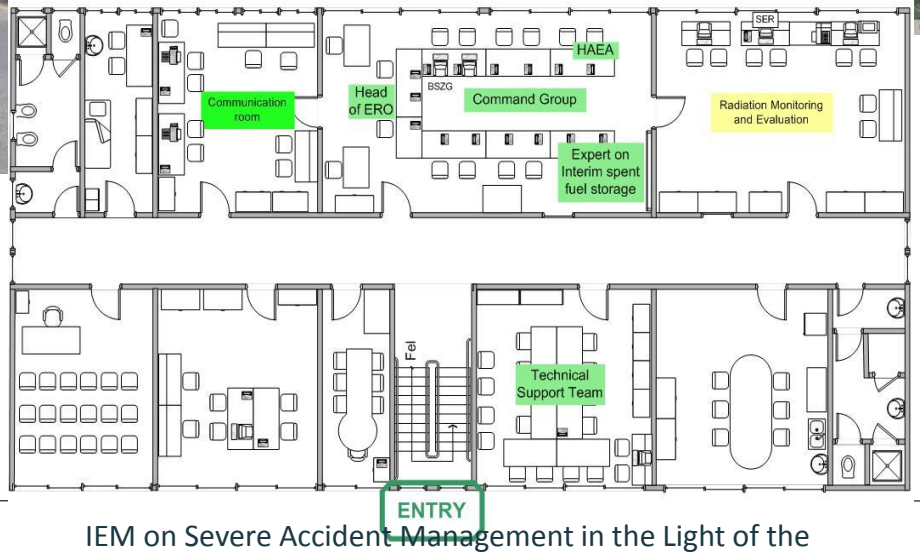
Alternate water supply from fire water system

New Backup Command Centre



BACKUP COMMAND AND CONTROL FACILITY OF ERO OF PAKS NPP



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Post Fukushima requirements

- Development based on 3 main sources
  - Draft WENRA revision
  - IAEA Draft of revised requirements
  - Hungarian stress test results
- Main issues tackled
  - Preparation for cliff edge effects
  - Multiple unit sites, neighboring sites
  - Supplemented requirements for external hazards
  - Generalization of requirements for spent fuel pools
  - Reinforcement of independent technical support centre
  - Use of alternative systems and cross connections between units
- Draft requirements are sent for public administration coordination. Expected to be issued by end of 2014

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Lessons for consideration

- SAM development is a long process
  - Selection of concept
  - Site and reactor-type specific solutions are required
  - Experimental evidence for some measures
  - Regulatory approval
- Requirements shall also follow operating experience
- PSA Level 2 is important tool to decide and measure SA
- Pre-condition for long term operation
- Harmony with Fukushima lessons
- Training and validation is important pre-condition

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Questions

Thank you for listening to me!