



REPUBLIC OF SLOVENIA

MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

# **Experience with Safety Reviews of Slovenian Research Reactor by PSR and IAEA INSARR Missions and the Stress Tests for the Krško NPP**

**Tomaž Nemec**

Slovenian Nuclear Safety Administration

Ljubljana, Slovenia, EU

[tomaz.nemec@gov.si](mailto:tomaz.nemec@gov.si)

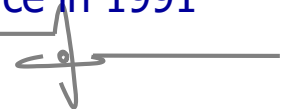


# Nuclear Slovenia

**SNSA** = reg. body



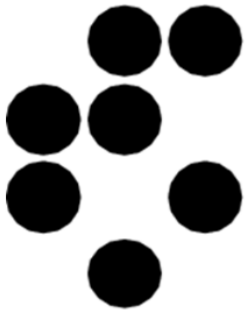
Slovenia = 8% of Australian population; 0.3% of Australia's size; SLO independence in 1991



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- Ljubljana TRIGA research reactor – 51 years of operation
- 1992 TRIGA RR modernization, INSARR mission
- 2009 New regulatory requirements
- 2011 Periodic safety review
- INSARR missions 2012, 2015
- 2011 EU stress tests

## Jožef Stefan Institute

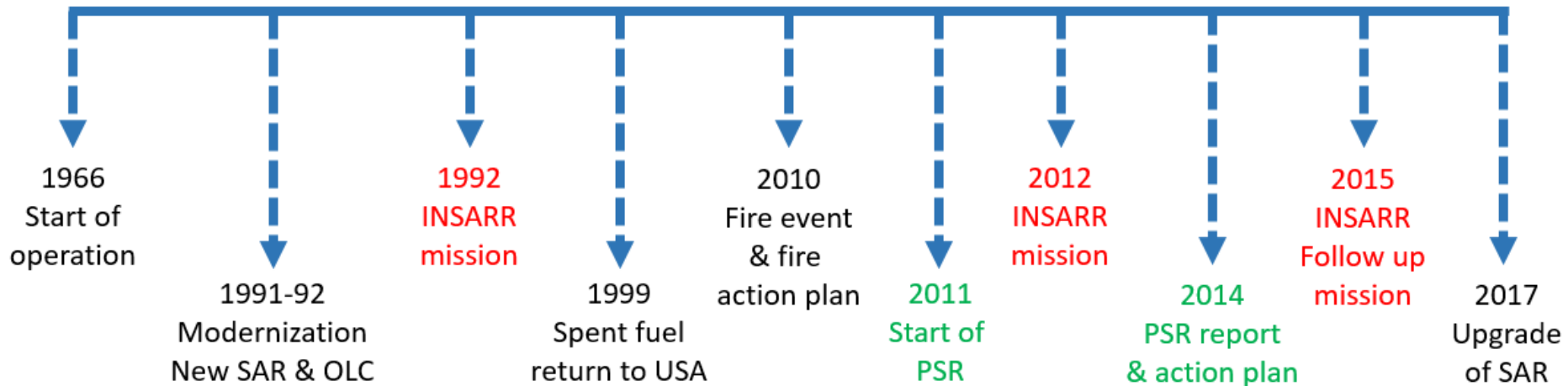


# 51 years of operation of Ljubljana TRIGA RR

- Modernization of the RR: 1991-92
- Major SAR upgrades: 1992, 2017
- Periodic safety review: 2011-14
- INSARR missions: 1992, 2012, 2015



## Milestones:

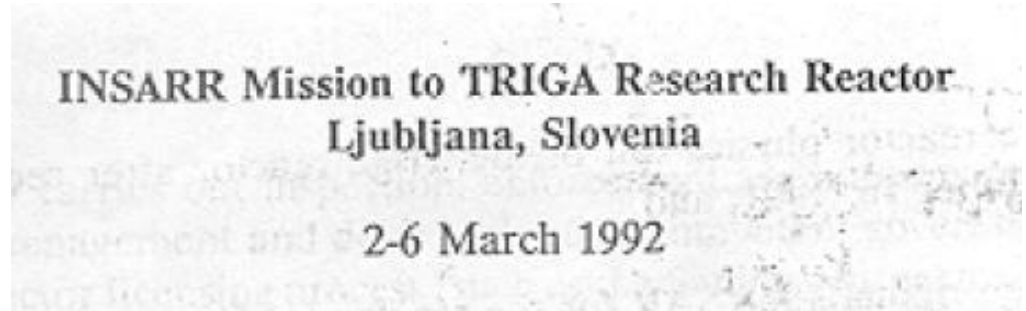


# TRIGA RR Modernization in 1992

- After 24 years of operation – instrumentation outdated
- Replacement of reactor control board, electrical connection
- Storage for spent fuel elements, new physical protection
- Capability for pulsing mode operation
- Preparation of a comprehensive SAR:
  - Safety analysis
  - OLC, also for pulsing operation
- Commissioning and reactor physics tests
- New operating license issued by the SNSA



# Independent safety review – INSARR 1992



- IAEA INSARR mission requested by SNSA to review results of reactor physics tests and SAR and OLCs
- Review of Nuclear Safety and Radiation Protection areas
- 16 recommendations (examples):
  - For improvements in reactor design, operation, documentation
  - To include in SAR safety analysis of external events
  - Procedures for operators
  - Criteria for reporting of events
  - Emergency preparedness

# TRIGA RR before 2011

- 1999 – spent fuel & HEU fuel returned to USA
- 2008 – hot cell facility merged with TRIGA RR, SAR was amended with a new chapter (safety analysis and OLC)
- 2010 – Fire event in the hot cell facility, **INES level 1**
  - Refurbishment of hot cells after fire damage
  - Installation of active fire protection in the TRIGA RR



- WENRA (2008) – Nuclear safety act amended, new regulations JV5 and JV9 issued in 2009
- Design requirements for RR based on IAEA NS-R-4
- Graded approach applied in requirements for TRIGA RR
- PSR required for extension of RR operating license





# Post-Fukushima safety reviews and upgrades



  
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SLOVENIAN NATIONAL REPORT ON  
NUCLEAR STRESS TESTS  
Final Report

December 2011



- EU stress tests for Krško NPP
- New WENRA (2014) – new regulations JV5, JV9
- TRIGA RR PSR, INSARR mission
- upgrade of TRIGA RR SAR





# TRIGA RR – first PSR 2011-14

PSR program,  
14 safety  
factors, graded  
approach (PSA)

- PSR scope based on regulation JV9 (IAEA SSG-25)

Safety Factors	
Plant design	Use of experience from other plants and research findings
Actual condition of SSCs important to safety	Organization and the management system
Equipment qualification	Safety culture
Ageing	Procedures
Deterministic safety analysis	Human factors
Hazard analysis	Emergency planning
Safety performance	Radiological impact on the environment

- **100** findings → **85** actions for improvement:
  - Revision of SAR (safety analysis, OLC, external hazards)
  - New programs: aging management, classification of SSC, EQ, OE
  - Radwaste management program, preliminary decommissioning plan
  - Operating procedures
- PSR action plan to be implemented by the end of 2019
- PSR confirmed safety of RR → operating licence extended

# IAEA INSARR mission 2012 and follow up 2015

- 14 safety areas reviewed
- New IAEA standards applied
- Recommendations

Safety Aspects of the Reactor Operation	
Regulatory Supervision	Conduct of operations
Operating organization and reactor management	Maintenance, periodic testing and inspection
Safety committee	Utilization and modifications
Training and qualification of operating personnel	Operational radiation protection and waste management programme
Safety Analysis Report (SAR)	Emergency planning
Safety Analysis	Quality assurance programme
Operational Limits and Conditions	Decommissioning plan

- to improve reactor fire safety (following fire event in hot cell facility)
- Responsibilities of reactor manager and reactor safety committee
- New operating procedures
- Update of SAR, emergency preparedness plan, radiation protection
- **Good practice = PSR every 10 years with scope similar as for NPP**
- **Government shall provide funds for upgrade of RR safety**
- **INSARR-FU → safety reassessment according to IAEA SRS No. 80**

# Upgrade of TRIGA RR SAR 2011-17

- Safety analysis and OLCs for RR experiments and materials irradiation
  - Update of data on RR site
  - Aging management program
  - Operational experience program
  - Radiation protection, radwaste management
- 
- Implementation of JV5 and JV9 requirements
  - Independent expert review by TSO → changes acceptable



# EU Stress tests campaign – 2011-12



## Krško NPP

in operation since 1983, Westinghouse PWR, 2000 MWt

Owners 50:50 Slovenian and Croatian utilities

steam generators replacement and power uprate in 2000

Aging management program, lifetime extension 2023→2043

1st PSR 2003, 2nd PSR 2013, Stress tests 2011, Safety upgrade program 2013



# Post Fukushima & EU stress tests

- By June 2011 – mobile equipment
- National report on stress tests - 2011
- Country review – early 2012



## Initiating events

Earthquake

Flooding

Extreme Weather  
Conditions

## Consequence of loss of safety functions

Loss of electrical power,  
including station black out

Loss of the ultimate heat sink

Combination of both

## Severe accident management issues

Means to protect from and to  
manage loss of core cooling  
function

Means to protect from/  
manage loss of cooling  
function in spent fuel pool

Means to protect from and  
to manage loss of  
containment integrity

- Krško NPP safety upgrade program 2013 – 2021:
  - PAR, FCVS, ECR, DEC equipment, flood protection etc.





# Conclusions

- 51 years of successful operation
- Many RR design upgrades since 1991
- New SAR in 1992, upgrade of SAR in 2017
- New Emergency preparedness plan
- New Aging management program, decommissioning program
- Change of generations in reactor management/operators
- Improvements currently in implementation: PSR action plan, INSARR recommendations
- Based on PSR report – license extended for 10 years
- **Continuous safety upgrades and safety reviews to assure high level of safety of the Ljubljana TRIGA RR**



# Thank you for your attention – **QUESTIONS?**



Vogel, Julian Alps, Slovenia

