SAFIR

The Finnish Research Programme on Nuclear Power Plant Safety 2003–2006

The Finnish Research Programme on Nuclear Power Plant Safety 2003–2006

SAFIR is the newest link in the chain of Finnish national research programmes in nuclear area. Organisation of public nuclear energy research as national research programmes was started in 1989 by the Ministry of Trade and Industry (KTM). Since then national programmes have been carried out in the fields of operational aspects of safety (YKÄ 1990–1994, RETU 1995–1998), structural safety (RATU 1990–1994, RATU2 1995–1998), and in FINNUS 1999–2002 that combined the operational aspects and structural safety. Simultaneously the research was carried out in nuclear waste management programmes (JYT 1989–1993, JYT2 1994–1996, JYT2001 1997–2001).

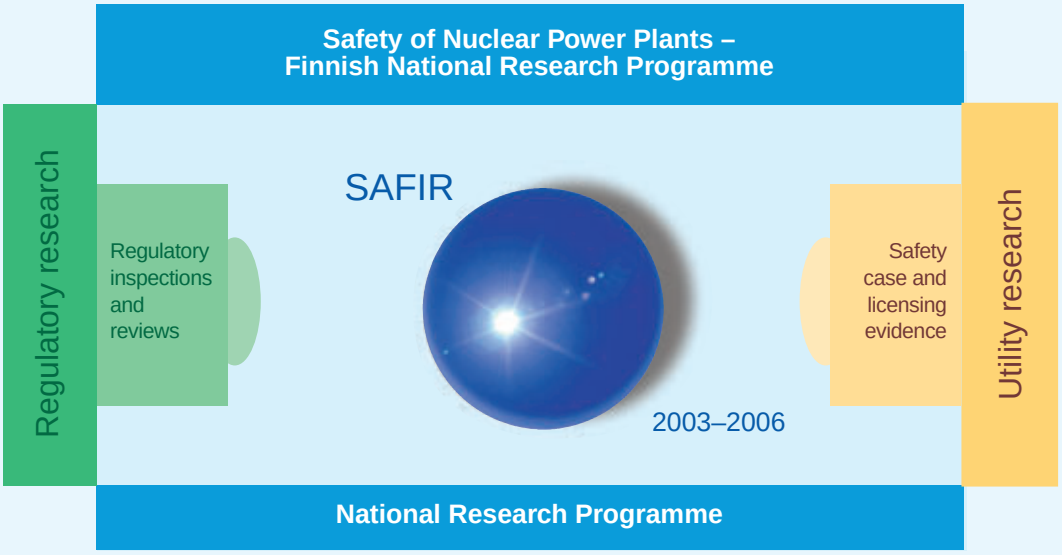
In parallel with the public programmes research has been carried out in the Finnish Fusion Research Programmes (FFUSION and FFUSION2) 1994–2002, programmes on Advanced Light Water Reactor concepts (ALWR) 1998–2003 and a project on component life management 1999–2003, partly funded by the National Technology Agency of Finland (Tekes). Currently fusion research continues in the FUSION (2003–2006) and nuclear waste management research in the KYT (2002–2005) programme.

In 2003 the main funding sources of the programme were KTM, STUK, VTT, TVO and Fortum. At the beginning of 2004 there was a major change in the funding structure of the programme in comparison with the year 2003 due to a change in the Finnish legislation on nuclear energy. The funding by KTM, STUK, TVO and Fortum was replaced by funding from a separate fund of the State Nuclear Waste Management Fund (VYR). This VYR-funding is collected from the Finnish utilities Fortum and TVO with respect of their MWth shares in Finnish nuclear power plants.

The main funding sources of the programme in 2004 are the State Nuclear Waste Management Fund (VYR) with 2.7 M€ and Technical Research Centre of Finland (VTT) with 1.3 M€. The rest of the funding originates from several partners.

In Finland the nuclear safety research consists of three components: regulatory research, utility research and public research. The regulatory research and utility research whose total annual volume exceeds the volume of public research is strictly separated from the public research programme.

Public nuclear safety research provides the necessary conditions for retaining the knowledge needed for ensuring the continuance of safe and economic use of nuclear power, for development of new know-how and for participation in international cooperation.



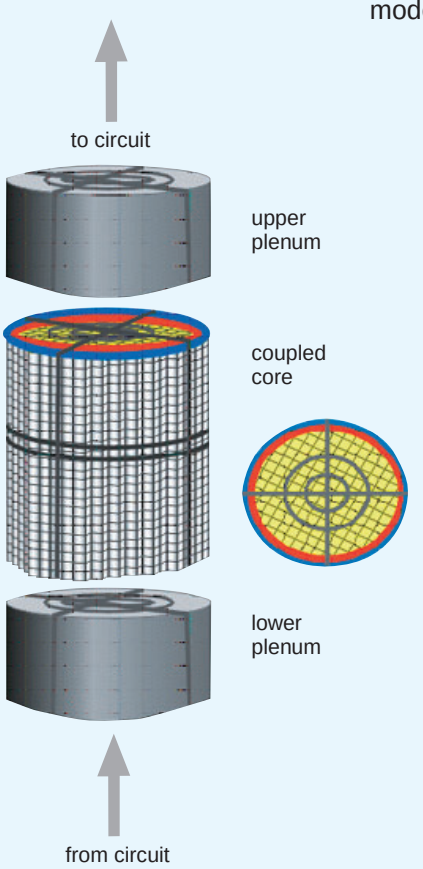
SAFIR

Reactor fuel and core

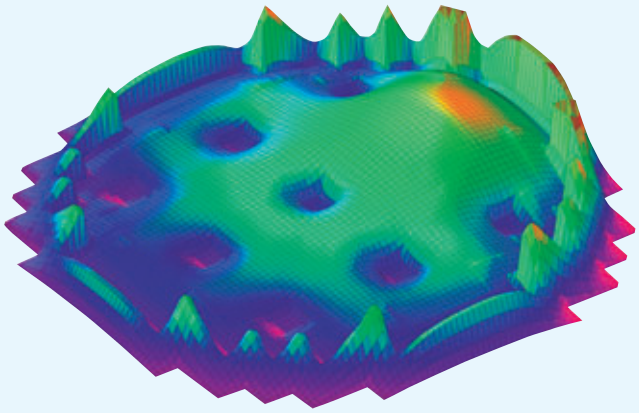
The area covers reactor physics, reactor dynamics and fuel behaviour analysis. The research is done solely with the help of calculational tools, partly with sophisticated tools developed at VTT and partly using tools developed elsewhere. The projects in this area have active contacts with international theoretical and experimental work, such as the OECD Halden Reactor Project, the OECD-IRSN CABRI Project and several other international research projects and working groups.

One of the main goals of the SAFIR programme is the education of the new generation. In this most 'nuclear-specific' research area of SAFIR, this task is particularly pronounced. All SAFIR research areas have links both between the various projects in the area and to neighbouring research areas. The most vital connections of the reactor fuel and core area are with the reactor circuit and structural safety area and with the containment and process safety functions area.

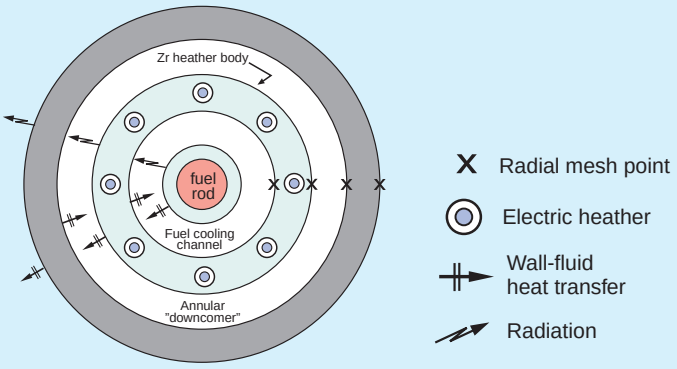
In 2004 there are two research projects in reactor fuel and core area, the Enhanced methods for reactor analysis (EMERALD) project dealing with reactor physics and dynamics and the High-burnup upgrades in fuel behaviour modelling (KORU) project dealing with the fuel research.



Internal coupling of reactor dynamics code TRAB-3D and thermal hydraulic code SMABRE.



Thermal neutron flux in a PWR reactor calculated by the AFEN code.



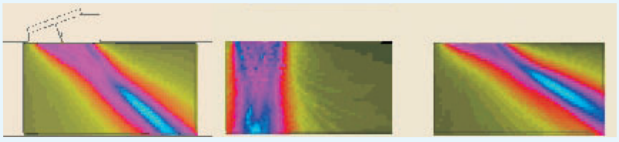
Modelling heat transfer in a Loss-of-Coolant accident test simulation.

Research Contributes to Nucle

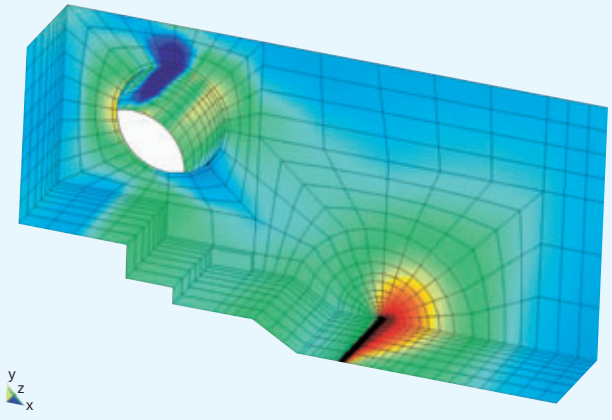
Reactor circuit and structural safety

The area covers the studies on the integrity and life time of the entire reactor circuit and the studies of containment building construction, inspection, ageing and repairing. In this area the projects include both experimental and theoretical studies. The projects in this area have active contacts with international research work, both in EU and elsewhere.

In 2004 there are four research projects in this area. The Integrity and life time of reactor circuits (INTELI) project is a very large one. The main objective is to assure the structural integrity of the main components of the reactor circuit of the nuclear power plant and to study the typical ageing mechanisms affecting the integrity of main components during the life-time of the reactor. The main components included in the scope of the project are reactor pressure vessel with nozzles and internals, piping of reactor circuit and other components (steam generators, pumps, valves, pressurizer, heat-exchangers). Oxide modelling is studied in the LWR oxide model for improved understanding of activity build-up and corrosion phenomena (LWROXI) project and the containment is studied in two separate projects, Ageing of the function of the containment building (AGCONT) project and Concrete technological studies related to the construction, inspection and reparation of the nuclear power plant structures (CONTECH) project.



Modelling of ultrasonic field. The fields shown in the figures are produced by a phased array ultrasonic transducer and demonstrate how the field can be directed using different delay laws for pulsing of the transducer elements.



Stress contours of a compact tension specimen finite element analysis model.

Module autoclaves for corrosion fatigue life tests in LWR.

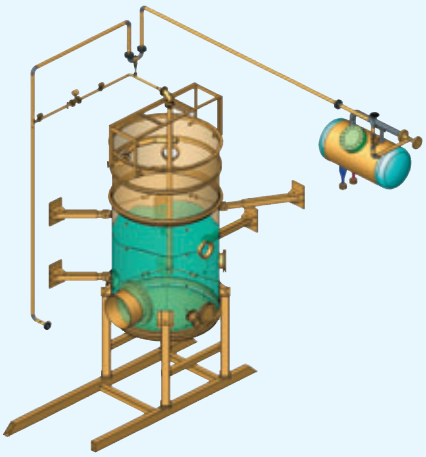
ar Power Plant Safety

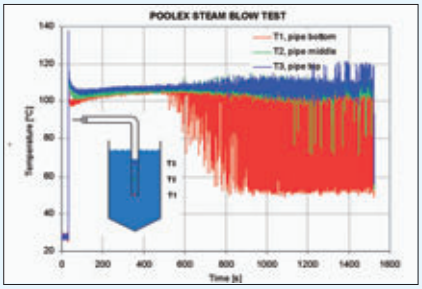
Containment and process safety functions

This area covers simulation of nuclear power plant processess, calculational thermal hydraulics and multiphysics approaches using several codes, experimental thermal hydraulics at Lappeenranta University of Technology (LUT) and various severe accidents projects, where both experimental and theoretical work is included.

Multiphysical approaches, strong coupling of experimental and theoretical work and active follow-up and participation in international research programmes are characteristic to the projects in this research area. In this field, with several very 'nuclear-specific' projects, fostering of a new generation of experts has a vital role, too.

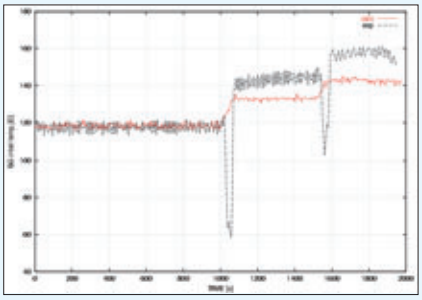
This by far the largest research area of SAFIR hosts currently altogether 11 research projects. They are the Wall response to soft impact (WARSI), Impact Tests (IMPACT), The integration of thermal-hydraulics (CFD) and finite element (FEM) computer codes in liquid and solid mechanics (MULTIPHYSICS), APROS modelling of containment pressure suppression systems (TIFANY), Thermal hydraulic analysis of nuclear reactors (THEA), Severe accidents and nuclear containment integrity (SANCY), Fission product gas and aerosol particle control (FIKSU), Development of aerosol models for NPP applications (AMY), Archiving experiment data (KOETAR), Condensation pool experiments (POOLEX) and PACTEL OECD project planning (PACO).





POOLEX test rig for steam blowdown experiments and a preliminary test result where oscillations inside the blowdown pipe are indicated by the temperatures measured at different elevations.

Core melt coolability test facility STYX-3 and post-test view of the simulant structure.



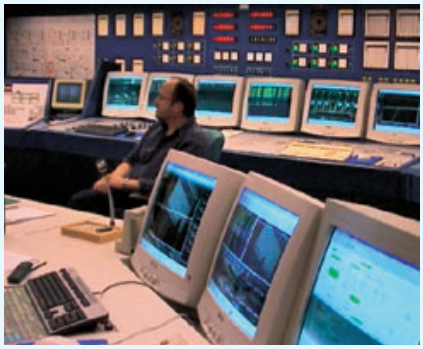
Calculated (APROS) and measured temperatures in the steam generators inlet in PACTEL experiment NCg-3.

The research in SAFIR in the areas of automation, control room and IT, organisations and safety management and risk-informed safety management concentrates on the nuclear-specific problems. A typical feature of all these research areas is that the majority of total research activities both in Finland and abroad are directed to non-nuclear applications and that same tools and methods can be used quite extensively both in nuclear and in non-nuclear research problems.

Automation, control room and IT

The focus of research is on the new technologies that are emerging at nuclear power plants both via new plants and via renewal of automation and control rooms in the existing plants.

Two research projects are currently included: Interaction approach to development of control rooms (IDEC) project aims at formulating a scientifically founded method for the evaluation of human-system interfaces of complex industrial systems and a pre-project study on Influence of RoHS -directive to reliability of electronics (ROVEL). Additionally, the research area is an important forum of information exchange on the work done beyond SAFIR in Finland and in some international projects.



Loviisa and Olkiluoto NPP simulators and Fortum Nuclear Services development simulator have been used in the automation, control and IT research area.

Organisations and safety management

In this area the research focuses on the organisational culture and management of change and on the tacit knowledge involved. The expertise of this research area is used also in the neighbouring areas in questions related to control rooms and automation and in research related to fires at NPPs.

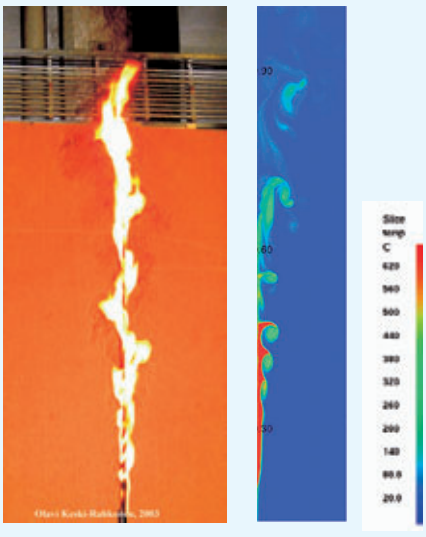
Currently the work in SAFIR in this area is performed in the project Organisational culture and management of change (CULMA) and pre-project Disseminating tacit knowledge in organisations (TIMANTTI). As well as in other research areas, participation in international research projects and working groups is included, too.

Organisational culture researchers analysing data from TVO maintenance organisation research.

Risk-informed safety management

Risk-informed safety management means use of information from probabilistic safety assessment (PSA) to support decision making in various contexts. The expertise on risk-informed safety assessment methods are used also in some projects in other research areas in SAFIR.

The research area includes currently two projects: Potential of fire spread (POTFIS) project, where the goal is to develop deterministic and stochastic sub-models to the same level as other branches of PSA. The major strategic problem in SAFIR is the ability to predict potential of fire spread in given scenarios. The principles and practices of risk-informed safety management (PPRISMA) project deals with the whole scope of risk-informed methods and application areas related to safety of nuclear power plants.



Fire spread studies have involved both experiments and calculations.

Projects in 2004

1. **Reactor fuel and core**
   - Enhanced methods for reactor analysis (EMERALD), 570 k€/VTT Processes
   - High-burnup upgrades in fuel behaviour modelling (KORU), 281 k€/VTT Processes

2. **Reactor circuit and structural integrity**
   - Integrity and life time of reactor circuits (INTELI), 1082 k€/VTT Industrial Systems
   - LWR oxide model for improved understanding of activity build-up and corrosion phenomena (LWROXI), 86 k€/VTT Industrial Systems
   - Ageing of the function of the containment building (AGCONT), 34 k€/VTT Building and Transport
   - Concrete technological studies related to the construction, inspection and reparation of the nuclear power plant structures (CONTECH), 107,5 k€/VTT Building and Transport

3. **Containment and process safety functions**
   - Wall response to soft impact (WARSI), 138 k€/VTT Industrial Systems
   - Impact tests (IMPACT), 202 k€/VTT Building and Transport
   - The integration of thermal hydraulics (CFD) and finite element (FEM) computer codes in liquid and solid mechanics (MULTIPHYSICS), 106 k€/Fortum Nuclear Services
   - APROS modelling of containment pressure suppression systems (TIFANY), 192,4 k€/Fortum Nuclear Services
   - Thermal hydraulic analysis of nuclear reactors (THEA), 158 k€/VTT Processes
   - Severe accidents and nuclear containment integrity (SANCY), 305 k€/VTT Processes
   - Fission product gas and aerosol particle control (FIKSU), 55,5 k€/VTT Processes
   - Development of aerosol models for NPP applications (AMY), 212 k€/Fortum Nuclear Services
   - Archiving experiment data (KOETAR), 60 k€/Lappeenranta University of Technology
   - Condensation pool experiments (POOLEX), 256 k€/Lappeenranta University of Technology
   - PACTEL OECD planning (PACO), 33 k€/Lappeenranta University of Technology

4. **Automation, control room and information technology**
   - Interaction approach to development of control rooms (IDEC), 196 k€/VTT Industrial Systems
   - Influence of RoHS-directive to reliability of electronics (ROVEL) – preproject, 20 k€/VTT Industrial Systems

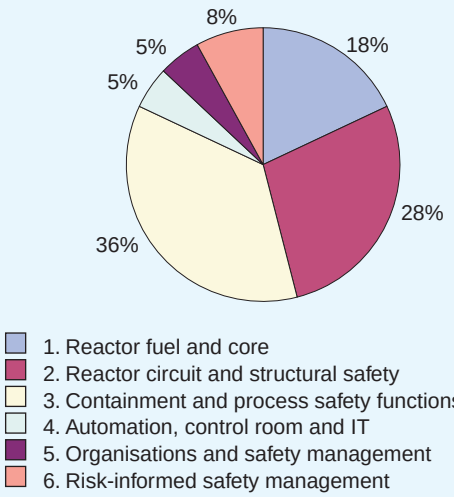
5. **Organisations and safety management**
   - Organisational culture and management of change (CULMA), 210 k€/VTT Industrial Systems
   - Disseminating tacit knowledge in organisations (TIMANTTI) – preproject, 27 k€/Helsinki University of Technology

6. **Risk-informed safety management**
   - Potential of fire spread (POTFIS), 158 k€/VTT Building and Transport
   - Principles and practices of risk-informed safety management (PPRISMA). 245 k€/VTT Industrial Systems

SAFIR research programme consists currently of 23 research projects in the six research areas. The volume of the projects in 2004 varies from some person months up to several person years, and the planned total duration from one to four years. In 2004 the planned volume of the programme is 35 person years and 4.9 M€.

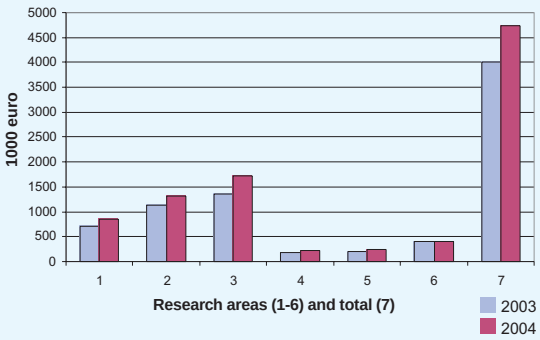
SAFIR 2004 FUNDING PLAN

Distribution of funding in SAFIR research areas



SAFIR 2003–2004 FUNDING

Distribution of funding in SAFIR research areas



1. Reactor fuel and core
2. Reactor circuit and structural safety
3. Containment and process safety functions
4. Automation, control room and IT
5. Organisations and safety management
6. Risk-informed safety management
7. Total

SAFIR
The Finnish Research Programme on Nuclear Power Plant Safety 2003–2006

The steering group of SAFIR consists of representatives from Radiation and Nuclear Safety Authority (STUK), Ministry of Trade and Industry (KTM), Technical Research Centre of Finland (VTT), Teollisuuden Voima Oy (TVO), Fortum Power and Heat, Fortum Nuclear Services, National Technology Agency of Finland (Tekes), Helsinki University of Technology and Lappeenranta University of Technology.

The six key research areas of SAFIR are 1) Reactor fuel and core, 2) Reactor circuit and structural safety, 3) Containment and process safety functions, 4) Automation, control room and IT, 5) Organisations and safety management and 6) Risk-informed safety management.

SAFIR is a dynamic research programme allowing inclusion of new projects or extension of the existing projects during the research year. Besides the research done within SAFIR and education of experts via this research, SAFIR is an important national forum of information exchange for all parties involved.

Contacts and further information:
http://www.vtt.fi/pro/tutkimus/safir

Chairperson of the steering group:
Dr. Lasse Reiman
Radiation and Nuclear Safety Authority (STUK)
lasse.reiman@stuk.fi

Contact person of the Ministry of Trade and Industry:
Mr. Jorma Aurela
Ministry of Trade and Industry
jorma.aurela@ktm.fi

Programme director:
Dr. Eija Karita Puska, VTT Processes
eija-karita.puska@vtt.fi