Modeling Resilience for Maintenance and Outage

Motivation
Nuclear power plants operate in an ever-changing environment. To produce energy safely and efficiently, the organisation needs the flexibility to adapt to short- and long-term changes, to internal and external pressures. Some approaches to safety and risk assessment, such as HRA/PRA, consider how reliably the system responds to known threats (e.g. design-base accidents). Resilience Engineering, on the other hand, looks for ways to enhance the ability of organizations to monitor and revise risk models, to create processes that are robust yet flexible, and to use resources proactively in the face of disruptions or ongoing production and economic pressures (Woods et al., 2010).

Resilience Engineering can be seen as a new approach to safety culture. It helps develop the reliability of activities without increasing rigid instructions, procedures, and excessive controls. At the power plants, this approach may have significant value since, for example, the organisational evaluation carried out in 2010 by VTT at a Nordic power plant suggests that work practices need to be supported in a coherent way and work needs to be more easily managed.

To safeguard against unforeseen and serious plant events it is necessary to have tools and methods that can deal with the under-specification of work and with the tight coupling of technology and organisational functions. Reiman and Oedewald (2009) have emphasized that understanding the risks and nuclear safety effects of one’s work is a central element of safety culture. However, knowledge of technical details or basis of working practices are not self-evident for employees or the subcontractors of the plants (Oedewald & Reiman 2007, STUK 2006). A resilient organisation that has a high level of a safety culture learns continually from its practices. It learns especially from successes and normal daily practices, not only from events and failures. It focuses on the approaches and methods that do not lead to negative outcomes, those that stop the evolution of accidents or limit the consequences. This is a broad and positive approach rather than just learning from the narrow band of accidents and events.

It is important to understand how to manage the potential negative outcomes of flexibility, i.e. how to balance the benefits of prescriptiveness (e.g. workload reduction), and the flexibility needed to respond to unforeseen events.

The results from this project can provide specific insights on how to support plant activities safely. Further, the project is expected to contribute significantly to the field of Resilience Engineering, both by providing case study material and by testing models and methods.

Method
Current research in Resilience Engineering aims for a description of resilience on a system level. We believe that resilient practices are on-going processes in all organisations today. They are most readily observed where sharp-end activities are
carried out. Therefore a bottom-up research approach is appropriate for the proposed project. An understanding of current resilient practices achieved in this project is necessary to understand how the entire organisation can be analysed and developed from a resilience point of view. In a follow-up activity in 2012, we will aggregate the results of the case studies to an organisational level.

**Phase I: Document review & data collection.** A case study of maintenance and outage (M&O) activities will be conducted at Ringhals and Loviisa. Information concerning the current working practices will be acquired by field observation, document analysis and interviews.

**Phase II: Analysis & modeling.** M&O work practices (and the organisational structures and processes supporting them) will be described and analysed from the point of view of resilience. We will investigate how organisational culture supports accurate knowledge of the tasks and how it enables flexible actions. Special attention will be paid to situations where employees face pressures from efficiency-thoroughness trade-offs (ETTO; Hollnagel, 2009). This part of the study will build on IFE’s 2010 work on ETTO and on the HRP project Teamwork in Outage (case study at a U.S. PWR plant), as well as on VTT’s organisational evaluation at a Nordic power plant in 2010. Data will be analysed using Organisational Core Task modelling (Oedewald & Reiman 2003, Reiman & Oedewald 2007), Functional Resonance modelling (e.g. Macchi, 2010), the Resilience Marker model (Furniss et al., 2009), and the Resilience Timeline approach (Hildebrandt et al., 2008).

**Phase III. Dissemination.** The results will be presented at a dissemination workshop and discussed with practitioners from Nordic and potentially U.S. plants. Feedback from this workshop will be included in the final report. Results will also be presented at industry meetings such as the Enlarged Halden Program Group meeting or the American Nuclear Society meeting.

**2012 follow-on.** An intermediate report on the proposed project will be delivered in December 2011. A follow-on activity is foreseen in 2012. This will further test resilience models and methods, and aim to develop management tools that can support resilient practices.

**Expected results and utilisation**

The project has practical and scientific merit. The research is initiated by the power plants and motivated by their need to develop methods to model normal activity and its safety effects. It will provide suggestions for organising and supporting work activities that can adapt to a changing environment. Further, the project provides information on models and methods to identify and analyse resilience in safety-critical organisations. Power companies can utilise the results to develop organisational structures and management approaches that support flexible, adaptive work practices. The results are expected to strengthen the current nuclear safety methods and models. In addition, we believe the project will provide an important milestone for future resilience research.

Foreseen results include:

- Description of resilient work practices in M&O at Ringhals and Loviisa
- Guidance on how to promote flexibility in the organisation and in daily work practices, including insights on balancing flexibility and reliability
- Test of several models that can help in understanding and supporting resilience
- Guidance on the assessment of resilience
- A dissemination workshop

**Fit with NKS framework**

The work is carried out jointly by researchers from Norway and Finland, and in close collaboration with Ringhals and Loviisa staff. The project fits into the long-term strategic agendas of the participating organisations and addresses industry needs for improved M&O performance and more adaptive organisations. We believe the project will strengthen existing competence in M&O and safety culture. Finally, it should be noted that the Resilience Engineering approach has emerged from a European, or more specifically Nordic, approach to Safety Science (e.g. Hollnagel and Rasmussen).

**Project administration and resources**

The project will be coordinated by IFE. The project team consists of:

**IFE**
- Michael Hildebrandt (coordinator)
- Magnhild Kaarstad
- Ann Britt Skjerve

**Ringhals**
- Christer Axelsson

**Loviisa**
- Magnus Halin

**VTT**
- Pia Oedewald
- Luigi Macchi
- Elina Pietikäinen

(Macchi and Pietikäinen are young scientists according to NKS criteria)

The proposed project will be linked to projects under the SAFIR2014 funding and to the Halden Reactor Project activity “Teamwork in Outage”.

**Applicants’ relevant experience**

The VTT group has worked extensively on organisational factors in maintenance, including several projects under NKS funding (Reiman et al. 2004, 2006, 2008; Svensson et al. 2006). IFE is currently conducting resilience research for the petroleum industry as part of the Building Safety project (Skjerne & Kaarstad, 2009). IFE also conducted one of the first studies of resilience in the nuclear industry under Ringhals funding (Furniss et al., 2009), with a follow-up project on efficiency-thoroughness trade-offs being conducted in 2010. A project on Resilient Procedure Use is proposed for the Halden Reactor Project 2012-2014 program (HRP-1301, 2010). IFE places increasing emphasis on maintenance and outage activities, with current activities investigating teamwork in outage (Hildebrandt & Koskinen, 2010), and the design of innovative HSIIs for Outage Control Centers.
Relevant publications


Other References

