Maintenance culture and management of change - Intermediate report 2004

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Abstract

Change management has emerged as an important topic in safety-critical organisations. A lot of knowledge on change management exists, but still lot of projects fail and the safety consequences of various changes are unclear. It seems that the problems of change management are interdisciplinary, but still solutions tend to only from one perspective (e.g. technical or personnel management). There also exists empirical evidence that change has been experienced as stressful in the nuclear power plants.

The cultural perspective taken in this paper strives to combine technical approaches to human resources approaches. It raises new questions that are not usually explicitly taken into account in change management. Financial pressures, change of generation and other changes in the environment have forced many organisations to reorganise their practices (e.g. downsize, outsource, and develop team-based organisations). These changes have had an impact on the culture of the organisation (and the organisational culture has mediated these changes in the first phase).

Key words

Change management, cultural perspective

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1. Introduction

Change management has emerged as an important topic in safety-critical organisations. A lot of knowledge on change management exists, but still lot of projects fail and the safety consequences of various changes are unclear. It seems that the problems of change management are interdisciplinary, but still solutions tend to only from one perspective (e.g. technical or personnel management). There also exists empirical evidence that change has been experienced as stressful in the nuclear power plants.

The cultural perspective taken in this paper strives to combine technical approaches to human resources approaches. It raises new questions that are not usually explicitly taken into account in change management. Financial pressures, change of generation and other changes in the environment have forced many organisations to reorganise their practices (e.g. downsize, outsource, and develop team-based organisations). These changes have had an impact on the culture of the organisation (and the organisational culture has mediated these changes in the first phase).

Maintenance was selected as a target for the study for various reasons:

- maintenance itself is multidisciplinary and heterogenous
- it has received less attention than the other areas of NPP operation
- it has high safety relevance
- problems of change manifest well in maintenance

There is thus a lot to learn from change management in maintenance to other areas of NPP operation as well.

As a starting point, we conceptualised a simplified model of organisational change (see Figure 1) to be used as a structure for this report.
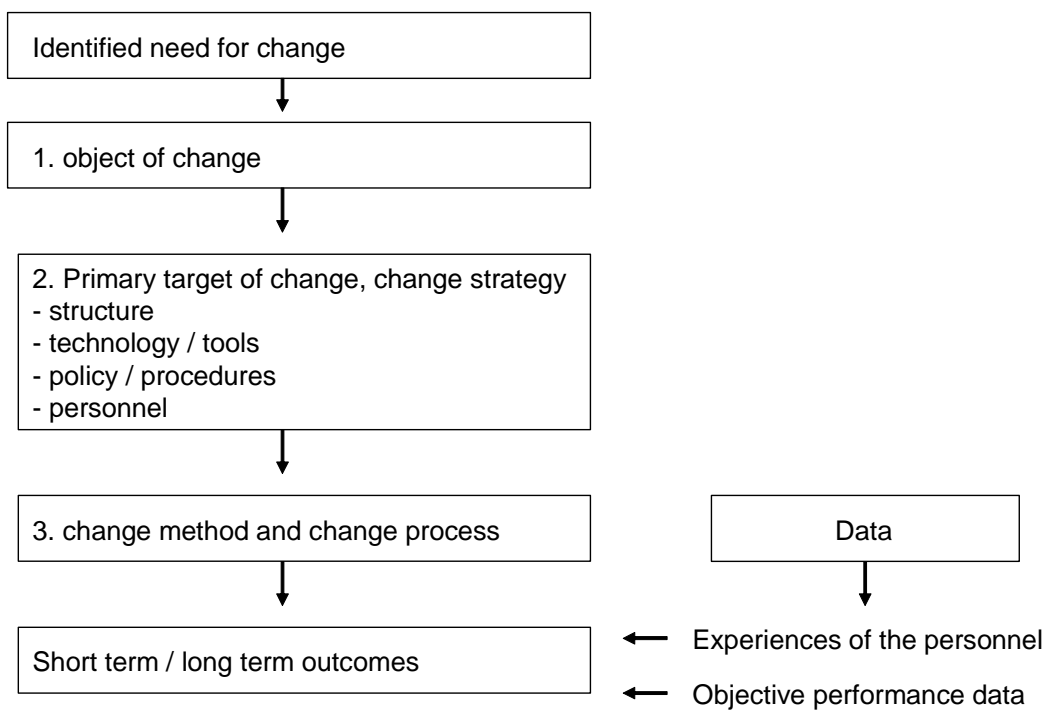
Figure 1. Simplified model of organisational change

Within the NKS-R program in 2002-2003, case studies were conducted at the maintenance units of the Olkiluoto and Forsmark NPPs (see Reiman et al. 2004b, in press). Also within the Finnish FINNUS nuclear safety program a case study at the Loviisa maintenance unit was conducted (Oedewald & Reiman 2003). The aim of these case studies was to assess the maintenance culture of the given organisations and to clarify the cultural features of maintenance work. One of the main features found was a strong ambivalence toward organisational changes and changes in the working environment: On the one hand personnel realise the changes that have taken place in the working environment, and perceive the need to change practices and optimise resources. On the other hand, they feel that the idea of change in one's own work is very stressful and one's own work is generally perceived as highly significant and incapable of change.

This project continues the work directly by focusing on the changes that are taking place or have recently taken place in maintenance, and on the impact of these changes on organisational culture. The project addresses organisational change in NPP maintenance and its effects on the maintenance culture and practices. The goals of the research were:
- to describe the personnel's experiences related to recent changes in the organising of maintenance
- to clarify what are the most stressing issues in change situations (e.g. the changed organisational structure itself, the way the change is conducted, or the uncertainty related to communication of the goals and methods of change) that have taken place

- clarify how a change in the organisational structure affects the culture of the organisation.

The results of this study further the means to manage cultural and organisational change in nuclear industry. The results include statistical differences before and after re-organizing of activities, personnel's experiences regarding different change projects (implementation and the outcome) and the "best practices" of change management from the personnel's point of view at the target organisations.

2. Data gathering

Maintenance culture was measured at Loviisa with CULTURE03-survey (see Reiman & Oedewald 2004). The survey includes four measuring instruments, workplace values, own job, maintenance core task and ideal values. The Loviisa maintenance culture was first measured and assessed in 2001 before the major restructuring of the maintenance activities at the plant. The results of the re-measurement were compared to the results of the first measurement and changes in work values, experiences of one's own work (meaningfulness, feedback, sense of control, job satisfaction) and conceptions of the demands of maintenance core task.

The interview and survey material collected within the NKS-R MainCulture project in 2002-2003 (Reiman et al. 2004b, in press) was reviewed from the perspective of the management of change.

Also other relevant material previously collected by the Finnish and Swedish researchers from the power plants has been utilised. For example, the case description from OGK is based on three internal documents being part of the material for the change decision.

Additional interviews were made at Loviisa on the subject of 2002 organisational change.

3. Results

3.1 Case descriptions

3.1.1 Loviisa power plant's organisation change 2002

Background and objectives of organisation change

On the basis of interviews conducted at the Loviisa power plant, there were several factors behind the organisation change. One of the most important was the generation change that was under way. A large group of white-collar workers was retiring, and the experience and know-how of the older generation had to be preserved. Operational activities were also taking up the older engineers'

time. At Loviisa it was understood that an opportunity had to be provided for the older engineers "to commit matters to paper" and to transfer their expertise to younger staff. This had to be carried out, however, while maintaining the motivation of the older generation.

Before the change, the systematic recruitment of new workers had been initiated at the Loviisa power plant. In the organisation it was perceived, however, that turnover among younger staff was high. It was clear that younger workers had to be given responsibility rather more quickly. The organisation had been very settled for nearly twenty years. During this time only small changes had been made in the organisation and the boundaries of responsibility had been set in stone. The interviews revealed that it was very difficult for young employees to penetrate this set-up. The managers of the Loviisa power plant understood that the organisation no longer corresponded to present-day requirements.

The effectiveness of plant life management also gradually began to be a cause of some concern for the plant managers, as an application for a new operating licence approached. Action was considered not to be proceeding as quickly as it should. A production life of at least 50 years was set as an objective. At the same time, changes occurred in Fortum, and within the company ideas were form as to how the plant's operations could be developed. On the basis of the interviews, it is apparent that these two factors – the generation change under way and the enhancement of plant life management – were closely linked to each other.

General Manager of Loviisa NPP set up a working group on 6th of November 2001 to prepare a proposal for renewing the power plant's organisation. The working group's assignment specified four key objectives: 1) Strengthening plant life management and utilising accumulated expertise, 2) making the power plant's costs comparable with other types of energy generation, recognising costs characteristic of the power plant, enhancing the efficiency of operations and maintaining competitiveness, 3) transferring information from those who were involved in constructing and commissioning the plant to the new generation, job rotation and transfer of responsibilities to younger staff, and 4) better direction of research activity funded by the plant. A new organisation was established based on four new units, which were built on the five groups which had existing previously. The new units had been specified in the working group's assignment as follows:

Unit	Basic task
Operating unit	Safe and optimal power generation, and acquisition of income for plant investments
Safety unit	Centralised control of nuclear power-specific operations as well as joint management and support functions
Technology unit	Taking care of long-term production conditions, production investments and the value of capital invested
Maintenance unit	Production of services required by the uninterrupted use of the plant

In addition to these four units, the new organisation comprised an executive staff under the general manager (e.g. personnel affairs, payroll and accounting, communications and controller tasks). The security function also forms a unit of its own.

Preparation and content of the change plan

The key objectives of the change project, the unit division of the new organisation and the basis tasks and managers of the new units, were determined by the power plant's senior management and an external consultant. Furthermore, it was decided to implement the project as quickly as possible. Thereafter a separate working group was set up whose task was to prepare a detailed plan for change. On the basis of interviews conducted by an external consultant and the views of the general manager, nine members were selected for the working group. As a matter of course, these members included the leaders of the new units. When selecting the unit leaders, every effort was made to include "opinion formers", who have a big influence of the organisation's activities. According to one of those interviewed, an effort was also made to ensure that the working group represented the power plant and the various points of view within it.

Although the project timetable, the new organisation's unit structure and the basic tasks and managers of the new units had been specified in the assignment, the group otherwise had great freedom of action, according to the people who worked in it. The assignment did not specify very precisely what the new units should consist of. The proposal for the distribution of different functions into the new units thus arose in the working group. According to the interviews, the starting point to defining the new organisation was a listing all the power plant's present and necessary new functions, after which the grouping of the functions under the unit division specified in the assignment began. This generated much discussion in the working group. "First there were clear issues, then there were matters of opinion and then there were 'bargaining cases' on top of everything else; as far I recall, however, we didn't have to resort to voting," said one of

those interviewed. Most debate arose over the division of labour between the Technology and Maintenance units. The table below describes the different subareas of the change plan.

Change subarea	Planned measures
Objectives, priorities and resourcing	Partially redefined, by emphasising e.g. plant life management, generation change and enhancing operational efficiency.
Organisation structure	The most significant changes fell in this subarea. It was decided to shift to a four unit model. Functions were transferred between the different units. The idea was, among other things, to break down technology-based divisions and to build more efficient operational entities.
Operational processes and practices	The working group's proposal emphasised the importance of process-oriented operating practices. Changes in operating practices, however, remained outside the actual change project and were left for the new organisation to consider.
Information systems	The organisation change had no direct link with the ERP system renewal project then under way, nor was change supported by other information system projects.
Other subareas	The organisation change can be considered to be linked to development projects relating to outsourcing of support functions and the development of procurement activity. The above-mentioned projects, however, had been left outside the actual organisation reform.

Interviews conducted at the power plant sought an answer to, among other things, why organisation change had been selected as the way to achieve the set objectives. The objectives had been formulated so that they could also, at least in principle, have been attained without changing the structure of the organisation. On the basis of the responses, the key reason was considered to be a certain kind of "opposition to stagnation", in other words a perceived need to change established operating practices in a situation where structures were seen to form a barrier to change. In addition, the strengthening of plant life management and the commitment of young employees were considered to require, among other things, a new division of labour and job rotation, which would be difficult to implement without organisational changes.

Another factor that occupied the researchers was the exclusion of process development from the actual change project. According to those interviewed, this was decided upon because simultaneously changing the organisation structure and operating practices was considered a too demanding and risky step. Motivation factors also had an impact on the issue. Those interviewed supposed that people commit themselves to new operating practices better if they are personally involved in defining them. That's why it was decided to leave the definition and development of operating practices to the responsibility of the new organisation.

The working group submitted its proposal for the new organisation on 17 December 2001. The Loviisa power plant's new organisation formally came into effect on 1 January 2002. There was no transition stage organisation. The plan was to implement practical measures by the summer holiday period of 2002.

Implementation and results of the change

The activities of the working group responsible for planning the organisation change ended on the publication of the proposal at the end of 2001. An external consultant was used to introduce the new organisation. The consultant did not, however, participate in the working group's activities nor was he involved in implementing the changes. Implementing the change remained in practice primarily the responsibility of the new units' managers and their chosen subordinates. The power plant's management group monitored the project's progress. Other, separate groups were apparently not set up to direct the implementation of the change. The interviews provided partly contradictory information about this, however.

The organisation has an enormous number of different tasks, which had to be distributed between the personnel. At the same time, an effort was made to ensure that no essential tasks were lost. An individual could therefore give up a task for which he was responsible only when a new owner had been found for it. This process was assisted by the use of task transfer forms, for example. The transfer of tasks was reported to have gone quite well within the units. A significant factor in the success of task transfers was how well the individuals involved knew each other. One interviewee reported that it proved difficult, however, to give up the old organisation's responsibilities – particularly if the individual concerned was involved in various projects. This contributed to slowing the final implementation of the changes.

When the project was being prepared it was considered that the transition stage would not last long. By summer 2002 the facilities and rooms had been assigned. Similarly the task transfer timetable had been finalised. It was not possible to keep to the original timetable, however. The transfer of tasks began in 2002 and continued throughout the whole of 2003. There were still few individual measures to be performed in spring 2004.

In April 2003, an evaluation meeting was held at the power plant to consider the results of the change project. In summary it can be said that insufficient attention had been paid to operational processes. The reform's further measures had also slowed significantly. Key problems that

followed on from these included: poor communication over unit boundaries, unclear job descriptions, slow decision-making and slow progress on matters in general. The meeting found that the organisation's further development ought to be based on the identification, modelling and documentation of operational processes. Interviews conducted at the power plant in spring 2004 revealed the most important topical challenges to be, among others, the development of guidelines, adjusting the division of work between the Technology and Maintenance units, and matters relating to supporting the transfer of expertise.

The technical objective set for the organisation change had, as a rule, been achieved in spring 2004: the new units and groups had begun their work under new leaders. From the researchers' standpoint, however, the most interesting aspect was to clarify the kind of results that had been achieved relative to the original objectives set for the project. In relation to plant life management, significant progress had been made, according to those interviewed. More responsible jobs and vacancies had also been arranged for younger employees. In terms of transfer of information and tasks, on the other hand, the impacts were perceived to be negative. While young employees had been appointed to new positions in the organisation, a number of older employees felt somehow marginalised. They felt that there was no desire to utilise their experience, and as a result their motivation to share knowledge was weak. This can be considered the most important challenge in follow-up measures to the organisation change.

Measure of the characteristics of the Loviisa maintenance culture before and after the change

The Loviisa maintenance culture was first measured and assessed in 2001 before the major restructuring of the maintenance activities at the plant in 2002. Some non-critical functions were outsourced, electrical and I&C maintenance were combined, and a new department was formed which concentrated on non-critical tasks such as real estate services and heating, plumbing, ventilation and electrical installation.

The results of this re-measurement were compared to the results of the first measurement. Significant changes were noted in the **values** perceived as being endorsed in the organisation. Almost all individual values are now felt as being endorsed more than before. Especially dramatic change was noted in the values that were very low in the first measurement, e.g. the mean score of "initiative" had improved from 3.3 to 4.1, "open communication" had improved from 2.9 to 4.0 and "questioning old practices" from 2.9 to 3.6. The only values that had not changed significantly in the terms of mean scores were values related to financial issues. Furthermore, two new factors

emerged from the data; responsibility and structured development. This means that the interrelations between individual value items (e.g. systematicalness used to be associated with hierarchy, now it is associated with development) are perceived differently than before the organisational change.

Conceptions concerning one's own work were in many respect same as before the reorganisation. Job satisfaction was quite good, and the job was experienced as meaningful. The working climate in one's own work group had gotten somewhat better (from 3.5 to 4.3). Work stress had risen slightly (from 3.3 to 3.6) but the original mean score was very low. The goals of one's own work were now seen more clearly (from 3.9 to 4.3).
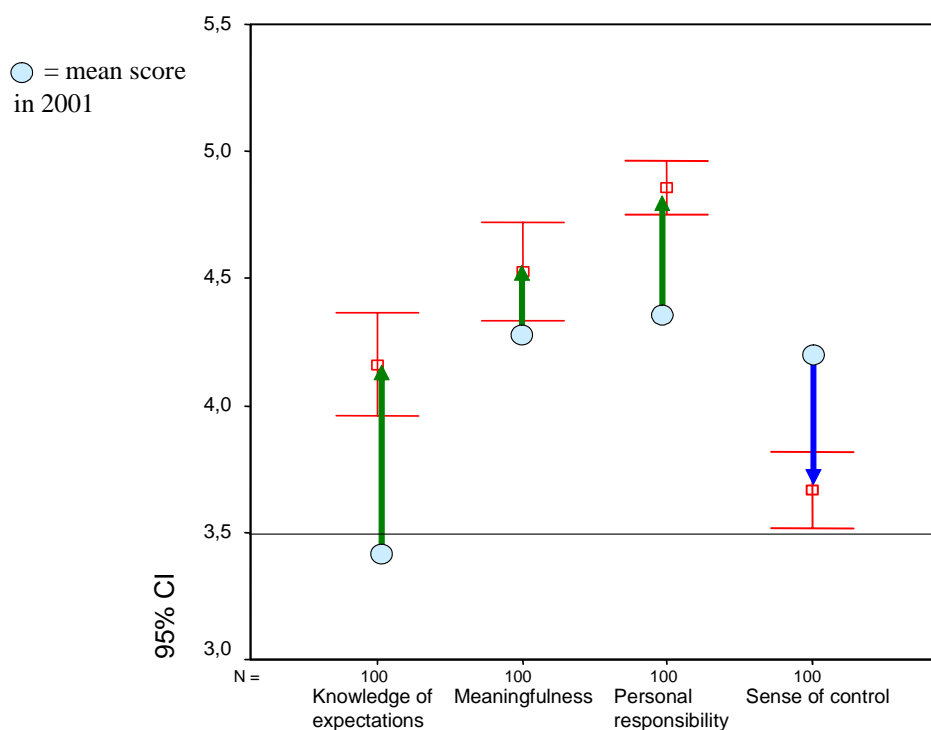

Figure 2. conceptions concerning one's own work in 2001 and in 2004

There are thus significant changes in the organisation in terms of perceived values and also in terms of individual work motivation and working climate. Nevertheless, the core task section gave implications of some new worries and tensions among the personnel. For example, question "economy contradicts with safety" received a higher mean score than three years before (from 3.7 to 4.1). What was interesting in the core task section was that question "bureaucracy is needed in order to guarantee safety" was increased from the mean score of 3.8 to 4.3 in the remeasure. Before the organisational change, the amount of bureaucracy was one of the major concerns among the personnel. Furthermore, a couple of the questions received quite high standard

deviations indicating a lack of agreement in the culture: "rules relieve of personal responsibility" and "economy contradicts with safety"

Interpretations of the findings

Perceptions of the organisational values had changed significantly. A question arises as to how permanent these changes are, since the working environment is currently much more turbulent than before. Will the factors remain in time, after the reorganisation is completely over?

In conceptions concerning one's own work, there have been some changes, mostly to the better. The only dimension that has decreased is the sense of control, which was originally very high. Also work stress has slightly increased.

It is interesting to note that before the reorganisation, the bureaucracy and the hierarchical decision making were heavily criticised. Now after the reorganisation personnel feel more that some amount of bureaucracy and the hierarchical decision making is needed in a nuclear power plant in order to guarantee safety.

The findings of the remeasure were presented to the project group at Loviisa and to the maintenance personnel in a maintenance unit's monthly briefing (December 2004) with about 90 participants.

3.1.2 Major organisational changes at TVO maintenance during 1994-2003

In 1994 TVO changed its organisation and united maintenance and operations under one umbrella called "production maintenance". At the same time, numerous other changes to the organisational practices and tools were made. For example, a system of equipment responsibility areas was taken into use to organize the maintenance work. Furthermore, a comprehensive new information system was taken into use to organize the work, store plant-related information and plan the maintenance activities on a short and long term basis.
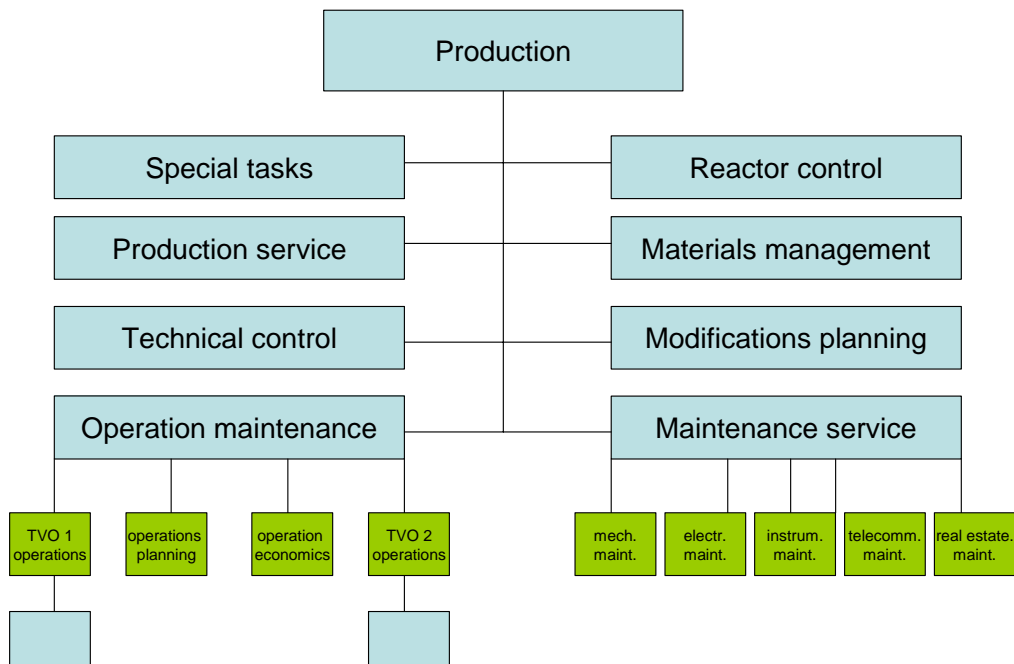
Figure 3. The production department of TVO in 1994.

The system of equipment responsibility means that the foreman or the group manager "owns" the particular equipment group and plans e.g. the program of preventive maintenance and budget for the machinery. The owner of the equipment plans all the maintenance activities conducted for the corresponding equipment, irrespective of the type of maintenance (electrical, mechanical, instrumentation) required. The owner utilizes experts of the other fields to accomplish this. For example a valve can include an actuation device and thus electrical and instrumentation work, but the owner of the valve can be from the mechanical maintenance. The owner also analyses operational data concerning the machinery, and makes inferences about the appropriateness of the schedule for preventive maintenance operations. The owner updates the plant information system (LATU) with the data concerning his area. There are currently about 30 "owners" at TVO.
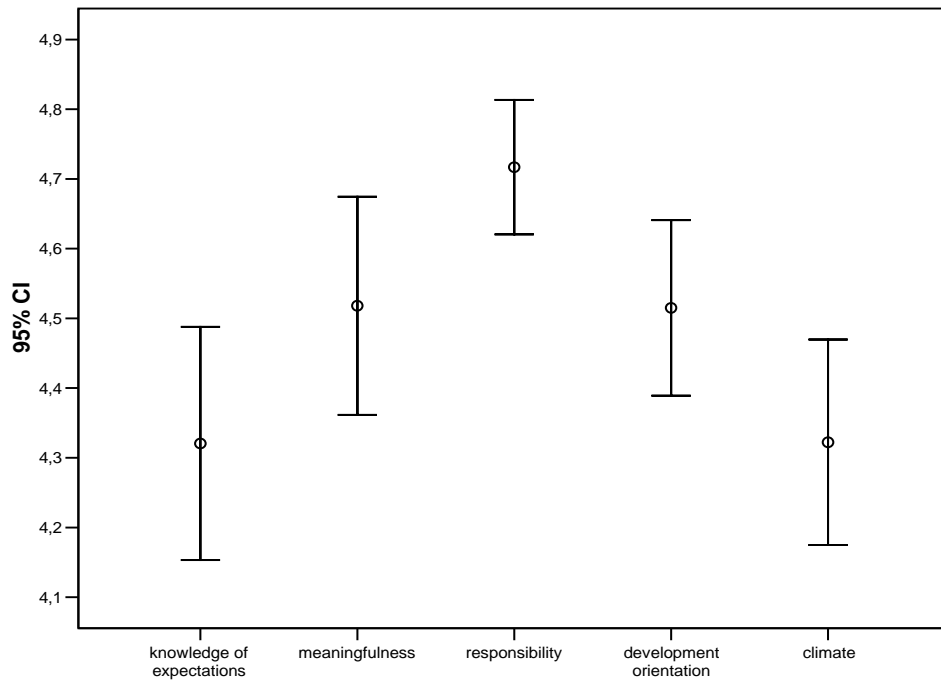
Figure 4. Conceptions concerning one's own work in 2003 (from Reiman et al. 2004b). The response scale was from 1 (totally disagree) to 6 (totally agree).

TVO's organizational structure was again reformed in January 2003, after the main data collection (interviews and CULTURE-survey). The new organization comprises five departments: Operation responsible for the operation and maintenance of units OL1 and OL2, Project responsible for the construction of the fifth NPP in Finland (OL3), Engineering, Finance and Corporate resources. Approximately 120 employees work with issues related to maintenance in the operation department. The case study concentrated on the two offices of the operation department in charge of the maintenance at Olkiluoto: The office of mechanical maintenance and the office of electrical and I&C maintenance. These offices changed little in the 2003 reorganization. The offices consist of a number of groups with a group manager, foremen and technicians. The group manager also attends to the duties of the foremen.

3.1.3 Organisational change at OKG maintenance

The maintenance organization was previously organized under each unit at OKG. The structure of the maintenance organization was also different at each unit, for example function- (reactor, turbine, etc.) and subject oriented (mechanical, electrical, etc). To develop and make the maintenance activities more effective, and also to obey de increased demands for savings, the maintenance at OKG was centralized by the year 2000.

The new organization was created by functionally constructing the maintenance department around four, smaller maintenance departments, yet with a substantial element of process orientation.
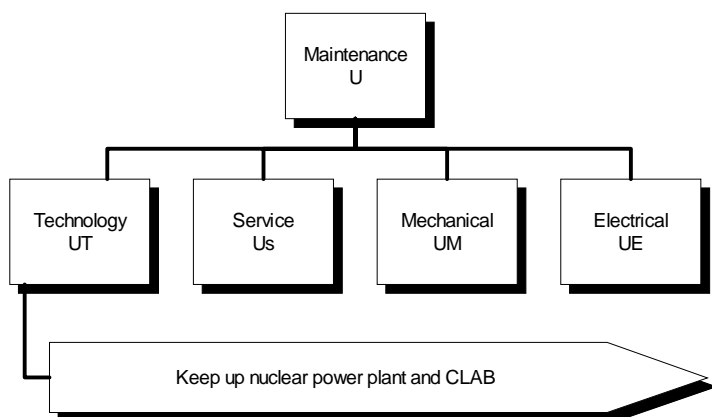

Figure 5. The changed maintenance organization at OKG.

An overarching description of the new maintenance organization:

o The department of technology, UT, is intended to work with overarching techniques, strategies, and administrative systems. The manager at UT was also process leader for the process "keep up the nuclear power plant and CLAB".

o The service department, US, is intended to provide the service functions which are common for the maintenance.

o The department of mechanics, UM, is responsible for the mechanical maintenance.

o The department of electricity and instruments is responsible for the maintenance of electricity and instrumentation.

The degree of process orientation gradually increased, and the process leader initially co-ordinated the processes to avoid mismatches between the different functions. Improvement teams were appointed to develop the processes.

The savings the organizational change was primarily linked to a more effective use of internal and external resources, among other things by rationalizing the personnel and by decreasing the costs on the purchasing side.

It was also estimated that the organizational change would give OKG a number of possibilities to influence the reactor safety in a positive way, among other things by introducing uniform working procedures and also to increase and create redundant competences.

Evaluations of the organisational change

Some experiences of the organisational change at the maintenance departments at OKG were (results are derived from a survey conducted in the spring of 2003):

- The working procedures has to a large degree been standardized
- There might be problem areas that relate to the clarity of responsibility which could explain the experienced problems regarding the availability of information and the feedback regarding delivered information.
- There are indications of problems regarding resource management, e.g. tools, time, and personnel.

The problem areas are being addressed at OKG.

3.1.4 Changes at Forsmark maintenance

Brief history of the maintenance organisation

Forsmark has, over the years, tried several different organizational structures for their maintenance organisation. Until 1982, a central maintenance organisation was in place, subdivided into mechanical-, electrical- and instrumental maintenance. In 1982 a reorganisation was launched so that each of the 3 individual power stations received their own maintenance organisation. According to interviews with personnel employed at this time, the benefit of this reorganisation was clearly shown in terms of clear responsibilities, an efficient local communication and decision structure and a sense of ownership among the maintenance personnel. In order to adapt to retrofit and modernisation plans, the maintenance organisations were again changed in 1994: an entrepreneurial relationship among the actors was introduced. Maintenance, at each site, was organised in reactor- and turbine sections that had the responsibility for the technical development and maintenance at each station. Specific maintenance disciplines were perceived as subcontractors coordinated by the reactor- and turbine sections. In the years to follow some changes were made in the structure, but not major ones, and the strategy of separate maintenance organisations at each station was maintained until 2001. Process analysis of maintenance has been conducted since 1996 and the output of these efforts became a major input for the reorganisation 2001.

The background for the major reorganisation of maintenance that begun in 2001 is to be found in the deregulation of the electricity market in Sweden – in the first years after the deregulation there was an sharp decrease in the prices for electricity. The changes in the maintenance organisation

were a search for more efficient resource optimization. Several changes were made, most importantly: (1) The individual maintenance units at each station were brought together to form one single maintenance organisation; (2) A matrix organisation structure was implemented for the maintenance unit, (3) At each station, order functions were developed to support dialogues with the four business areas found at the central maintenance unit (business areas: operative maintenance, projects, analysis and montage), (4) Some services, that previously was in-house operated, had already been outsourced in 2000 (building service, cleaning, transportation services etc.).

Several follow-up studies and evaluations (with several different methods and also carried out by independent evaluators) conducted after 2001 gave evidence of experienced problems in the maintenance organisation. Among the problems encountered were the following: difficulties for many of the employees to cope with the matrix organisational structure and the roles that were associated with the new organisation, experienced coordination and communication difficulties, conflicts over resources, vagueness regarding responsibilities, and negative working climate. Figure 6 depicts the results of a measurement made with CULTURE-survey as part of the NKS-project in 2002.
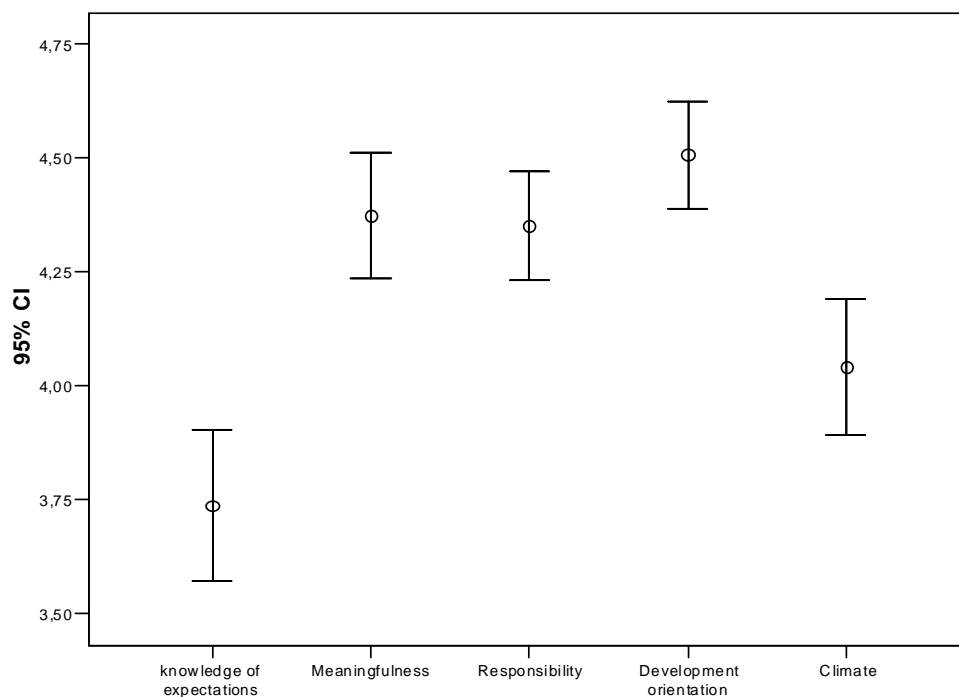

Figure 6. Conceptions concerning one's own work in the aftermath of the reorganisation (from Reiman et al. 2004b). The response scale was from 1 (totally disagree) to 6 (totally agree).

At the interviews conducted in 2002 (Reiman et al. 2004b, in press), the following categories emerged when the personnel were asked about the demanding features of their work:

- **prioritising the tasks, the work load** (6)
- **seeing the goals, trust in the management** ("purpose of the reorganisation") (4)
- **social demands** (3)
- **technical competence** (2)

From the interviews and the survey results several indications were obtained that one of the problems at FKA was to allocate resources in a wise way and to know the current work load of the personnel. Especially managers had difficulties in arranging the work tasks, allocating the resources and planning the everyday activities. On the other hand, some of the personnel felt that the new matrix organisation did spread the work load more evenly than it had been spread in the previous organisation. When asked about the development targets, clarification of the new organisational structure was the single most frequently mentioned item. (Reiman et al. in press) Many people also commented on that the actual work (micro processes) had not changed so much in spite of the reorganisation but that much energy was devoted to "clarification" of how the macro processes should be implemented in the new organisation (Reiman et al. 2004b).

Due to e.g. the above mentioned problems, it was decided to change some aspects of the organisation in December 2003 – one of the most important changes was to replace the matrix organisation with a more traditional line organisation: the former business areas disappeared so that maintenance is managed directly by the maintenance sections. The planning function was also strengthened in order to coordinate the activities. The current maintenance organisation is led by a maintenance manager that has seven sections (electrical, mechanical, control equipment, installation, planning, technology, protection).

3.2 Features of work in complex organizations

Our research has given us implications about the common features of work in complex organizations (e.g. Reiman et al. in press, 2004b). We propose that the work could be characterized along the following psychological dimensions:

- Structure (manifesting as knowledge of expectations)
- Communication climate
- Experienced control over one's own work
- Meaningfulness of work

We define *structure* as the degree to which people feel that goals, tasks and responsibilities are well defined. New information technology and the new forms of organizing work (e.g. outsourcing) are not only changing the structure, but also the nature and requirements of the maintenance work. This seems to happen in quite a similar way to what Zuboff (1988) noted happening in the late 70's in the process control task in industrial work.

The current focus on strategic optimization and new information technology can threaten the traditional conception of proficiency (based on handicraft skills and experience) among the personnel. The new expectations created by the new technology are not congruent with the old cultural conceptions of a skilled worker. The personnel do not want to see the machinery as merely numbers on a computer screen or data base, but as concrete objects to work and play with (cf. Zuboff 1988). This means that when new structural solutions are introduced, the other dimensions of the work, communication climate, sense of control and meaningfulness also have to be taken into account. It was noted in the pilot study that the personnel with longer tenure saw the maintenance organization as more change-oriented than the newcomers did. Implications were also found that the employees with longer tenure did not like the changes that they perceived (Reiman & Oedewald 2004).

Communication practices appear to be more and more abstract and in some sense also to have less of a face-to-face nature in today's workplace. Orr (1996) noted that the technical knowledge of the machine repairers was strongly dependent on face-to-face encounters between the repairers and on the task-related stories that they shared in the meetings. Our results have suggested that the quality of communication is more important than its quantity (Reiman et al. in press). Hence we use the term *communication climate*.

Experienced control means the degree of personal sense of coping with the tasks and the demands that they set (cf. Karasek & Theorell 1990, Lazarus & Folkman 1984, p. 65). Control has been noted to increase with tenure and experience (cf. Reiman et al. in press). Long tenure or experience as such does not, however, guarantee competence. New technology sets new requirements (cf. Cooke 2002, p. 979), which means that some of the old habits have to be unlearned. The longer the habits have been in use, the more difficult the change. Long tenure can also lead to routinization. Experience is then no longer a benefit, but can actually be a source of errors when the work and its outcome are not actively reflected upon (experienced control is too high). At the same time a change of generation is happening. This means that some of the cultural values and artefacts (e.g. emphasizing certainty and talking about proficiency as something taken for granted) have to

change. The newcomers should achieve a realistic sense of control based on one's own skills and abilities and on the demands of the work.

Meaningfulness is a complex psychological state resulting from several dimensions, such as the content and variation of the tasks and the feeling that the work is important and leads to personal development (Hackman & Oldham 1980). Meaningfulness was in the present study found to exhibit a high, significantly positive correlation with job motivation and job satisfaction. Maintenance work appeared to produce a feeling of meaningfulness when there are technical problems to solve with safety significance and time pressure (see also Reiman et al. 2004a). This is a paradox in the sense that one of the goals of maintenance is to avoid problems and keep the technology running reliably. If one assumes that the technology in the future can be made more reliable and fewer problems will occur, then this could be a challenge for the personnel to retain meaningfulness of the work. The maintenance task should be focused on maintaining the entire plant, not some individual pump or valve. In other words, we propose that meaningfulness in one's work should be connected to the organizational core task (cf. Reiman & Oedewald 2004, p. 884). One possibility for enhancing the meaningfulness of the maintenance work is to try to give the maintenance workers more opportunities to participate in the various modernization projects (Cooke 2002).

An interesting and somewhat neglected dimension is *sense of personal responsibility* (Hackman & Oldham 1980, cf. Reiman & Oedewald 2004). The sense of personal responsibility can be hypothesized to refer more to the internal state of motivation and a feeling of being personally accountable for the results of one's actions. In nuclear power plants, the achievement of a sense of personal responsibility is complicated by strict rules, procedures, and a tendency to emphasize shared responsibility and collective action instead of individual action (Reiman & Oedewald 2004, Rochlin 1999, p. 1554, Hackman & Oldham 1980, p. 75). An ambiguous sense of personal responsibility could lead to overemphasis of the formal structural features of the organization as a source of sense of control and meaningfulness. Responsibility would then mean that you do what is formally required, not what would be felt personally as a sensible course of action in the given situation. Personal responsibility is thus not directed towards the fulfilment of the organizational core task, but towards the fulfilment of the subtasks and subgoals that the given actor is directly accountable for.

Our study also gave implications that organizational changes do not seem to affect the safety climate or safety culture as defined by the employees valuing safety. Instead, the changes affect

more the psychological work characteristics, such as meaningfulness of work and sense of control. Changes that seem to endanger safety are experienced as highly stressful, especially *since* safety remains highly valued. Developing only the safety values and safety attitudes of the organization is thus not beneficial, since the safety attitudes are at least as high as before the change (most likely even higher). Still, incidents can be caused by e.g. unclear organizational structures, lack of communication, or low sense of control among the workers.

3.3. Organisational change in maintenance – challenges and opportunities

3.3.1 The identified goals of the changes

On the basis of the case studies, the following goals of change initiatives in maintenance were identified (see Table 1). In the final year of the project, the goals are discussed in terms of their actual fulfilment and the differences between the plants in the goals chosen are highlighted.

Table 1. Examples of the goals of the change initiatives in NPP maintenance units

GOALS of the maintenance change
reduce costs
separate nuclear power specific costs
maintain nuclear safety in the long term
enhance the status and role of maintenance
enhance the status and role of technical department
enhance the status and role of operations
standardise work procedures in maintenance
enhance the availability of the maintenance personnel to different units or tasks
enhance the efficiency of the maintenance
enhance coordination between operations, technical and maintenance
a bad previous reorganisation
climate and personnel issues*
change of roles and responsibilities between operations, maintenance and technical departments
provide career opportunities for young people
give the personnel more responsibility
maintaining and developing competence
"waking up" of the organisation
increase cooperation with operations and maintenance

* enhancing the working climate, getting more development oriented people into manager positions

3.2.2. Changes in the role of the foreman – implications for change management

All the four case studies indicate that the responsibilities and the role of the foreman have gradually changed. The implications of this will be tackled in the final report.

3.2.3 The common features of the case studies

On the basis of the case studies, a framework model was created (see Figure 7) to be tested and iterated in the final year of the project.
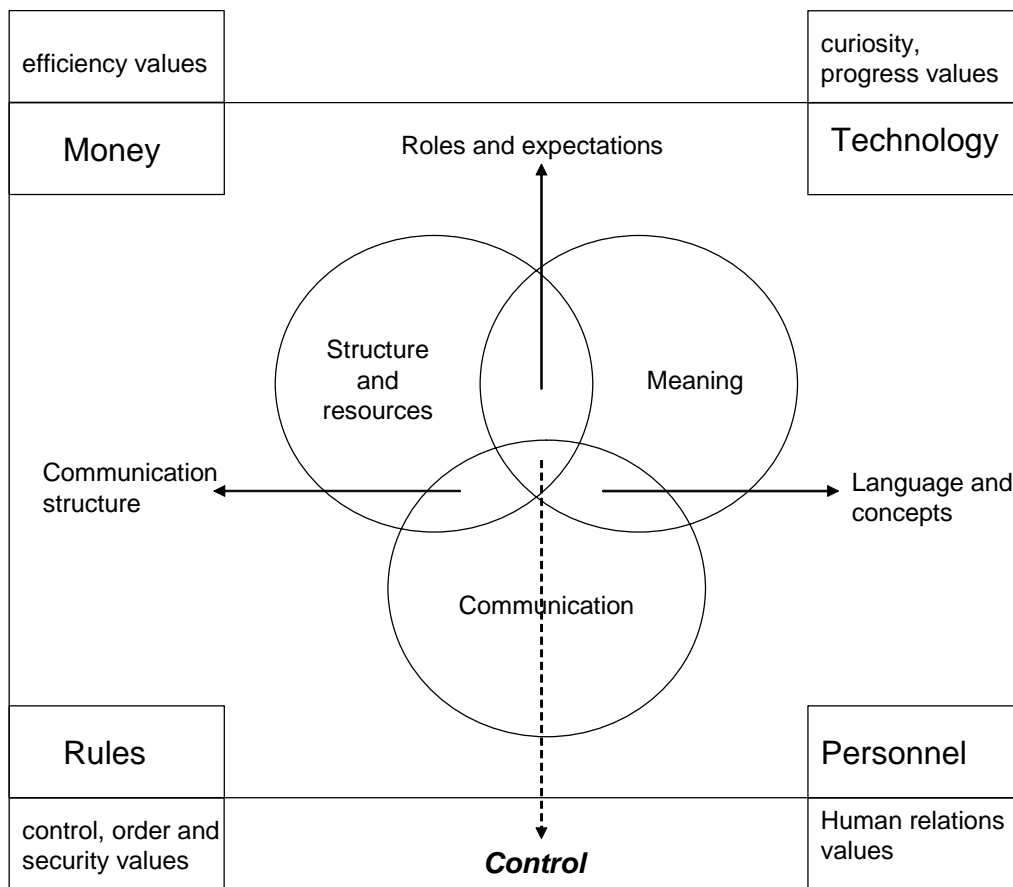

Figure 7. A framework model used for characterising some issue domains of importance in the study of organisational change

The figure has three main issue domains (structure, meaning and communication) and four overlapping fields created by combination of two or three domains (communication structure, roles and expectations, language and concepts, and control). In the centre there is *control*. It means both a personal sense of being in control and control over the issue domains. In change situations, control should focus on the entire system, not only on e.g. personnel or technological solutions. In

the corner there are also four general focus areas of rules, money, technology and personnel, and values connected to these areas.

On the basis of the model in Figure 7, a set of hypotheses are set to be tackled in the final year of the project:

- the above mentioned dimensions have to be balanced in order to reach control of the organisation in all situations, including change situations
- the dimensions also compensate each other, e.g. communication can compensate deficiencies in structure
- driving forces of change can be made explicit with this model
- it is possible to identify basic value domains associated with the four focus areas of rules, personnel, technology and money => can be used to clarify implicit models behind change management initiatives (e.g. an implicit assumption that control and order values are dominant way leads to emphasis on rules as a means of the organisational change)
- the framework orders information concerning change management, both theoretical and empirical data; concerning empirical data, the framework structures the data concerning the four maintenance case studies
- assumption: imbalances are not healthy for organisations in the long run => framework can be used as a tool in risk analysis
- the model can be used as a tool in planning change and anticipating the consequences of changes => can also be used as a communication instrument

For example, all four driving forces can be extracted from the case studies. Organisational structure seems to be a starting point of most planned radical changes (e.g. FKA). Furthermore, the interaction between the issue domains was clearly perceived in the case studies. For example, the change of structure at FKA had negative impacts to roles and expectations. In all case studies communication was also an issue of concern. Furthermore, the experienced meaningfulness of work declined in some cases since the structure and communication were felt vague in the new organisation. The connection of meaningfulness to the task itself and the gradual shift of the source of meaningfulness (e.g. to social relations) in change situations are important phenomena to take into account when considering the overall reliability of the system.

In all the three power plants measured with CULTURE-survey, the sense of control was quite high among the maintenance personnel (cf. Reiman & Oedewald 2004, p. 882). This was especially so

at TVO. This is partly explained by the more stable situation at TVO and the higher average tenure in comparison to the other plants (Reiman et al. 2004b).

The organisational solutions (outsourcing, decentralisation, flat organisations) simplify the mental models used to manage the entire system, but not the world as such. They thus function as an escape from the need for a complex control system such as Weick et al. have described. These solutions only work for a certain time, since the reality as such does not simplify, only the representation of it. Too simple models thus lead to unanticipated incidents. This recreates the need to clarify and simplify the organisational structures, responsibilities and procedures. Depending on whether the previous solution was to outsource or decentralise, the next solution will be to insource and centralise. Another reason for the need to shift focuses from one extreme to the next is that any system starts to "drift" (see e.g. Snook 2000) as soon as it is implemented. This means that the working practices and routines develop gradually and adjust to local requirements. In time the system is not identical to the one that was designed. A solution to this problem is usually a new even more tightly coupled design. (cf. Snook 2000)

As Weick (1993) implies, organizational design and redesign is not a rational decision-making situation, but a social process based on interpretation of incomplete information and the history of past events. Organisational culture has an influence on the redesign of structures and processes. For the personnel, the objects and tools in the environment represent the history of their use. In other words, the concepts and tools mean whatever they have been used for in the past (Weick 1993). Herein lies the danger of organizational change: the change process usually focuses more on the organization's past than on the organization's current or future working environment, the and demands caused by them. The possibilities offered by new technology, brought in from the outside, are also interpreted and perceived within the boundaries of an organization's culture. The need for organisational change and the redesign of organisational structures should arise out of careful analysis of the present state and the formulation of the preferred state on the basis of the (changed) requirements of the organisation's core task.

4. Conclusion

Anticipation, emphasis on certainty and cultural stability are central features in high reliability organizations (Rochlin 1999, Oedewald & Reiman 2003, Reiman et al. in press, Perin 2005). Change seems to endanger all of these, and thus change situations are demanding and experienced as stressful. Resistance to change on the part of the personnel can actually reflect the strong

commitment to safety that they feel is in danger in the new situation. This requires better communication of both the goals and the methods of change to the personnel. Furthermore, the managers would benefit from listening more to the ideas of the field workers since they usually know the plant best. As stated by Woods and Cook (2002, p. 142), changes in complex systems are "opportunities to learn how the system actually functions".

Dunphy (1996) suggest that following elements are found in any comprehensive theory of change:
a) a basic metaphor of the nature of organization;
b) an analytical framework to understand the change process;
c) an ideal model of an effectively functioning organization that specifies both a direction for change and values to be used in assessing the success of the change intervention (e.g. survival, growth, integrity);
d) an intervention theory that specifies when, where, and how to move the organization closer to the ideal;
e) a definition of the role of change agent.
These issues will be tackled in the final year of the project.

The project will continue in 2005 with a focus on the management of change in nuclear power plants and on the development of methods and tools to aid the organisational and cultural change. The main goal of the activity in 2005 is to identify good practices of change management and critical issues that have to be taken into account in all change initiatives. The aim is to study how to anticipate the consequences of organisational changes to the safety and effectiveness of the organisation, and to identify what change strategies and associated structures would best facilitate the psychological characteristics of work (meaningfulness, knowledge of expectations, sense of control, sense of personal responsibility). More specific questions to be addresses are:
- what goals and methods of change are best accepted by the personnel at NPPs
- how the different organizational changes affect experiences concerning one's own work
- what consequences to safety can the changes in the personnel's experiences concerning one's own work (e.g. sense of control) have.

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Abstract	Change management has emerged as an important topic in safety-critical organisations. A lot of knowledge on change management exists, but still lot of projects fail and the safety consequences of various changes are unclear. It seems that the problems of change management are interdisciplinary, but still solutions tend to only from one perspective (e.g. technical or personnel management). There also exists empirical evidence that change has been experienced as stressful in the nuclear power plants. The cultural perspective taken in this paper strives to combine technical approaches to human resources approaches. It raises new questions that are not usually explicitly taken into account in change management. Financial pressures, change of generation and other changes in the environment have forced many organisations to reorganise their practices (e.g. downsize, outsource, and develop team-based organisations). These changes have had an impact on the culture of the organisation (and the organisational culture has mediated these changes in the first phase).