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ORGANISATIONAL CONTROLLABILITY

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Summary: This working paper has been written as one of the spin-off tasks within the LearnSafe project. Ringhals AB initiating the task by challenging the LearnSafe researchers from SwedPower and VTT to find a workable explanation of the concept *controllability* as applied to organisations. Given a better understanding of organisational controllability it was assumed that it would be easier to find appropriate control actions for adapting organisations at nuclear power plants to changes in their operational environment.

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Disclaimer: This report has been written on the basis of discussion between the authors and people at Ringhals AB. It has intentionally taken a rather theoretical point of view, which means that organisational problems presented in this context do not necessarily have exhibited themselves within Ringhals AB. The views taken in the report are purely those of the authors and do not necessarily reflect the views of neither VTT nor SwedPower AB.

1 INTRODUCTION

LearnSafe[1] has been investigating processes of *organisational learning* and *management of change* at nuclear power plants across Europe. The focus of the project has been upon senior managers at nuclear power plants, who are responsible for strategic choice and resource allocation. This focus was selected due to the importance of their role in decisions, approaches and attitudes that have a large influence on the safety and economy of the plants.

This working paper has been written as one of the spin-off tasks in which Ringhals AB challenged the LearnSafe researchers from SwedPower and VTT of finding a workable explanation of the term *controllability* as applied to organisations.[2] Given an understanding of organisational controllability it was assumed that it would be easier to find suitable control actions to adapt the Ringhals organisation to changes in its operational environment.

This working paper is based on information collected at Ringhals AB on how managers in various positions at a nuclear power plants view their task of managing and what kind of demands this task is creating. The intent of the paper is to invite to a broad discussion of different aspects of controllability as applied to the management of nuclear power plants.

The body of the paper is divided into five main sections. Section 2 takes a look on controllability as seen from a systems thinking point of view. This section combines traditions of the mathematically oriented systems theory i.e. hard systems thinking with concepts from the so called soft systems thinking.[3] Section 3 brings up concepts from management science, which have an application to the concept of controllability. Section 4 gives references to aspects connected to psychology, social psychology and sociology, which are relevant in this context. Section 5 gives a brief description of the situation at Ringhals AB, the data collected and the main observations made. Section 6 gives a broad reflection on the most important observations made together with recommendations on how an organisational controllability can be ensured.

2 CONTROLLABILITY IN SYSTEMS ENGINEERING

Controllability has been defined in systems theory. According to common definitions controllability can loosely be said to be an ability to control a certain system in wanted directions. Controllability is also connected to the effort that is required to transfer a system from one state to another. In considering the effort of control it is often assumed that a larger effort will be needed if the transfer has to happen in a shorter time. These concepts are investigated in more detail below.

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[1] The project FIKS-CT-2001-00162 "Learning organisations for nuclear safety" has been funded by 5th Euratom Framework Programme during the years 2001-2004. Additional information can be obtained from the web-site http://proxnet.vtt.fi/learnsafe/, which is open for all LearnSafe partners. Access to this web-site can be gained by requesting a user name and a password by e-mail to Ulla.Peltonen@vtt.fi. The LearnSafe project has also established a public web-site at the address http://www.vtt.fi/virtual/learnsafe/.

[2] The English word controllability is used in this connection for the Swedish word "styrbarhet", which actually is more restricted in its interpretation to mean control from one state to another. The Swedish language actually separates between control in two meanings, i.e. to maintain a system in a certain state (kontrollera) and to transfer a system from one state to another (styra).

[3] Peter Checkland (1999). Systems thinking, systems practice, Wiley.

2.1 Models, analogies and metaphors

People are using models, analogies and metaphors continuously as means to understand and describe observations they do. In control theory models are used as substitutes for real systems for some specific purpose. Models are simplifications and they can never in all aspects substitute the system they model. Models bring out the essential features of a system by separating between phenomena that are included in the model and those, which are not. In constructing models a separation is made between the system to be modelled and its environment. The construction of a model of a system takes an outside view, i.e. the view of an agent, who is decoupled from the system and builds the model as an artefact for some specific use.

Models carry the concepts of *whole* and *parts*. In taking a look on a system of some kind, the interest is the system behaviour as a whole. The understanding is conveyed through an understanding of the parts of the system and how the interaction of these parts determines the behaviour of the whole. This division between parts and whole is one of the key ingredients of the so called systemic thinking.

Models can be built on different levels depending on their purpose. A simple relation between a set of objects can serve as a model for example to indicate influences between certain variables in a system. Models can also be accurate mathematical descriptions of some phenomenon that can be used to predict future behaviour. Analogies and metaphors can also in a sense be considered as models, when they provide an opportunity for inferring certain properties or behaviour of the real system.

2.2 The control task

A control task carries the following concepts, a *system* to be controlled, a control *action* by which the system is influenced, the *output* of the system and the *set-point* at which the output should be kept. Systems and controls go back to the tradition in cybernetics that was developed after the Second World War.[4] In control theory a separation is often made between open and closed loop control, where closed loop control is implemented through *feedback* from the output to the control action. In the feedback loop a mismatch between an actual output and set-point is detected and acted upon to make the mismatch smaller through a set of corrective actions. In practice the distinction between open and closed loop control is not so important, because any control task will at some level include feedback loops that are implemented either by artificial controllers or through people.

A control task can in principle be interpreted broadly to encompass most human activities, where someone (an actor) is influencing something (an object) through actions with the *intent* to achieve something better. This implicit control task is present also in the construction of theories and models that help people to understand their environment. It is also important to note that the control task always carries an intent or objective.

2.3 The concept of controllability

In defining controllability from a control theoretic point of view one has to make a few distinctions. One is the concept of a *state* of a system, which is assumed to integrate the history of all earlier inputs the system to make it possible to consider all future outputs only as a function of the initial state and the input to the system from that point on. The concept of a state

[4] Norbert Wiener (1961). Cybernetics or control and communication in the animal and the machine, MIT Press.

assumes that it cannot be observed directly, but only through observations of the output of the system.

Controllability has in systems theory been given the interpretation that there for any state of the systems exists a control input taking the system to the zero state.[5] In this context controllability is shown to be a property of the system. Controllability in systems theory is closely connected to the concept of observability, which in a similar way is interpreted to mean that observations of the output of the system in response to a zero control suffices to determine the initial state of the system.

Controllability and observability are dual concepts of which one gives an assurance that the system state can be controlled by given inputs and the other that the system state can be observed through the output of the system. This interpretation can be applied at least in a metaphorically sense, in noting that organisational controllability and observability implies that there are sufficient means to control and to observe the state of the organisation.

2.4 Agents, actors and artefacts

Control of a system assumes the existence of an *actor* that is outside the system to be controlled and who controls the system either by own actions, by an intermediate *agent* or by building an *artefact* for that purpose. The control actions of an agent acting as an intermediate for an actor are assumed to fulfil some purpose, which is either given to or defined by the agent. In a discussion of organisational controllability this distinction between the controlled system and a controlling agent is fuzzy, because the control agent will in a way be a part of the system to be controlled.

The separation between agents, actors and artefacts is important in a discussion of organisational controllability in several ways. The distinction between agents and actors is assumed to carry the difference between organisational entities and single individuals. Artefacts again are any technical or organisational system that is built either by an agent or an actor. Artefacts are in their construction process given intentional properties such as providing control for systems or organisations, but they cannot change their behaviour as a result of self-reflection. Instructions used for the control of activities and work processes are examples of artefacts that are used to control organisations.

2.5 Control structures

A satisfactory control of systems is seldom achieved using simple feedback controllers. Instead more complex structures are needed to reflect requirements that are defined in a control task. Sometimes there are large delays in the systems, which make it unpractical to use only feedback control, because the control would then become very slow. This can be taken care of by introducing *feed forward* control. In practice more complex control tasks are always implemented with multiple interacting control loops.

In practical control tasks there are no single control algorithms that can be applied irrespectively of initial state of the system or the control path to be taken. This is usually solved by *adaptive control* in which the controller has some adaptation mechanism, which senses the state of the system and tunes the controller for an optimal response. *Learning control* systems are a further refinement of adaptive control structures in which the controller gradually builds a model of the controlled system and its own performance. Sometimes it is beneficial to build

[5] Lotfi A. Zadeh, Charles A. Desoer (1963). Linear system theory, McGraw-Hill, New York.

a control system in a hierarchical fashion, where higher control levels co-ordinate controllers on a lower level through the definition of control criteria to be fulfilled.

Stability is an important concept within control theory. Basically stability implies that a system will return to its point of equilibrium after small perturbations. Homeostasis is a similar, but somewhat broader concept that is borrowed from biology and has been given the interpretation of stability around some optimal point of behaviour. Linear systems are stable or unstable in their whole state space, but nonlinear systems usually are stable only in a small region around the equilibrium. Large perturbation of a nonlinear system may therefore fling the system into completely new regions of operation.

2.6 The control objective

The control of systems is always connected to the intent of some actor, i.e. a *control objective*, which loosely can be interpreted to mean that actor considers some outputs from the system to be more attractive than others. The control objective could simple be to reach a certain target state or it could be a combination of the target state, the path of state transfer, the control efforts and the time required for the transfer. In practice the control objective is often formulated as a combination of costs and benefits incurred during the transfer from the initial state to the target state.

The solution of a control task always involves a prediction of how the system will react to a given input, i.e. a *model* of the system. The distinction between the real system and its model brings in other considerations such as the structure and the accuracy of the model. For technical systems it is often possible to build accurate mathematical models, but this is not the case for organisational systems. Models of organisational systems are usually qualitative and indicating only influences between variables.

An important observation is that complex systems have a need for more complex control systems. This is called the principle of *requisite variety*,[6] which states that a controller should have the same order of complexity as the system that it is controlling. Complexity in this context is not a well defined concept, but it can be interpreted to be related to the dimension of the state space of the systems, to the interconnections within the system and to the existence of possible non-linearity in the interconnections.

2.7 Communication

Communication is important for system controllability due to different reasons. Firstly there is the need to transfer the control signals over geographical distances. Secondly the capacity of a communication channel may set limitations on the rate of control. Thirdly delays caused by coding and decoding messages sent over a communication channel may have an influence on the quality of control. Finally there may be errors in the communication, which are caused by errors in the coding and decoding of messages or by detection errors due to a noisy communication channel. In considering how communication limits accuracy and speed of control these mechanisms should be carefully considered.

In a discussion of organisational controllability the communication between agents becomes an important issue, because there are many possibilities for messages to be misunderstood. In

[6] W. Ross Ashby (1960), Design for a brain; the origin of adaptive behaviour (second edition revised), Chapman & Hall Ltd, London.

organisational communication one has also to consider the possibility that agents for different reasons do not reveal their intentions truthfully.

2.8 Uncertainties

Uncertainties are central in a discussion of controllability, because already the concept of control is a mean to handle uncertainties. Considering a control task there are uncertainties different levels. One type of uncertainty is connected to stochastic processes in nature, which determine future inputs to the controlled system. Another uncertainty is connected to fluctuations in control, which are due to inaccuracies in the algorithms that are used to calculate the control action. If there would not be any uncertainties, it would at least in principle be possible to build an ideal clockwork that would optimise the system output over arbitrary time intervals.

The need consider many independent agents brings in the need for considering additional distinctions of uncertainty, which are encountered in the communication between agents. One distinction is to separate between three types of uncertainties.[7] The first could be termed *truth uncertainty*, which is connected to uncertainties connected to truth or falseness of statements. The second could be termed *semantic uncertainty*, which is connected to the uncertainty regarding the meaning of a statement of some agent or actor. The third uncertainty could be termed *ontological uncertainty*, which means an uncertainty about entities in the world, their interactions and how the entities change in response to the interactions. Ontological uncertainties can in a way be interpreted as uncertainties that are connected to an understanding of the world, including beliefs on how other agents and actors act and why they act in these ways.

2.9 Additional control related concepts

The concept of *satisficing* behaviour in control is connected to the fact that a controller always is resource restricted and has to carry out its task in real-time. This implies that there is a trade off between the costs of giving the controller more computational power and the benefits of obtaining a better control. This trade off is connected to efforts needed to provide the controller with appropriate means to observe system state and to act for its proper control.

The *theory of games* provides one metaphor for situations, where two or more actors with conflicting interests are interacting. In drawing on recent theoretical results the on repetitive play of non-zero-sum games illustrate interesting behaviour, where actors select between co-operation and defection. One of these results demonstrates the robustness of the so called tit-for-tat strategy, which simply states that a player should respond to co-operation with co-operation and retaliate for defections.[8] Practical situations in organisations are however rapidly becoming too complex for an accurate theoretical treatment.

Another interesting theoretical result is connected to the finding that also simple rules and algorithms sometimes can generate astonishingly complex behaviour. This result proposes that at least some of the complexity of human and organisational systems may be generated by relatively simple principles of interaction in the interplay of a large number of intelligent goals seeking actors. Unfortunately however, this route of thinking does not seem to be very fruitful, because most theories and models that have been constructed to explain human and organisational behaviour are unverifiable due to their inherent degrees of freedom.

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[7] David A. Lane, Robert Maxfield (2003). Ontological uncertainty and innovation, paper available at the website http://www.santafe.edu/.

[8] Axelrod (1984). The evolution of co-operation, Basic Books.

3 CONTROL OF ORGANISATIONS

Control of organisations has been studied within management science. A vast literature is giving managers guidance on efficient ways for managing organisations. The concepts and models used are anchored in a tradition of administration and military organisations, but they have for a considerable amount of time influenced and been influenced by many other disciplines. In organisations the management is supposed to formulate goals for the activities and be in control of them, i.e. act as control agents for the organisations. This section goes through concepts that can be assumed to be helpful for managers in the control of organisations.

3.1 Models of organisations

Research in management science has produced many models of organisations. Some of them are quite general and other describes very specific phenomena. The models build on the general control paradigm, where the intent of the modelling is to produce a better understanding of the organisation and thereby to be able to do things smarter. Models of organisations are mostly qualitative and defined on a high level of abstraction and some models are used in a metaphoric sense. Influences between variables in organisations are seldom are one way, but mostly two-way interactions.

One difficulty in modelling organisations as compared with technical systems is that it is very difficult to find causal explanations for phenomena observed. Causal models of people and organisations have to rely on psychological and sociological explanations, which either are not available or are impossible to validate. The formation of intent and its influence on actions are poorly understood, but they are important driving forces in all organisational interactions. Influences in organisations are mediated through spoken and written messages that are interpreted and acted upon. Cause consequence relationships in organisations are therefore not based on physical measurable event, but on thoughts and idea of various actors in the system. How such thoughts and ideas are able to influence is again influenced by their attractiveness as seen by other actors in the system.

3.2 Models in organisations

Models are used in organisations as tools for understanding, prediction, control and training. All these purposes can be seen as instances of the general control paradigm, which aims at making things in a smarter way. Managers in organisations can be seen as agents of control that define control structures and that set various goals. To perform well the managers have to have at least an implicit model of the organisation they are managing in order to understand and predict how different control actions will influence its performance. Because the managers actually are a part of the organisation themselves, they have to include themselves in the model of the organisation.

In the control of organisation it is necessary to have some model of the environment in which the organisations operates. The usual assumption is that organisations will have only a small influence on their environments, which means that interactions between the environment and the organisation can be considered one way.

Models can be seen as a tool for understanding and predicting the future. When models are included in the organisational planning cycles they could be seen as a way to decrease uncertainties in decisions to be made. If the uncertainties are small, the planning could be extended into a large degree of detail, but with large uncertainties a detailed planning is largely futile.

3.3 Organisational structures

Organisations become efficient through a division of labour. Specialisation and co-operation implies that activities are co-ordinated and that the benefits of co-operation are shared between members in the organisation. Control of organisations is exercised both directly in management actions and indirectly through various formal and informal systems. The management and quality system is one example of a formal system, where the values and norms that control organisational activities and behaviour is one example of an informal system.

Organisational structure is defined in a management system through authorities and responsibilities for different positions. An organisational hierarchy is usually associated to the positions giving their holders one superior and a varying number of subordinates. In such hierarchical organisations the co-ordination of activities is achieved through a line of delegation, where managers at each hierarchical level are given general goals from above and converting them to more specific goals for his/her subordinates.

There are different possibilities for nuclear power plants to define an organisational structure. One possibility is to select a functional structure, for example with separate departments for operation, maintenance and support functions. Another possibility is to use a task oriented division for example into production units, which are further broken down on lower level either using functionally or task oriented subdivisions. Matrix organisations have been proposed as a new kind of organisational structure, which combines features from both functionally and task oriented organisations. The difficulty with matrix organisations however, is that they are more complex than the hierarchical line organisation and that they create a need for some kind of dual loyalty.

3.4 Organisational planning

Organisational efficiency builds on systematic work in specialised organisational units. Further improvements in efficiency can be pursued through improved skills and competencies, better methods and tools or through a clever utilisation of opportunities. Organisational control has to identify and build up necessary functions to be operational before they are needed. This is typically done in a process that includes both prediction and planning. If the uncertainties in the environment of the organisation are small this planning process can go to a large degree of detail.

Organisational planning is typically done on a strategic and an operational level. In the planning process goals and visions are considered together with outcomes from previous operational periods. A systematic assessment of strengths, weaknesses, opportunities and threats provides the basis for building plans for the incoming operational period. Plans in organisations have an important control function in making it easier to detect upcoming problems to give time for corrections. From a control theoretic point of view this process of strategic planning could be seen as a simulation of possible futures to identify crucial decisions that have to be given attention.

Organisational planning has many similarities with the control structures used in systems engineering. It also has many points in common with quality systems and the concept of total quality control (TQM). Large organisations often have organisational units that are specialised in strategic and operational planning, but to be functional and generate realistic results the planning process has to go through a bottom-up process of collecting information on capabilities and opportunities and top-down process of setting goals and operational frames.

3.5 Decision making

Control of organisations is exercised through decisions that are made on various organisational levels. There is an immense literature on decision making in organisations. In decision analysis a separation between descriptive, normative and predictive models is usually made.[9] One common observation from human decision making in practice, is that certain situations are difficult for people in making good decisions.

In decision analysis a distinction between stages of decisions is often made to differentiate between different phases, such as recognising the need for a decision, identification of decision alternatives, analysis and evaluation, implementation of the decision and follow up. These phases also suggest possible decision errors, such as for example when the need for a decision is not recognised, some important alternatives are overlooked, some salient feature of the alternatives is not analysed deeply enough, the decision is not communicated clearly enough to the actors supposed to implement it or the implementation of the decision is not followed up.

Decisions at nuclear power plants are characterised by the absolute requirement not to endanger nuclear safety under any conditions. This brings the need for assessing long chains of interconnected decisions and events of which some can have a very small likelihood to occur. Such decisions are known to be difficult for people and a reasonable approach is therefore to have very clear pre-thought instructions for situations were a mounting time pressure can be expected.

3.6 In search for good decisions

Good decisions rely on a correct assessment of the situation in which the decision is to be made. There is a trade off between costs of collecting additional material supporting the decision and the benefits obtained by the possibility of better decisions. Most decisions have to be made in real time, which means that costs for making the decision too late should be weighted against the benefit of a better decision. Practice demonstrates that not making a specific decision can be the costliest of all decision alternatives.

Decisions have a scope and a time frame. Restricting a decision in scope and its time frame makes it usually easier to find the best alternative, but carries the risk of a sub-optimisation. Decisions are typically characterised by several attributes, which have to be weighted together to find a satisfactory compromise between conflicting objectives. Decision makers are often forced to take possible decisions of other actors into account. Decisions are typically coupled in such a way that initial decisions and actions are used to create favourable situations for subsequent decisions.

An organisational control task is usually sub-divided into a large number of interlinked decisions and actions. A common strategy is to decompose the inter-linkages in some way or another to reduce the complexity of the control task. Theoretically the only correct method is to carry out this decomposition from the goal state, but unfortunately this method usually leads to a problem formulation that is not possible to resolve. A practical approach to the decomposition is to separate between means and ends on several hierarchical levels.[10] According to

[9] David E. Bell, Howard Raiffa, Amos Tversky (eds.) (1988). Decision making; descriptive, normative and prescriptive interactions, Cambridge University Press, Cambridge.
[10] Robert H. Elrod, Charles L. Hubbard (1979), Applying means-end decision trees, Business Vol.29, No.1, Jan/Feb. 1979, pp. 17-25.

this model one general end can be reached by different means, which in turn define their own ends at a lower hierarchical level. This means-ends hierarchy is to some extent reflected in the so called balance score card approach that is in use at many nuclear power plants.

3.7 Emergent organisations

A selected organisational structure is often implemented and enforced as a top-down construction of authorities and responsibilities. In this case the organisational structure is the result of deliberate control actions by one or a few persons among the senior managers. The benefit with this intentional construction that it is consistent over the whole organisation and that it has an internal logic. The drawback however is that the imposed structure may not be adapted to the work in the organisational unit and the affected persons may not accept the selected organisational structure.

An alternative to a top-down construction of the organisational structure is to allow a bottom-up formation of authorities and responsibilities in the organisational units in consideration. In such cases management literature often speaks about emergent organisations. Emergent organisations have the benefit of being adapted to their tasks and they are easy to accept by their members. On the other hand they may not have the consistency and logic to fit in to the common whole. In practice construction of organisational structure typically relies on a combination of the top-down and bottom-up mechanisms. When large organisational changes take place there is often an emphasis on top-down processes, where solutions are anchored at lower organisational levels through a participative communication and decision process.

3.8 Work in small groups

Most work in organisations is done in small groups or teams. The composition of the groups may vary with time and for example project organisations are always restricted in time and scope. In a team view organisational controllability relies on one hand on how the work in the teams can be controlled and on the other on how the work of the teams can be co-ordinated.

Work teams in an organisation typically consist of one team leader and less than ten members. The team leader have a responsibility to co-ordinate the activities of the team and s/he is hierarchically connected to higher organisational levels through a channel of communication for defining team goals and tasks and reporting group achievements.

Team leaders have an important position in forming the lines of command and reporting in the organisation, which means that they can be seen as the main communication nodes within the organisation. Within their team the team leaders have a very important influence on group dynamics and research results give a clear indication that they have a crucial influence on group performance.[11] Team leaders are also important in the socialisation and norm formation processes. These observations suggest that team leaders on all levels in the organisation should be selected with a large care.

3.9 Communication in organisations

Processes of communication are in any organisation one key to performance. Goals have to be defined and explained, people should agree on tasks and work practices, there should be an agreed and accepted ways to report on progress. All this should be communicated, understood

[11] Amy C. Edmondson (2003). Speaking up in the operating room: How team leaders promote learning in interdisciplinary action teams, Journal of Management Studies, Vol.40, No.6, September, pp.1419-1452.

and accepted. All communication has a goal and this goal can be a part of the communication or it can be hidden behind something that is believed to be acceptable. In a long run however, honesty is the only sustainable strategy, because it is difficult for people to be believable in conveying a message that they themselves do not believe in. It is important for an organisation to ensure that communication is understood, because if senders and receivers of messages have vastly different interpretations on their content, it is difficult to control the organisation.

One may differentiate between external and internal communication. Internal communication in an organisation can take place vertically between hierarchical levels and horizontally between adjacent functions. In a hierarchical organisational structure the vertical communication is the most important, but with the introduction of so called flat or lean organisations the horizontal communication becomes more important. Internal communication is important in finding optimised work practices. External communication is important to exploit innovations that have been made elsewhere. Efficient organisations are continuously searching their environment for new opportunities and they have a willingness to take in new methods and tools. In the external communication it is important to have an early warning system of trends that may have to react upon.

In ensuring organisational controllability is important to create structures and tools for communication. There should be appropriate communication networks supported by key persons or gate keepers and there should be appropriate interaction loci for the personnel. It is necessary to understand that in all organisations there is a formal communication network, which is supported by various informal communication networks. If the formal and the informal communication networks can support each other, the risk for misunderstandings will be smaller.

4 PSYCHOLOGICAL CHARACTERISTICS OF CONTROLLABILITY

There are many psychological phenomena that have important influences on organisational controllability. The perception of situations and people is one area, which has a large influence on what single individuals say and do. Motivational aspects are another important area that can explain a large amount of differences in work performance between people. Personal capabilities and orientation can also be used to understand why people behave differently in similar situations. This section brings in some concept from the behavioural sciences that are important when organisational controllability is considered.

4.1 Situational awareness

It is a well known fact that people do not react on how situations are, but on how they perceive them to be. A highly stressing situation can for example shut off people from important clues in a kind of tunnel vision. A typical characteristic is also that a feeling of time is very unreliable in situations of low or high stress. A common observation is that the first impression of a situation is very persistent and requires very strong cues to be substituted with new impressions.

Situational awareness is also connected to an impression of how other people perceive a specific situation, which is mediated through their comments and behaviour. This impression carries components of self-reference and self-reflection. People are often very quick to read an intent into what other people say and do, which may lead further attempts to a rational deduction astray.

A realistic situational awareness in nuclear power plants is important especially in situations, where decisions and actions are irreversible and can cause failures of component and func-

tions within a short time frame. Situational awareness can be improved through a proper design of indicators and signals that are further supported by detailed instructions. Training in simulators can also support a proper situational awareness.

4.2 Motivation

A common observation from organisations is that people show a higher performance when they work with things they find interesting as compared to when they are forced to do something the do not find meaningful. There is a vast literature on what drives people and how motivation can be ensured for important tasks. Many organisations use formal systems for rewards and sanctions, but they do not always function well. Group pressure exercised in all social groups is an informal mechanism for sanctions by which organisational rules and norms are enforced.

Management control of organisations often carries mixed feelings. On one hand strong leaders are seen with admiration, but managerial entanglement in day-to-day routines is on the other hand often seen as de-motivating. Management interest in the work their subordinates do, has in turn a strong motivational effect. The management in organisations is sometimes forced to make difficult decision concerning their subordinates. If there is a reasonable understanding of the background and the reasoning leading to selected solutions, decisions are easier to motivate. If here is a suspicion that the management has a hidden agenda it may lead to a rapid deterioration of the motivational climate. Similarly a conception of fairness within the organisation can support a good motivational climate.

Commitment and ownership are concepts within the nuclear industry that have positive loadings. Commitment and ownership are expected to flourish in democratic organisations, where management has selected a route of delegation and empowerment. On the other hand when this route is taken, control is likely to require persuasion instead of forceful control actions.

4.3 Capabilities, attitudes and beliefs

A consideration of organisational controllability has at least on some level to consider individuals. Capabilities, attitudes and beliefs of members in an organisation will influence its controllability. The organisation can always to some extent influence individuals through hiring preferences and training programmes, but that influence is usually small at least in a short time frame. People that have started their careers in the nuclear industry have usually gone through a socialisation process, which makes it easier for them to understand and accept practices that are used. On the other hand they may be less likely to put the practices into question as compared to persons entering the nuclear industry with a background from somewhere else.

One important issue connected to organisational controllability is the orientations people have. Orientation is associated with attitudes to work and people and it is connected to a self-image and action styles. Orientation has also to do with a willingness to take initiative as compared with waiting for orders. Orientation can be used to explain differences in the willingness to dig deep into technical issues to understand how some system or component is constructed.

Orientation can be important on a managerial level in the choice between leadership styles. One attribute is the willingness to delegate and empower. In control engineering terms this orientation is connected to a choice between direct and indirect control. Direct control is exercised through commands to subordinates, where indirect control has more to do with the creation of opportunities for subordinates to take their own initiatives.

4.4 The need for being in control

People have a need to feel that they are in control of their own situation. This feeling of control is easily lost in a rapid sequence of many seemingly unrelated events or when a major event does not seem to relate to anything that can be understood. When people feel that they are not in control of their own situation, it can have severe repercussions on their work performance. In such situations it is easy to put the blame on some evil intent by some of the actors involved. If a manager gets a feeling that s/he is not in control of the situation, it may create a lot of confusion within the organisation.

To build a feeling of control in an organisation it is necessary to create a shared understanding of events and their relationships and consequences. If there have been earlier confusions, their causes should be investigated, explained and communicated. It is perhaps not so important that this communication is very detailed, but more important that it can be understood and accepted within the organisation. A final step is to build concrete action plans by which organisational helplessness can be combated.

Control by objectives has been brought as the paradigm of management into many organisations. This practice has certainly been important in a process of empowerment, but one may ask if this process of setting and following up goals actually takes away some of the control of the day-to-day situation, which people feel to be important for motivation and wellbeing at work.

4.5 Voice and silence in organisations

The concepts of *voice* and *silence* in organisations have been discussed in a set of recent papers.[12] In a consideration of organisational controllability this mechanism has an important influence on internal communication in the organisation. If silence is the dominant behaviour in the organisation, communication is likely to be impaired. There are many characteristics that influence the choice between voice and silence of which some are related to organisational values, norms and climate and other are related to individual traits such as courage, social orientation, attitudes and beliefs. The choice is evidently also dependent on the situation and the issue in consideration.

The historical record is an important component when people select between silence and voice. If for example initiatives from below are handled in a negligent way and appropriate feedback is not given, it is very likely that ideas for improvements will ebb away. Similarly ridicule can put a check on ideas and thoughts to be presented at meetings and other similar occasions. An open communication of ideas is very important for organisational creativity.

For nuclear power plants one of the most important responsibilities is to speak up on issues that may have an influence on safety. This is especially targeted to their own mistakes people do, because unreported mistakes may introduce hidden safety threats.

4.6 Co-operation, competition and power

Co-operation is necessary in all organisations, but there is always some kind of competition between organisational units. Competition may even sometimes be encouraged by the man-

[12] Elizabeth W. Morrison, Frances J. Milliken (2003). Guest editors' introduction: Speaking up, remaining silent: The dynamics of voice and silence in organisations, Journal of Management Studies, Vol.40, No.6, September, pp.1353-1358.

agement as a mean to get a better efficiency in the work. Competing forces in organisation are often associated to power structures, where sets of people with some commonalities create their own networks of co-operation. Such structures are often are based on favours exchanged within the network. If such structures become uncontrolled, they may have a negative impact on the working atmosphere in the organisation.

Organisational power is sometimes seen as an end in itself. This is easy to understand, because power brings status and other benefits. Organisational power has also negative influences, such as the tendency for people to emphasise positive messages instead of negative. Power also tends to create a false self-image of flawlessness in the powerful. In a discussion of power it is important to understand that it changes people.

Power was in the old organisations connected to positions. This power was to some extent linked to the power of information, because information was available only for certain positions. Today the power of money has become more explicit with an increasing market orientation of all organisations. The power over people, i.e. to be able to make decisions that influence many people, is one important aspect of power. Today all members of organisations have the power of expressing a dissenting opinion. To be functional for the good of an organisation, power should be considered legitimate by the members in the organisation.

4.7 Communication and narrations

Communication has many psychological characteristics. Communication can only succeed if the sender and the receiver of a message have reasonably similar frames of reference. A sender has an intent with messages that is sent. In the communication act this intent is usually made clear, but it is always possible that the sender tries to disguise the true intent. People are usually very sensitive to deceitfulness, which implies that such messages can be more harmful than good.

Messages to a larger group of people usually have to be embedded in a larger frame. In this case one may talk about narrations, which means a story that is complete and internally consistent and therefore can be considered believable by its readers or listeners. Narrations have many similarities with more formal models in the sense that they support an understanding of interrelated events. Narrations may in fact be used as instruments in organisational control, for example to provide an understanding of the present through descriptions of the past.

A narration has a beginning, a middle and an end and it usually conveys a morale. Rumours and myths in an organisation often take the form of narrations. In a rapidly changing environment there may be many competing narrations and they could change rapidly over time. Narrations, their emergence and use have been a rather novel concept in organisational research, but it seems possible that they can provide interesting insights in communication.

4.8 Organisational culture

Organisational culture is another concept that has to be discussed in relation to organisational controllability. Without going into a deeper into what is meant with culture, it may be assumed that the concept encompasses common language, history, values, norms, practices, etc. Culture is also connected to symbols, myths and heroes that are used to articulate specific events in an organisational sense making. It a usual assumption is that organisational culture cannot be controlled, but that it emerges as the result of interactions and events. Organisational culture has will influence the selection of actions both in small and large.

Ethics, values and behavioural norms are important concepts in this connection, because they are building stones of confidence and trust between people within organisations. Norms should be communicated, understood and accepted, and there should be sanctions for not adhering to them. This has not so much to do with specific rules, because norms and rules cannot cover all situations that may emerge, but it has more to do with leadership and integrity to select between alternatives in a fair and honest. It is important to have some a collective understanding of important issues, but a consensus is not an end in itself, because sometimes diversity in views can be helpful in avoiding mistakes.

The emergence of an organisational culture relies on communication. Communication is dependent on many characteristics in the organisation, such as means for communication, loading on resources, opportunities for informal communication, etc. In the development of an organisational culture it seems that more communication is better than less, which means that it is more the amount than the content of the messages that makes a difference. Communication supports an understanding between people and that this understanding is necessary in coping with unforeseen events.

5 THE RINGHALS CASE

Ringhals AB was in the late 1990ies, like many other nuclear power plants in Europe, faced with the need to adapt to a large amount of changes in its operational environment. The most important of these changes was the deregulation of the electricity market, which together with other changes implied that the plants had to achieve more with fewer resources. It is evident that such an adaptation cannot be achieved without innovations, restructuring and organisational change. This section gives an account of data collection methods and findings from the Ringhals case.

5.1 The operational environment of nuclear power in Sweden

Sweden was in the late 1980ies and early 1990ies characterised by an intense political debate on nuclear power. This debate resulted in the political decision to close down the Barsebäck unit 1 reactor in 1999. At the same time there was a decision that the second reactor would be closed down one year later, provided that the electricity production situation in Sweden would allow for it. The decision to close down the second reactor in Barsebäck has since then been postponed two times and the present situation is still open. The second reactor in Barsebäck is since the year 2000 an integrated part of the Ringhals AB company.

The situation in Sweden has also been characterised by a tightening regulatory atmosphere. One incident at the Barsebäck plant in the year 2002 led the Swedish regulator to file a consideration of charges to the prosecuting authority in Malmö. This case has not yet been resolved. Another incident during the year 2003 at the Oskarshamn 3 reactor during a large black out in southern part of Sweden has also caused a large deal of discussions within the regulatory body on signs of a weakening safety culture. A tightening regulatory atmosphere has a direct influence on the possibilities of the plants to control their own situations.

5.2 The organisational change

Ringhals AB went through a large organisational restructuring a few years ago, which has been described in an earlier report.[13] The present study was a follow up the earlier study with

[13] B. Wahlström, C. Rollenhagen (2003). Merging of two organisational cultures, PLEM – LearnSafe – W005.

the specific goal to be a part of a general assessment, which evaluated the lessons learned of the organisational change. This assessment was decided to take place already when the organisational change was initiated, but a recent organisational survey indicated some problems that warranted an investigation.

The organisational change at Ringhals AB actually consisted of several independent parts. One part was connected to the integration of the Barsebäck unit 2 as the fifth reactor of Ringhals AB. A second part was the transfer from a unit oriented organisation to an organisation, where support functions served all reactors within Ringhals AB. A third component was connected to an introduction of process oriented work practices in the whole organisation.

The organisational change was carried out in two steps. The first step was focused on ensuring that the short term benefits from the merger of the organisations at Barsebäck and Ringhals were utilised. The second step focused more on long term benefits and the need to introduce efficient working practices to achieve a sustainable position on the market.

5.3 Information collected

Both authors of this report have a long co-operation with Ringhals AB, which formed an excellent basis for an understanding of the organisation. This co-operation was also the basis of the openness Ringhals AB showed in providing information. The researchers were basically given access to all relevant information they could think of. This information included findings from a large management review, a management training programme, recent organisational surveys, findings from a recent periodic safety review, quality audits, etc.

The specific data collected consisted of a few interviews and one system group discussion. The system group consisted of 15 persons from different parts of Ringhals AB. The idea with a system group is that it represents the organisation in miniature and discussions are invited, with regard to both problem identification and problem solving. The problem solving part of this exercise is important, because it give a possibility for the participants to use their creativity on problems they see in their own day-to-day work. The participation of people from different parts in the organisation gives an opportunity to see similarities and differences and to create a better understanding of tasks within different parts of the organisation.

The interviews were carried out with people that have a good insight in the company and in the organisational change. The interviews were conducted with the dual goal to identify how the concept of controllability could be interpreted and to serve as a problem identification exercise. These discussions provided an opportunity to take a more abstract view on some of the events that have occurred in the past within Ringhals AB. The interviews and discussions proved to be very open and some of the discussions were actually carried out as a mutual learning exercise.

5.4 Main findings

Three key areas were found to warrant additional attention by the management at Ringhals AB. The first of these areas was termed *communication and culture* and it was triggered by several observations pointing to difficulties in explaining selected management structures within the new organisation. This difficulty seems to be at least partly due to the relatively large structural change in the organisation. Another part of the difficulty is apparently connected to a misinterpretation of messages sent out to the organisation by the senior management.

The second key area was termed *co-ordination*, where indications of difficulties to co-ordinate activities were found in some places. One of the difficulties at Ringhals AB seems to be connected to the initiation of new activities, where a better consideration of strategic goals seems necessary. Another problem seems to be connected to the co-ordination of work between functions. A third difficulty seems to be connected to the vertical communication necessary to ensure everyone is aware of what is going on within the organisation. Comments on the organisational change could also be interpreted to indicate that a satisfactory co-ordination of the joint resources of Ringhals AB has not yet been reached.

The third area was termed *deviation management and decision making*. This was based on an assessment of recent audit and event reports that indicated difficulties in handling findings. One reason seems to be connected to the difficulty of stretching the analysis to a level, where generic improvable findings could be identified. A second weakness is that within the organisational structure at Ringhals AB, it seems to be difficult to reach appropriate decision makers for remedies to be initiated. It also seems to be some difficulties in initiating a watertight follow up of decisions made.

In an attempt to identify a common denominator within these three fields, it is evident that improved communication is the most important step towards improvements in large. The communicative atmosphere is generally very good at Ringhals AB and the organisation is to a large extent consensus oriented. Recent changes in the organisation seem however to have introduced gaps between functions that have to be bridged. In this endeavour communication both horizontally and vertically seem to be the most important remedy.

5.5 Experience from the evaluation

The whole assessment of the organisational change at Ringhals AB can be seen as a large exercise to collect information on organisational climate and culture. Such exercises are important especially after large organisational changes, but they should not be restricted only to such situations, because the senior management needs such information on a continuing basis.

The information was collected using many different methods and tools. The information from different sources seems to confirm each other quite well, which give confidence in the conclusions. Discussions of preliminary conclusions have been very open and indicate a true willingness of Ringhals AB act on the problems identified. The methods and tools that were used in the evaluation seem to be relatively easy to adapt for a continuing use.

6 REFLECTIONS

The study conveyed many important occasions for reflection on the interactions between nuclear safety and issues connected to organisation and management. Of the findings the need for an efficient inter-organisational communication was the perhaps most important. In retrospect however, it is natural that a common understanding in the whole organisation of targets and goals has become increasingly important. If this common understanding can be combined with efficient decision making structures there should not be too large difficulties in adapting to the needs of finding efficient work practices in support of safety and efficiency. This section gives some reflections on some issues observed in the Ringhals AB study that are connected to organisational controllability.

6.1 The conceptualisation of controllability

A good understanding of the system to be controlled is crucial. Concepts themselves carry implicit assumptions and models, which means that they can support an understanding of the phenomena involved and thereby can be of help in pursuing organisational controllability. The important concepts in controllability are the control agent, the controlled system, possible inputs and resulting outputs and the control objective. The controlled organisation is influenced by its environment and one aim of the control is thus to compensate for negative influences and use the opportunity of positive influences.

The state of an organisation can be thought of as a combination of all physical and mental states that encompasses the plant, the personnel and organisational practices. The organisational memory is one important component in the state of the organisation, which is interpreted in a very broad way. Organisational memory has a tendency to fade away with time, which means that important information should be collected and archived. These concepts should at least in a metaphoric sense be applicable when the control of organisations is considered.

6.2 Control of safety

In the nuclear power industry, as well as in other high reliability organisations, the control of safety is the crucial issue. Safety and economy have sometimes been considered as competitive concepts, but this is misunderstanding, because an unsafe plant can never be economic. From a control theoretic point of view the absolute demand for safety can be seen as the threat of very large penalties on being in unsafe states. The realisation of such large penalties can actually also be seen in some events, where non-conservative decision have brought costs that have been several orders of magnitude larger than the costs of corresponding conservative decisions.

Control of safety relies on an understanding of how safety is constructed both in the design and the operation of the plants. There are many models of how safety is built into the technical systems and how the resulting safety can be analysed and evaluated. Unfortunately there are far less models of how organisations should be controlled to achieve a high safety. Present practices have been built on operational experience that has been collected world-wide. This experience has set one norm that has been documented in many reports and guides. This norm can to some extent be used to assess safety capabilities of an organisation, but the methods are to a large extent based on expert judgement. Deviations from these accepted norms always carry a high risk of costly incidents.

In the day-to-day operation the control of safety to a large extent is governed by images of risk and safety that develop over time. If these images are not grounded from time to time with systematic assessments of actual risks and safety, there is the danger that successful operation will influence organisational risk taking in a negative way. One remedy is to have a continuous ongoing discussion of issues connected to risk and safety to form clear appreciations of the border between what can be considered as acceptable and what cannot.

6.3 Expectations on managers

It is interesting to consider how the expectations on managers have developed since the present nuclear units were taken into operation. In the earlier days managers were supposed to know everything better than their subordinates. This has today become mostly impossible. Managers were also seen as important nodes in an information network, because only they had access to information in the whole organisation. Today most of the information is accessible through the intranets at the nuclear power plants.

With the emergence of performance based management, managers are supposed to be responsible for the creation and enforcement of internal norms through the definition of visions, goals and objectives. As before they are given the responsibility to make the needed operational decisions. This also implies a resolution of possible conflicts in the organisation. Managers are also supposed to be the sounding boards for their subordinate managers to support them in their careers. Finally managers have a public relations function towards the environment of the organisation.

6.4 Problem identification versus problem solving

There is a bulk of collected evidence that it is difficult to transfer from an identified problem to actions that would solve the problem. This difficulty is perhaps mostly associated to the need to transfer a feeling of urgency for the problem identified to the people who have a possibility to do something about them. The urgency is again connected on one hand with the possible consequences of doing nothing and on the other to the effort needed to create a sustainable solution.

At one level problem identification and solving has to do with finding ontological uncertainties and to nurture relationships that have a generative potential. Problem solving has to do with a capability to exploit opportunities, i.e. bring the right people together and to engage them in a creative communication exercise to find solutions. The problem today seems however to a large extent to be connected with finding the time for such problem solving exercises.

6.5 Self-assessments

Self-assessments are used by the nuclear industry as a systematic method to identify possible areas, where actions of improvements are necessary. Self-assessments in a broad sense can be seen as creating a situational awareness of the state of the organisation. Self-assessments rely to a large extent on comparisons between an actual state and various normative states. These normative states can be found fore example in the management and quality systems that are used at the nuclear power plants.

When deviations from the norms are detected in a self-assessment an analysis should be undertaken for finding the reasons for deviations. In that analysis effort it is common to use various cause-consequence models. The corresponding methods and tools are typically aiming at finding a root cause for deviations, but this is usually futile when organisational deficiencies are concerned. Sometimes the models used in the analysis efforts are implicit and taken for granted, but it is always a good policy to make them as explicit as possible. This implies that the analyst sometimes has to take a modellers view in trying to understand how various observable conditions can contribute to a deviation and how the conditions are influenced by management actions.

Self-assessments on an organisational, group and individual level are important in ensuring a good performance. At different levels it may be necessary to use slightly different methods to get the best results. Self-assessments can in a control theoretic perspective be seen as an important instrument for introspection and self-reference

6.6 Ensuring that communication is understandable

There are different types of communication that should be kept separated. The communication of facts is a simple and straightforward form of communication. Communication connected to events, their causes and consequences can be far more difficult, because such com-

munication often contain various interpretations and beliefs. The enforcement of organisational norms and rules of conduct, typically require quite extensive communication before the norms and rules are understood and accepted. Finally managers are expected to communicate goals and visions that they are using in the control of the organisation.

Considering a various means for communication it seems that narrations are an underutilised instrument. Narrations are important in every-day communication and a systematic investment in the art of story telling may help the management in conveying understandable images, visions and needs. By using narrations as a conscious instrument they may help the internal sense making in organisations. There is also a danger in this route, because narrations can serve in a restructuring of history and after-rationalisations when bad decisions have been made. Like any other control instrument the narrations may backfire if they are not considered honest and fair.

There are many examples from literature and from events that illustrate common problems in communication. Such problems can only be solved by more and efficient communication. One common problem in the communication in organisations is when messages from the management seem to be in conflict with actions or earlier messages. If messages and actions are not consistent there is a large danger that the communication is assumed to carry a hidden intent. The management should when communicating always be sincere, because people are very sensitive to deceit.

6.7 Control of organisational change

Organisational change often becomes the probing stone of controllability. The difference between present and needed organisational performance is the driving force of change. If there is a consensus that a change is needed, there is a feeling of urgency and a fair agreement on how it should be done, organisational changes usually are successful. In the selection of an organisational structure there are typical several possibilities that have to be weighted to each other. The actual implementation of the organisational change has to be planned in a rather large degree of detail to avoid problems further down the road. In this planning it is necessary that decisions are made after a thorough pondering not just to follow the fashion.

Any organisational change has to be preceded with a large communication effort in which the reasons for the change are explained. It is often necessary to overcome organisational inertia to create an understanding of the urgency of the change. If the situation in the organisation is perceived as stable it may be difficult to create a willingness to change. When the change has been initiated and is under way it is often necessary to introduce a close hands-on control to ensure that the process of change is taking the correct direction. Finally after the organisational change it may be necessary to hinder a fall back to old habits.

Organisational changes may have a window of opportunity, where it is possible to initiate changes without too large efforts. Organisational change is also connected to a search of matches between capabilities of people and giving them opportunities to engage in the process. Organisational changes are connected to changes in the environment or in the own personnel, they may be connected to new technologies giving new opportunities, or they may arise from organisational innovations that carry the promise of a better organisational performance.

After an organisational change it may take time for the new management to find the appropriate leadership style and orientation. New leaders are typically received with large expectations from the personnel creating a kind of a honeymoon of enthusiasm. After such a period it is

usual that an increasing criticism takes power with suspicion and comments that the situation has changed from bad to worse. Fighting these trends can be very hard and will require both statue and leadership.

6.8 Preconditions for organisational controllability

Organisational controllability is to some extent opposite to organisational stability. Organisations have an inertia, which gives them stability and predictability. Stability is in one sense a good characteristic, because it can prevent the adoption of new practices that in a more close scrutiny would show to be inappropriate. Goals for organisational controllability should therefore always be set in relation to the need for organisational stability.

In assembling a list of preconditions for organisational controllability the perhaps most important factor is the trust between the personnel and the management. This has to do with the existence of a common understanding of the situation, the existence of and agreement on a goal state and a set of actions that are believed to solve the problems. This also implies that there is a large consensus within the management on these issues, because divergent views will leak into messages sent out, where they can cause decreased confidence and trust. Preconditions for controllability have on a second level to do with preconditions for a mutual trust between management and personnel.

Responses to unexpected demands require an organisational flexibility. It is often advantageous to have scaffolding structures in the organisation on which ad hoc organisations can be built. Competence networks within the organisation are one example of such structures, which could be used to get the right competencies together when some urgent problem has appeared. This organisational flexibility has also to do with the need to bridge gaps of understanding and to rapidly line up aspirations in a problem solving exercise. This alignment should however not mean that critical voices are silenced during such urgent tasks.

6.9 Recommendations

In a discussion of preconditions for organisational controllability, the perhaps most important observation is that organisations today are leaner and flatter. This means that the hierarchical control structure of the organisations has become weaker. Empowerment and motivation has in this process substituted an earlier command structure for organisational control. In this development process it however not been recognised that the new organisational structure may place a larger need on efficient and convincing communication. This communication should ensure that all members in the organisation have a proper situational awareness.

In all organisations a reasonable consensus is necessary to avoid action paralysis. A full consensus on the other hand brings the danger of single-mindedness, which can be disastrous if a wrong path of action is taken. A suitable blend of consensus and constructive disagreements can be assumed to lead to the best results.

It is necessary for the management to be able to have a realistic perception of the state of the organisation. It is also important that they monitor the environment to identify new threats and opportunities. In setting goals and priorities a common sin is to try to do too much. If the organisation becomes overloaded other priorities will start to compete and organisational controllability is easily lost. Further consequences could be an increasing backlog of work and minor incidents. In this process a conservative regulator would act by insisting on evidence that the safety culture is according to standards. To be able to meet the challenges of organisational controllability, one important issue is to be able to run the plants smoothly without mistakes that may decrease regulatory trust.

7 CONCLUSIONS

An understanding of organisational controllability relies on a combination of systems thinking and the use of models from management science and the behavioural sciences. It is necessary to bridge single disciplines that all have their own concepts, models and traditions. It can help in making concepts and models explicit and used in the discussion of upcoming decisions connected to organisational control.

Organisational controllability boils down to the need for establishing efficient communication practices in both large and small. The communication should be open and sincere. Senior managers should be very sensitive to possible misinterpretations of messages they send out. The systematic use of narrations way may prove efficient as a tool to ensure consistency and comprehensibility of messages from the management. If the stories told are not convincing, or if there is a suspicion that there are hidden agendas involved, the organisation can easily loose its possibility to operate efficiently.

Senior managers have a key role in creating preconditions for organisational controllability. These can be created only elevating visions and enlightened leadership. Unfortunately however, it is only seldom that all virtues of a good leader can be found in one single person. This means that management is a team effort. In assembling management teams it is important that the members complement each other and that they are able to communicate with each other. It is beneficial if they, in spite of a large common understanding of important issues, still have diversity in their views to allow for important decisions to be looked at from different angles.

Organisations today have to master both complexity and uncertainty. Control of all important characteristics of an organisation involves many issues that need their own specialists. The senior management have an important task in integrating and communicating all these issues as visions and norms of conduct. When this is successfully done it should be possible to build and maintain safe and efficient work practices at the nuclear power plants.

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