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FRAMEWORK FOR EFFECTIVE IMPLEMENTATION OF ADVANCED TECHNOLOGY IN ARMENIA

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Abstract: This paper examines how Sliding-Mode Control (SMC) technology can be implemented more effectively and, at the same time, serve as a means to enable profound organisational change. A framework for effective SMC technology implementation (called "the SMC Model") is derived and introduced. The key message of the paper is that the approach and methodology dealing with this kind of technology must seriously take into account the existing cultural, economic, political and social environment of the organisation intending to introduce advanced technology. The arguments are supported by a short description of some results and experiences of introducing the SMC model in Armenia. *Copyright © 2002 IFAC*

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1. INTRODUCTION

Effective implementation – i.e. adaptation, introduction and diffusion – of SMC technology is, at its core, a task of managing change. As such, not only technology issues are at the heart of the implementation process, but also structure, culture and process issues are at least equally important. Although this insight is not new, in practice, an overemphasis on the technology part can still be observed in too many cases. Especially the SMC-technology experts and managers tend to believe in "magic" and forget all they know about best practices of change management when the "magic bullet" of the SMC technology comes into play, as Markus and Benjamin (1997) put it. They want the excitement of revolution, but without the fear and risks which social upheavals bring with them (Kling, 1993). These findings indicate that people are insufficiently aware of the need for a proper alignment between the organisation and SMC technology. Most commonly, the SMC technology is simply pushed into the organization, based on the assumption that subsequent organisational adaptation will follow automatically. Evidence for these findings is given in many surveys (e.g. McKersie & Walton, 1991) and is especially obvious in current efforts regarding the introduction of advanced SMC technology in Armenian firms like the JVC Transistor (Mkrttchian, 1995).

Aiming to find better ways for introducing the SMC technology in Armenia, it is interesting to look at the current approaches. Advanced technology, including automation and information systems, is widely recognised as a means of strategic importance for enterprises and organisations striving at improving their competitiveness as well as overall performance. Unfortunately both, those who are responsible for justifying the return on investment, as well as those who directly use the advanced technology, continue to have their expectations greater than results delivered. While this finding may be understood as a positive tendency towards further improvement, many researchers, developers and manufacturers of advanced technology are working hard to improve the ratio of successful applications, often supported by associations such as e.g. INCOSE, CIMOSA or MESA (http://www.incose.org; http://cimosa.cnt.pl; http://www.mesa.org).

With time, the technical features of advanced technology have matured to the point where further improvements seem to be possible only through major technical innovations. On the other hand, it becomes more and more obvious that there is still a great potential for improving the effects of advanced technology within the non-technical aspects of its implementation, such as: human, organisational, strategic, economic, cultural and educational aspects (Cernetic and Strmcnik, 1991). In this context, various systematic approaches, paradigms or technology design frameworks have been established and promoted, such as Systems Engineering, GERAM, Capability Maturity Models (http://www.sei.cmu.edu/cmm) and the Human-Centred advanced technology design paradigm (Brandt and Cernetic, 1998). However, it seems that within these approaches, frameworks and paradigms either the human, or strategic, or managerial or cultural issues are underestimated.

A number of so-called business-driven approaches (e.g. Hales, 1989; Sun and Riis, 1994; Bysinger and Knight, 1996) and other initiatives (e.g. the ASTA – Accelerating Software Technology adoption: http://www.sei.cmu.edu/adopting) have been developed in highly developed countries that are intended to bridge the mentioned gap in the area of business aspects and new technology adoption. These approaches are indeed very valuable as guidelines and examples for improving the process of introducing advanced technology. However, according to the experience of the authors, they cannot be directly implemented in social and cultural settings other than those typical for developed countries. This paper makes a contribution towards improving this situation by considering these issues from the viewpoint of post-socialist countries, in particular the Republic of Armenia. An approach and methodology for introducing the SMC technology (called "the SMC Model") are proposed (Mkrttchian, 1995) that have been developed as well as successfully used for years in Armenia, previously being part of the former USSR.

2. THE SLIDING MODE CONTROL MODEL

The SMC Model is a framework for advanced technology-induced organisational change that suggests using the following three components: **technology, strategy/structure and culture** as critical for a holistic view on the introduction of advanced technology. Strong emphasis is put on the culture, including the consideration of the basic underlying assumptions of the actors involved. The framework is based on the notion of the organisation as a pattern of communications and relations among a group of human beings, as introduced in the preceding section (Mkrttchian, 1998).

Additionally, the SMC Model puts a strong focus on the interfaces between the three components, with the aim to stress the necessity of their alignment and to enable a holistic view on advanced technology-introduction. These interfaces are called "**interaction spheres**" and they not only address an alignment of the content, e.g. organisational structure, but also put special emphasis on the alignment of the basic underlying assumptions. The emphasis on the element "culture" is not only stressed by the component ***culture*** itself, but additionally by the distinction of two layers of activity: the content layer and the assumption layer.

The background of this distinction is derived from the recognition that one of the biggest impediments to organisational change lies in the non-alignment of three distinct *subcultures of management* (Schein, 1996):

- Technologists who design and introduce the information technology and who usually identify themselves with their worldwide occupational community, having the "**engineering culture**".
- Executive managers that define strategies and are responsible for the organisation structure and, as with the technologists, identify themselves with their worldwide occupational community, having the "**executive culture**".
- Line managers and line workers as the users of technology and representatives of the "**operator culture**" that evolves locally in organisations or organisational units.

Thus each component of the SMC Model does not only represent the factual issues of technology, strategy/structure and culture in the content layer, but also the basic assumptions of the corresponding subcultures in the assumption layer (Mkrttchian, 1997). These assumptions are forming a kind of filter or membrane around the content of each element. This filter is considered a major source for problems, but also a major lever for success during the implementation process. These subcultures and their basic assumptions are assigned to those components that usually have most influence. For example, technologists are assigned to the component ***technology***, executive managers to ***strategy/structure*** and line managers and workers with the ***culture***.

2.1 Content Layers

"*It would take at least that long before people would use computers for doing what human beings had never done before*." This statement is a strong support for what has been elaborated in the above sections: for most organisations it is still reality that advanced technology is used to speed up existing processes instead of using advanced technology as a means to enable new ways of doing business. In order to close the gap between the potential of advanced technology and its actual exploitation, it is crucial that the strategy for introducing the advanced technology and the business strategies are aligned from the beginning. The focus of this alignment should not be limited only to the internal strategy and to the support of the administrative processes, as derived from the business strategy. Still more important, it is to focus on the external strategy of the organisation, i.e. the position of the organisation on

the competitive technology market, regarding the overall scope of information technology and its systemic competencies. This alignment is a dynamic process, and its critical lever lies in an organisation's capability to leverage technology, in order to differentiate its operations from those of competitors. An internal strategy for introducing advanced technology that is conducive to profound and sustainable organisational change should include the following aspects: architecture, processes of advanced technology, roles and skills needed to exploit this technology, the coupled pair of strategy and structure, and organisational culture. These aspects are briefly discussed below from the viewpoint of the SMC model presented in this paper.

Architecture: The organisation of hardware and software architecture should be interconnected to the maximum. At best, it should be technically possible that every employee has access to all existing information, to give a maximum of decision support. To provide this degree of flexibility, the network must support all common standards and be independent of hardware platforms.

Advanced technology processes: The development, introduction and maintenance processes for information systems (IS) should be incremental and follow a strategy for continuous improvement. Due to the extremely fast changing advanced technology market, the time between conception and implementation of a new IS should not exceed a time frame of nine month. Also a project should be divided into short cycles of implementation, and it should be possible to assess each cycle in terms of measurable business results.

Roles and skills: Advanced technology experts in modern organisations will increasingly be assessed not only by their technical, but also by their social skills. The aim is twofold: first, to enable the users to take full advantage out of the available possibilities which technology provides, and second, to deal with the resistance or fears that many employees have when faced with the challenge of a new IS. The SMC technology expert will more and more have to become an agent of change (Mkrttchian, 1999).

Strategy/Structure: In the SMC Model, the strategy and the organisational structure are considered very closely interrelated and thus appear in one single component. This view is based on the fundamental assumption that the economic performance depends on the ability to create a strategic fit between: a) organisation's position in the competitive product market arena, and b) design of appropriate processes to support its execution (Rockart & Short, 1990). In other words, aspects considered for the strategy of introducing advanced technology have their correspondence in the business strategy. Both, the external and the internal business strategy of the organisation have to be highly consistent and also closely meshed with each other.

Much has been written recently about the structures of the new organisation. A wide majority of the authors call for the elimination of the organisational chart and for replacing hierarchy by more flexible structures like fractal (Pasmore, 1994) or networked organisational structures (Rockart & Short, 1990).

Unfortunately, there is no classical or universal structure that can be good for all organisations. Therefore the idea of the outdated hierarchy is not supported here. Nevertheless, there are indeed many areas in business where, also in the future, hierarchy will still be the most effective organisational structure. But regarding an organisation's ability to change, to innovate, and to grow with stability, more decentralised structures are more efficient. This argument is backed up by research in General Systems Theory (Laszlo, 1972) where two patterns of general systems are of particular relevance in this context. The first systemic pattern is the observation that complex systems are made up of lower-level and standardised, but self-regulating independent subsystems. The second relevant systemic pattern is that complex systems made up of self-regulating subsystems are more stable than systems of similar size where all parts react to all stimuli.

An organisational structure also has a strong cultural aspect. According to Schein (1992), technology is a very important artefact of an organisation's culture. Therefore the fit between a new organisational structure and the existing organisational culture has to be carefully assessed when introducing advanced technology, such as the SMC. A powerful way to create this fit is to have new processes designed bottom-up instead of top-down, and to involve participants from all affected areas into organisational redesign.

Organisational culture: What is true for the structure is also true for the respective information system that is to be implemented. Before introducing such a system, the fit with the culture has to be assessed. Special attention should be given to the **openness to change**, which, admittedly, is not easy to do. There is no determined analytical structure helping to analyse or to quantify the basic assumptions of an organisation. Thus, to decipher an organisation's culture, one has to begin with its visible aspects, the **artefacts** (Schein, 1992). Artefacts include all the phenomena that one sees, hears and feels when encountering a new group with an unfamiliar culture. There are phenomena like the architecture of the physical environment, the language or, occasionally, the published list of values. Of special interest is the **atmosphere at meetings**. The following questions are appropriate in finding out clues about organisational culture. Do people reflect into their own perceptions and do they mutually inquire into each other's mental models, or is there usually a debate present where one side is trying to beat down the other? Would people, when being asked about their work, rather give a job description, or would they speak about their goals,

their customers and about the quality of cooperation with their colleagues?

The next step in deciphering a culture is to ask the question "***why people are doing what they are doing***" (Schein, 1992). This question usually leads to value statements and gives insights into the espoused **values** of a culture. The next question to be asked is, whether the identified espoused values do explain the observed artefacts, or whether the described artefacts have not been explained by, or are in conflict, with the articulated values. This question leads to the deeper-rooted basic **underlying assumptions**. Shared assumptions that are conducive for a profound change to occur rather smoothly are, for example, when:

- the environmental context of the organisation is manageable to some degree,
- human beings are by their very nature proactive problem solvers and learners,
- human nature is basically good and in any case mutable.

The basic underlying assumptions are the access to and the lever for profound change to happen also during the introduction of advanced technology. As such, they are explicitly being addressed in the assumption layers of the presented SMC Model (Mkrttchian 2000).

2.2 Assumption Layers

In the preceding section, possible configurations in the content regarding technology, strategy/structure and culture were described. Whatever configuration is chosen, its operative effectiveness is determined by the degree of alignment regarding the basic assumptions of technologists, executive managers and line managers. The challenge is to bring these assumptions to the surface and to create time and space for this to happen. The following is a selection of typical, often contrary assumptions about advanced technology, organisation and management, human nature and learning elaborated by Schein (1992) out of 25 years of his experience. These assumptions are congruent with the findings of cases examined in this article.

Assumptions of executive management:

- Computers limit and distort thinking by focusing the user only on those kinds of data that can be packaged and transmitted.
- Hierarchy is a necessity for coordinated activity and thus intrinsic to organisations.
- Personal success and career security are measured by progressing up in the hierarchy of an organisation.

Assumptions of line management:

- A paperless environment is not generally more efficient and desirable; therefore the possibility to work with paper is still an important prerequisite for many tasks.
- Local organisational units are mostly capable to solve their own problems and do not need to be controlled.
- Technology should adapt to people and not vice versa.

Assumptions of technologists (engineers):

- More information is always better than less.
- A leaner, more automated organisation will be a better one.
- People already know how to communicate and to manage and the SMC technology only needs to enhance these processes.

For the SMC Model, it is very important to consider carefully the above assumptions during all phases of technology deployment. If these assumptions, especially those being in a strong mutual contrast, fail to be addressed, it is almost certain that subtle patterns of behaviour will occur, that can be detrimental to the implementation process and the deployment of the respective information/automation system to be introduced.

2.3 Interaction Spheres

The term "interaction sphere" was coined to address the usually neglected necessity of aligning the socio-technical consent among the employees on the assumption layer. Namely, the assumption layer is the filter that strongly influences the alignment on the content level. Interaction spheres are those elements of the SMC Model that provide the space for this alignment to occur. There are many possibilities for how this alignment process can be managed. So far, it has been proven successful to begin with one or several workshops where at least two of the subcultures are present. The major aim of those workshops is to bring the underlying fears and concerns of the people, as well as their goals on the surface and to create a common vision, where the different subculture's goals and assumptions can be aligned. What is important here is to assure that each subculture's fears and concerns are taken seriously and are discussed without bias. It is crucial for each subculture to realise that the other subcultures have a unique capability of contribution to the common goals, as they can provide genuine know-how to which the others would not have access otherwise. Activities in these interaction spheres not only allow for successful introduction of information/automation systems, but also can serve as the start of organisational learning, with positive effects also on other areas of the organisation.

3. TECHNOLOGY MANAGEMENT IN ARMENIA

Implementation of any technology, particularly the advanced one, in the concerned former Soviet Union country Armenia is strongly characterised by specific circumstances of production management there. The key factor is a considerable lag in the state of development when compared, e.g. to the countries of the European Union. One of the main reasons for this is the lag of technology development in these countries. In general, the indicators measuring the state of technology development in the post-

socialistic countries point to a major lag of ten to forty years. Obviously the societies in these countries were not able to face the coming changes.

The general lag in the former Soviet Union countries is accompanied by a lack of progressive scientific discovery. Unfortunately, the expectations from the science to shed light onto the desired directions of societal development were not satisfied. The consequences of such ignorant behaviour in the presence of changes are evident and dramatic. The main characterisation of the current economic situation in Armenia is pretty similar to that of some other post-socialist countries and can be described as follows.

- The country is working its way through the processes of economic transition and privatisation of "public" property.
- A considerable number of firms have begun with the introduction of new technologies, but these activities were slowed down pretty much because the management was (and partly still is) occupied with the process of privatisation.
- The greatest industrial firms that have previously formed the backbone of national economy fell apart or were disintegrated. Those rare remaining is currently in the process of major restructuring and change of ownership.

In spite of these difficulties, the economy in Armenia, similarly as in all former Soviet Union countries, is facing a great need for opening towards the world. Such opening is considered as the crucial factor, first for surviving and then for normal development. However, it is clear to many that real progress in the favourable direction will not be possible without throwing away many outdated illusions and boldly confronting the new realities. Among these new realities, the introduction of new technologies like automation, control and information technology presents a particular challenge for Armenia.

4. SOME RESULTS AND EXPERIENCE

The problems and projects dealt with during the introduction of the SMC Model and methodology in Armenia included many relevant results in terms of various business aspects and of great importance for different organisations. Two issues worth to be discussed here are: the SMC technique standard and the SMC human-machine interface.

4.1 Sliding-mode control technique standard

Prof. V. Mkrttchian in 1990 originally introduced the Sliding Mode Control Technique Standard Protocol (SMCTSP). This protocol was developed for providing a standard equipment communication protocol for power-transistor equipment companies in former Soviet Union countries (Mkrttchian, 2001a). It becomes the widely accepted standard for equipment communications in the Power Transistor Industry. The SMCTSP–compliant capability is nowadays the default requirement for power transistor equipment. The SMCTSP defines the transfer of messages between a host and the equipment and covers functions such as control, data collection, process monitoring, and error detection.

The basic three components constituting the SMCTSP application for power transistor equipment are the following:

1) communication medium (with individual components COM port or TCP/IP network),
2) data link protocol (with SMCTS-I or High-Speed SMCTS Message Services), and
3) formatted messages (with SMCTS-II).

The SMCTS-I component is defined for application based on a simple point-to-point topology. For applications over networks when the SMCTS-I is neither sufficient for communications nor is it applicable for the environment with simple point-to-point topology, the third component SMCTS-II is used. The SMCTS-II component defines a set of more complex message formats designed for control of power transistor equipment. A SMCTS message includes both, a) a simple SMCTS header used in general maintaining proper end-to-end communications and b) a SMCTS-II formatted message, to be encoded by the sending user (host or equipment application) and interpreted/decoded by the receiving end user. A complete message transaction consists of a request message and possibly a reply message. There are more than 150 possible transactions defined in the SMCTSP covering various equipment, alarm and error management, etc.

4.2 Sliding-mode control human-machine interface

A prototype system using a pacing mental task was developed based on the above concept, in order to test the sliding-mode human-machine interface. Pacing stress is said to be a kind of stress that elicits physiological and psychological changes (Mkrttchian, 2001b). However, the results of many studies on pacing stress are not unanimous. Some researchers reported that paced industrial workers were less satisfied with their jobs. On the other hand, the other researchers found that satisfaction was highest for the workers having mostly automated jobs in the sanitary products factory. The satisfaction was moderate for the manual workers without automation and lowest for the workers with semi-automated jobs. Some researchers found that repetitive jobs of a motorcar manufacturing plant showed lower worker satisfaction than non-repetitive ones. There was no difference in job satisfaction between those who were paced by an assembly line and those who were not.

The algorithm was experimentally developed, based on the following rules:

- When there is no satisfaction change, the interval remains constant.
- The interval changes when the satisfaction level changes.

- The amount by which the interval changes at one time is constant.
- To initially set off the algorithm, when the subject first registers dissatisfaction during the mental task, the interval is shortened.
- When the interval is changed to become zero, the previous (non-zero) interval is maintained.

5. CONCLUSION

This paper claims that successful implementation of SMC technology is only partly a function of the technology and its alignment with business strategy and with organisational structure. The other part that is often neglected or only superficially addressed is that successful implementation of advanced technology is also a function of the organisational culture into which the information system is introduced. This is the reason why the existing approaches and frameworks are only partially applicable in developing countries.

In summary, the cultural-specific and business-driven SMC technology introduction model is proposed for helping managers in different organisations in Armenia to master the changes brought about by this and similar advanced technologies. It is considered that at least some concepts and issues from this model can be used also in other transitional societies.

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