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Technological Development and the Human System

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Abstract: The reasons for flaws of technological development at present are pointed out. Examples from complex projects like in telecommunication, transportation, or Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) are giving insight. The change of actors of the past intensifies tremendously the difficulties given by globalization and complexity of new systems for developing applicable human solutions. New technology in fields like medicine demands new requirements and paradigms. Stable human solutions are a prerequisite for economy and efficiency. This demands a holistic approach, which considers also history, psychology as well as organizational aspects itself together with educational and creativity environment. Goal systems, adequate decision-making, importance of experience gained in the field of complex software development, and the limits of metrics or strong preference for mathematical solutions are pointed out.

1. INTRODUCTION

Technology has reduced the weakness and limitations of human being. Development of organizations and formalism like mathematical notations has the same purpose. These prerequisites are important for developing stable human systems. But it is obvious that technology transfer itself depends on such support for getting suitable solutions.

Following example is one among many others for not suitable technology transfer as it can be recognized at present. In the past the user could use a telephone network with almost the same telephone handling, whether the person would be in Africa, Asia, Europe, U.S.A. or somewhere. The classical receiver was designed according the results of ergonomic studies at this time (Oden, 1968). Even the industry admits that to day you need learning effort for using a mobile phone, which is not your own utensil already accustomed. The ergonomic aspect is wretched in comparison to the classical telephone, which fitted also for most of the senior citizens. Usable stable solutions seem not important anymore. Fast technology changes do not take in consideration the impact of fast change of interfaces particularly for human being. Novelty neglects in many cases experience and does not mean creativity.

Just the enforced globalization requires harmonized approaches with minimizing the steady learning effort for the user and operator in order to have a system dependable, economical and effective in the long run.

The entering of electronics and software in safety related systems had not only strong impact on the organizational approach but stimulated also new methods for dealing with such complex tasks (Genser, 2005).

New technology in fields like medicine causes a change of paradigm and new view on risk and responsibility.

Technology does not only change products as it was given in the past. It is moved from a human system to a technological one. The automotive industry had to learn that it has to be taken in account not only the product “car” rather the system “telematics” or intelligent highway system.

2. TECHNOLOGY TRANSFER TO APPLICATION

We use complex systems like air transportation or even the classical telephone network for example more or less with satisfaction. The seat reservation system for airplanes can be used all over the world since many years. But even now the European Railway Seat Reservation System has not reached such quality. What are the reasons that some systems are according the state of art as well as human oriented and other developments are not adequate?

Comparative cases will demonstrate causes of such different success for new technology in application.

2.1 Military and similar Systems

The military systems were the main actors to bring new technology to application in real life, which could be used then also successfully in the civil sector (Richardson, 2002). This can be recognized in the fields of medicine, telecommunication, transportation, computers, Internet, and even kitchen equipment for example.

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It is a prerequisite for military to be according the state of art. They have not only strong interest to catch new ideas rather they have the financial resources for developing new solutions. But most important is that the military system comprises the stating of requirements by feedback of real environment of application and forms also the market for economical success in the sense of industry. The power of enforcing requirements has supported that industry uses such harmonized standards also in the civil area on global level.

The high quality of civil aviation is not only a result of the developments work done by military system. The US Federal Aviation Administration (FAA), together with ICAO (International Civil Aviation Organization), has the power for enforcing global harmonization and quality of civil air transportation for the advantage of society.

Organizations with similarities to military structure, like railways or public utility companies as it was given for the EDF (Electricité de France), had also stimulated suitable technological transfer. They have had interest for technical solution of problems and covered the stating of requirements from real application with providing a market for industry. Such organizations differ especially by the strong feedback of real application among other aspects from not very effective planned economies.

Solutions for complex problems in real life demand strong actors, which can ensure a stable framework and trust in decisions. The realization of EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport) is a result of such preconditions.

Human oriented solutions need the cooperation of researchers, operators, users, industry and authorities.

2.2 Market driven Systems

Telematics for road transportation, but also the confusion for the customer in the field of digital storage of video signals, are examples of unsuitable approach. If no actor is streamlining the industries in competition then industries have the prisoner problem of game theory (Lloyd, 1995) and the real optimum is failed. The "market" cannot reach optimal solutions if the time-delay of feedback for consequences takes longer than the open range given for change. Groups for consumer protection are accustomed to criticize products on the market. But even if they would state the requirements for future developments they do not have the power in general to enforce them without political support. If very strong interest of individuals with expertise and possibilities for application in real world are given as well as the political environment is prepared for such solution then a bottom-up approach may be successfully. Solar heating for households started under such conditions in Austria for example.

The implementation of telematics for road transportation is hampered because of many strong actors in diverse systems like automotive industry, freight forwarding, highway authorities etc. In the past the background of experts in road transport had been mechanical and construction engineering with knowledge for products but no one on electronics and telecommunication. Experience on systems engineering was not given. The automotive industry stuck to a bottom-up approach. The Commission of the European Communities installed by the influence of French representatives DRIVE (Community programme in the field of road transport informatics and telecommunications) in addition as top-down. The OECD (Organization for Economic Cooperation and Development) installed ERTICO (European cooperation for development of Intelligent Transport Systems and Services) besides DRIVE.

But Japan was more successful with the transfer of new technology to application than Europe. This is caused by the culture given, which accepts new technological development easier and encourages cooperation. Practice oriented educational and training systems together with strong interest for information gathering are the substratum.

2.3 EDIFACT

EDIFACT reveals that a very complex project comprising different fields on a global level can be carried out very successfully. The basis for digital signature and XML (Extensible Makeup Language) etc. would not be given world wide without EDIFACT.

Inside EC (European Communities) and EFTA (European Free Trade Association) customs documents have been transferred to electronic processing, encouraged by the French government. SAD (Single Administration Document) was enforced as a bootstrap for switching to electronic data processing. Many groups like automotive or chemical industry, air transportation, railways, governments etc., developed standards for electronic data exchange for their own area. The disadvantages of such not coordinated approach without bearing in mind the global aspect and influences of other fields with very long historical tradition like trading were obviously.

The Working Party 4 on Trade Facilitation at the UN/ECE (United Nations Economical Commission in Europe) has taken over the task to harmonize the electronic data interchange for administration, commerce and transport (EDIFACT). The scope covered also the electronic data interchange of construction industry, insurances, hospitals etc. (DIN, 1994). The interest of France and the United States of America has given UN/ECE/ WP4 the backing that besides the governmental representatives all influential and international organizations like International Civil Aviation Organization, International Maritime Organization, International Union for Road Transport, International Railway Union, International Chamber of Commerce, International Telecommunication Union, International Association for data Exchange etc. have taken part. Pan European Groups like CEFIC (chemical industry), EAN (European Article Numbering), ODETTE (automotive industry), SWIFT (banking sector) etc. have been included in the development structure for EDIFACT on European level.

The PRO-organizations acted on a national level all over the world. The Commission of European Communities (CEC) started TEDIS (Trade Electronic Data Interchange System) with a matrix structure covering all fields and actors afflicted, see Fig. 1.

Extensive investigation of legal area and of business processes has been cared out. The requirements of areas afflicted could be received by the broad and effective organizational structure. But much effort was mobilized for feed-forward for improving awareness and acceptance. Governmental representatives of highest level committed themselves for achieving success.

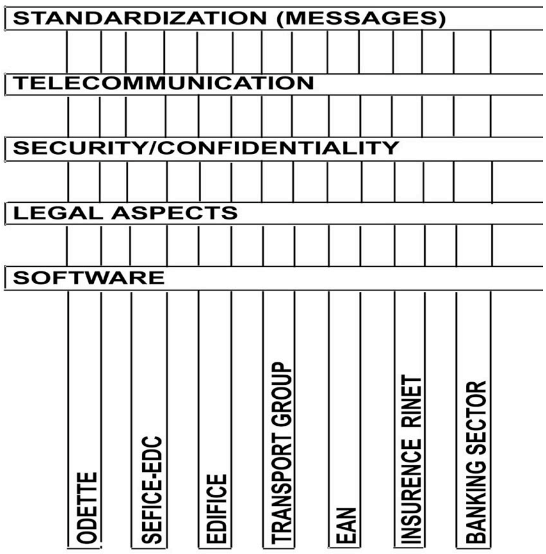

Fig. 1. Organizational structure of TEDIS (Trade Electronic Data Interchange System)

The technological solution had to consider the different state of arts for electronic data processing in the world. But XML as a technological better solution got now the basis for broad use.

The framework for using digital signature was achieved.

At present a similar approach is desired again for the INTERNET (Cerf, 2004).

2.4 Some European Projects

An important feature of the era of the Commissioner Carpentier at CEC was the recognition that industry and research have to collaborate together with operator, user and authorities.

Prof. Theodore J. Williams from the Purdue University in West Lafayette, USA, founded the Purdue Workshop on Industrial Computer Systems 1967 bringing together experts from different fields for getting feedback of applications and for smooth implementation in the future by developing feed-forward.

The lack of trans-European organizations for dealing with development of digital computers and microelectronics in different application areas in a coordinated and effective manner induced the Commission of the European Communities to found Purdue Workshop Europe 1974. The U.S.A. had organizations like IEEE (The Institute of Electrical and Electronic Engineers). But at this time even on national level in Europe, no cooperation among standardization bodies dedicated to electronics on one side and computers as well as software on the other was existing. In many application areas, like railways, no concern was given for solutions of similar problems in other fields.

The full support by the CEC for using an organization, which enabled the selection of experts by snowball system and by stimulation to be active at participation, facilitated the emergence of European solutions in many areas of technology. For example, the international standard IEC 61508 on Functional Safety is based on such activities. Experts from EC and EFTA countries but also from Hungary and Poland have taken part. It was the first time, representatives from different railways (like British Rail, German Federal Railways, Swiss Federal Railways, Swedish Rail etc.) worked together with different industries, EDF, research institutes for nuclear power, authorities etc. to explore the use of microelectronics in safety related systems.

The shut down of support by CEC happened under the era of commissioner Bangemann. At this time the ideology evolved, the market will solve the problems. Even the German standardization body DIN had to obey the decision to develop standards only if it is paid by the industry. Legislation, regulations, and standards prevent chaos and ensure an efficient society and economics. The market force can be a measure to reduce some problems, but this approach is only suitable for subsystems.

The Programs of the European Union have been created. Only industry and research becomes significance.

But big industry is not interested to sell state-of-the-art solutions as long as customers will buy products from the old production line. Even if customers demand advanced solutions, it may be difficult to get them. The industry is much engaged in EU projects. But grandiose solutions can scarcely be seen on the market in Europe.

The European cooperation in the field of science and technical research (COST) finished successfully the research into technical and economic conditions for the use of electric road vehicles (COST action 302) 1985. Almost all European automotive companies had been involved. But the hybrid car was realized in Japan and sold in the U.S.A.

High definition television was presented as a European development already 1987. It is superfluous to mention, already for some years consumer can enjoy it in Japan and America, but the public German television stations decided to start in the year 2010.

3. HUMAN BEHAVIOR

Automation and electronic data processing revealed quite early in the phase of introduction, people dislike things, which they do not know. Processes accustomed are preferred against changes. This is not only because of learning effort needed rather because of unknown and also exaggerated risks of new solutions in comparison to a given situation already accustomed.

Restrained perception and psychological deception besides disinformation and asymmetric information causes wrong decisions.

Trust is not rational. It depends on human character and environment.

Selfishness and the fear of losing power hinder to get improvements.

Human beings neglect long-range objectives and even rationality. The drunken driver as example is the evidence.

To know does not mean that something is conscious.

In many areas others than railways or aviation for example only knowledge was taken in account and the importance of skill was not recognized. Fig. 2 tries to illustrate what happens if a person, or even a system, without skill translates a plan into reality. Mathematics taught without exercises or to learn driving a car only by theory will result an incorrect performance of the task. The Bay Area Rapid Transit System in San Francisco is an example what can go wrong by missing experience (Unger, 1973).

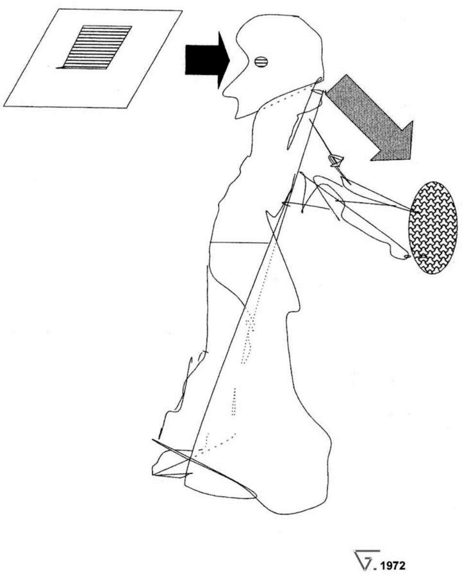

Fig. 2 Influence of SKILL

The quality of performance of systems with human being can be ensured only if the psychological aspects are considered and consequences are applied in an adequate manner.

4. HUMAN-ORIENTED APPROACH

The technology transfer in complex systems demands the **consideration of history** if human oriented solutions are thought for.

Some organizational solutions seem suitable in theory or are preferred by ideology. But in practice, the human peculiarities in the long run have to be borne in mind.

An organization is only effective if **responsibilities** are transparent and **consequences** are according to the human nature. Flaws disclosed by audit offices are not cured if responsibilities are hidden and consequences are not given by political situation. Prosecution of violation in road traffic shows that behaviour of drivers can be improved effectively in taking in account human learning feature.

A **strong actor** is a precondition for developments with diverse stakeholders. Complex systems on global level necessitate top-down together with bottom-up approach. A t**rustable framework** should be given with giving a chance for producers for return of investment.

Research, operator, user, authority, and production have to be involved in active participation from the very beginning for receiving **feedback**, evolving **feed-forward** and improving acceptance as well as trust. Prototypes and pilot projects have to be used for improving decision basis in case of complex problems. Information systems, nano-technology, gen-technology etc. have drawn the interest on trust aspects (Beyond the Horizon, 2006; Misztal, 1998). The Japanese are very active to bring the population in contact with new technology in an early stage. Japan Rail not only invites seniors to ride on the first part of the Magnetic Levitation Line for Tokyo to Osaka, 2003 a country wide prize competition was running for this opportunity.

Besides the problem of judgment by experts (Stringini, 2002), the general educational and training systems given may cause unfit solutions. Research is undertaken on technology creation and knowledge-integration in a holistic way, see for example (Nakamori, 2000).

Human-oriented development is considering human limitations. Uncertainty and fuzziness of information require adequate procedures like

- **Multi-step decision-making process** (from rough model to context oriented model, object oriented approach etc.) with **human-oriented presentation** (standardized abstract and formal methods for reducing amount of information, visualisation by graphs and pictures etc.)

- **Liberty for adaptability** (robust solutions, modifiable plans, limited obligations, bearing in mind possible occurrences like war etc.)

- **Evolutionary optimization** (<u>cooperative competition</u> with meaning to reach the goals by strict rules for competitors, genetic methods etc.).

Risk cannot be reduced fully. The discussion on acceptance of risk is not finished. New aspects are taken in consideration being due to new technology-based safety related systems in medical area (EWICS, 2007).

Risk-based management is applied in plants with hazardous materials, railways etc. A high degree of modelling is used. Extension of new technology to safety related applications in medicine, embedded systems etc. demanded improvements of methods and paradigm.

Precaution-based management considers high uncertainty as it is given by green biotechnology. Also the railways had in the beginning severe restrictions. The precaution-phase is not only for learning and getting skill for using new technology rather for adapting social and legal systems if stability and human solutions are strived for.

Discourse-based management is applied if the risk is seen very controversial. Transparency, participation and two-way communication are a precondition for reasonable results.

Systems engineering and **holistic approach** has to be applied in general. The Austrian General Conception of Transportation shows such approach as example (Genser, 1991; Genser, 1987). But because of change of main actor the results have not been realized in Austria.

4.1 Goals and Decision-Making

Not considering goal systems of reality entails inadequate solutions. Influenced by strive for mathematical solutions, the dynamic of goals (Genser, 2004) is neglected in general. Multi-objectives are pressed in a single criteria function instead of dealing with different categories of objectives using graphical methods, pattern recognition or approaches as pointed out by (Makowski, and Wierzbicki, 2003; Wierzbicki, and Makowski, 2000). A bouquet of solutions is preferred instead of a single one for dealing with complex problems of real live.

"Organic computing" (Schmeck, 2006) uses architecture of self-organization for adaptive control. Constructions and electrical engineering tackle uncertainty with safety-factors. Anti-optimization (Elishakoff, 1999) tries to tackle problems in earthquake areas.

Important goals for stability and human-oriented solutions may be neglected if inadequate metrics are used. Exclusive use of the metric "Money" can cause not suitable solutions.

To take in mind only a short time range in case of long living systems may create wrong decisions. Especially infrastructure, public utility etc. demands long range (100 years and more) and holistic considerations. At present economical aspects are overrated by preferring medium range objectives. Stability of societies may be endangered. Outsourcing is economically driven mainly. But for long living systems, the loss of skill and strategic aspects may cause many disadvantages and even economical loss in the long run.

The implementation of technology for missions in military systems has to be distinguished from the use in common long living systems. The time span of utilization is longer in civil area giving possibilities for self-organization as well as drastic measures are limited.

The experience by history should be not neglected. The topic "security" reveals wrong approaches and hyper activities if experience is not taken in account (Genser, 2006).

A strive for the extreme prevents Pareto optimum, equilibrium as well as smooth adaptation according change of conditions or environment.

Usually such targets are stated what should be strived for. But objectives for measures, which support achieving targets in spite of human shortcomings, have the same importance (Genser, 1991).

Parameters are transformed to single numbers because of relaying on mathematics. In reality it has to be dealt with classes. The voltage in electric power supply is a class and not a deterministic value. For example 230 V is the nominated effective value of alternative current, which comprises harmonics, flickers, and tolerances according the supply contract. The calculation

10x "230" = 2300

is may be wrong.

Fuzzy sets are used these days for dealing with fuzzy information. Fix probability distributions are assumed in the intervals of possibilities. But problems of real world are not solved by such fuzzy sets (Genser, 2000). Context based decision processes, pattern processing, ALARP (as low as reasonable practicable) or best and worst case etc. are applied.

5. CONCLUSIONS

Also in complex situations the transfer of state-of-art technology for creating human-oriented systems is possible with proper organizations if historical experience is not neglected, human attributes are taken in account, tools and knowledge available together with systems engineering and a holistic point of view are applied.

Trust makes decisions more rational. Participation, the use of feedback from real life, learning by pilot projects and stability of conditions and requirements foster trust and enable therefore economical success in the long run.

EDIFACT has shown that a global harmonized and human oriented solution can be achieved also without a military system.

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