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# **Use of Advanced Technologies and Information Solutions for North Sea Offshore Assets: Ambitious Changes and Socio-Technical Dimensions**

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## **ABSTRACT**

*The use of various forms of advanced technologies and information solutions are in common place to manage industrial assets today. This is widely seen as the way forward in various industrial sectors owing to range of commercial benefits offered by new technologies and its importance to gain competitive advantage. The objective of this paper is to describe such an ongoing major technology-dependent re-engineering process termed Integrated eOperations in oil and gas exploration and production business in North Sea since 2004-2005, and to highlight the nature of ambitious techno-managerial changes and its critical socio-technical dimensions. The change process focuses on a new development path based on 24/7 online real-time operations, with direct implications on organizational forms and managerial tasks. Given the nature and the scale of ongoing change processes, there are emerging concerns that increasing complexities, ill-defined interfaces can easily lead to serious vulnerabilities and major risks. To avoid such undesirable circumstances that will surely have long-term commercial repercussions, a holistic socio-technical consideration and early measures to ensure fully-functional and fail-safe system are absolutely necessary.*

## **INTRODUCTION**

Industrial assets today undergo major changes both in engineering and management terms. The formal practice that has been dependent heavily on in-house knowledge sources and expert groups, is largely being challenged today demanding more flexible and open strategies to support global business operations. Business-to-Business (B2B) partnerships appear to be growing and the web-based networking solutions seem to be actively contributing to implement new business solutions introducing a new landscape for transactions between commercially important stakeholders (see for instance Faulkner & Rond, 2000, Tidd, 2000, During, Oakey, et.al., 2004, Hosni & Khalil, 2004). This seems to be a generic trend among almost all the commercial business sectors where the business dependence on large-scale ICT solutions is rapidly growing.

The global production, manufacturing, and process industries cannot afford to divert their operational strategies away from the mainstream techno-managerial change. They have to adapt appropriate forms of smart and integrated solutions to manage their assets to reduce underlying commercial risks. Often, advanced technologies and robust data management techniques are at the heart of such innovative solutions, and they are commonly seen coupled with the rapid development in information and communication technologies (ICT).

The growth of implementation of advanced ICT solutions seems to have been very pivotal to generate new opportunities particularly to manage complex and high-risk assets for instance in such industrial sectors as oil & gas (O&G) exploration and production (E&P). Such ICT solutions may vary from more centralized LANs (local area networks), primarily localized within given corporate organizational limits, to large scale WAN (wide area network) solutions that open up transaction routes for complex B2B data traffic. The specific need for such robust integrated solutions for O&G industry in North Sea have largely been growing over the last 2-3 years, demanding more common platforms for instance to manage complex E&P data (Liyanage & Langeland, 2006). The implication of these ongoing ICT-driven change processes is far beyond being pure technical, for instance with direct ramifications at human and organizational levels. This occurs owing to the fact that rapid expansion of limits of

conventional organizations towards partnership-based collaborative network of organizations induces a new socio-technical environment with inherent characteristics and complexities (also see discussion by von Glinov & Mohrman, 1990; Mankin, Cohen, et al., 1996). Proper understandings of this socio-technical dimensions are critical for the North Sea E&P industry to avoid vulnerabilities and risks of ongoing techno-managerial change processes associated with rapid implementation and use of common ICT platforms and advanced application technologies.

### **NORTH SEA OIL PRODUCTION ENVIRONMENT: A GLOBAL TREND SETTER OF DIGITAL CAPABILITY**

Oil and gas (O&G) exploration and production (E&P) activities in North Sea have been undergoing a major reengineering process since 2003 (OLF, 2003). The change process has been stimulated and directly supported by some key socio-political and socio-economical sources. The commercial reasoning behind this large-scale change process by far is two-fold;

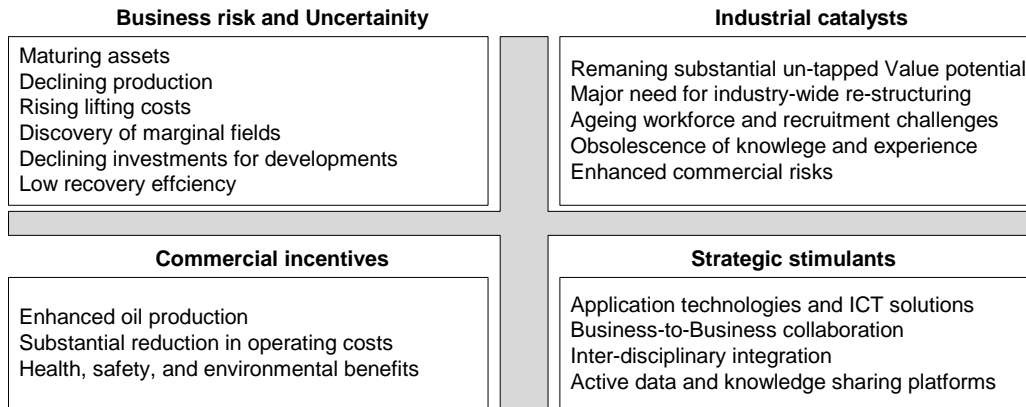
- Major players of North Sea O&G business have acknowledged that the risk exposure of the industry has become obvious owing to maturing assets, declining production, rising lifting costs, discovery of marginal fields, etc.

- Key commercial stakeholders in Norway have identified that the remaining value creating potential on the Norwegian Continental Shelf (NCS) is substantial, and that smart techniques and technologies should be implemented to address critical challenges to sustain production.

Apart from the pure commercial aspects, the industry has also been exposed to various other circumstances over a certain period of time. For instance, ageing workforce and recruitment challenges have been quite common across the industry with no immediate solutions to overcome the subsequent problems. On the other hand, there have been some major interests to challenge the conventional practice by encouraging ICT enabled industry-wide integration and advanced technological applications. Despite that the risk-and-uncertainly profile on NCS was very obvious; there had been other principal factors that implicitly or explicitly contributed to the nature and scale of technology-driven change.

A review of industrial circumstances in fact revealed that there has been a range of complex issues that induced a compounded contribution to the current pace of developments on NCS. They constantly compelled to bring strategic step-changes to offshore E&P environment through advanced application technologies and ICT solutions. Those range of issues can mainly be divided into four principal clusters of influence namely; *Business risk and uncertainty* (i.e., those that mainly relate to financial exposure and economical well-being), *Industrial catalysts* (i.e., those that have added an additional momentum to the need for change), *Commercial incentives* (i.e., those benefits that can be expected as a consequence of re-engineering), and *Strategic stimulants* (i.e., those that have caused some influence as a part of continuous industrial development). Figure 1 illustrates some of the identified contributing factors under each cluster of influence.

**Figure 1. Clusters of major influence towards offshore-onshore business process re-engineering of E&P activities through application technologies and ICT solutions on Norwegian Continental Shelf.**

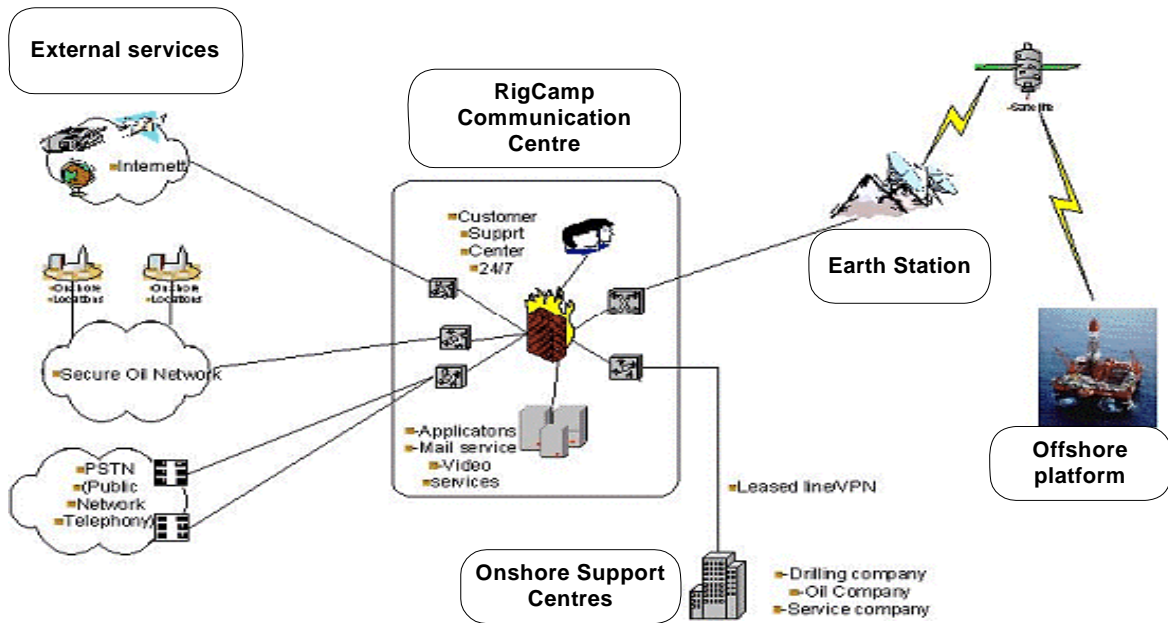


Subsequently, E&P business in Norway stepped into a new development scenario termed *Integrated eOperations* (IO) since 2003. The major focus is on gaining substantial commercial advantage through smarter solutions to manage complexities and uncertainties of offshore E&P activities. This new development scenario (IO) was first introduced as the ‘3<sup>rd</sup> efficiency leap’ for the *Norwegian Continental Shelf* (NCS). This was further envisioned by the *Norwegian Parliament* through the report no.38 (2003-2004). Ever since, this has become a program with national interests drawing NOK billions of investments from various sources. This was readily accepted by major part of the industry as the means to acquire necessary digital capabilities through application technologies and new organizational forms. This today is seen gradually growing towards various corners of day-to-day practice, for instance ranging from active use of collaborative technologies to joint planning of offshore drilling activities, completely re-engineering the conventional E&P practices in North Sea and also the industry infrastructure (for more information see Liyanage 2004, 2005a, 2005b, 2006). This is a trend-setter for global E&P activities and has already become an icon towards the establishment of *smart assets of the future*.

## APPLICATION TECHNOLOGIES AND INFORMATION SOLUTIONS FOR SMART ASSETS

The new integrated asset management scenario (IO), as aforementioned, pays principal emphasis on the techno-managerial change. It implies that the change is largely technology dependent, and that technology-enhanced change also substantiates rapid changes in organizational forms and the managerial practice. For instance, IO blends digital technologies and infrastructures with active operational networks and B2B collaborative partnerships. The industry infrastructure is reformed in such a way that it establishes tightly integrated online and real-time collaborative partnerships with the other sectors of the industry (e.g., engineering contractors, expert service providers, etc.) using large-scale common IT platforms. The connectivity and interactivity is achieved by far through systematic integration of third party business partners through a dedicated ICT infrastructure termed SOIL (*Secure Oil Information Link*) (see Liyanage, Herbert, et al., 2006). Figure 2 gives an abstract schematic diagram of this information and communication infrastructure.

Figure 2. SOIL technology based digital infrastructure for North Sea assets.



SOIL in principal is an ICT-based active data exchange and communication network. It was introduced to Norwegian E&P industry in 1998 due to growing demands for integrated data management capabilities and B2B communication solutions. SOIL applications today are widely used along the entire E&P value chain, i.e. from reservoir management to O&G distribution, actively connecting almost all the business sectors of the Norwegian O&G industry. This digital network between offshore facilities, major producers, and third-party organizations facilitates the connectivity through the use of fiber-optic cables, radio links, and satellite communications.

SOIL enables the establishment and growth of highly reliable information and knowledge sharing networks to remotely manage offshore assets regardless of the geographical location. Today, SOIL is expanded to the UK sector resulting a rapid growth of membership status to almost 170+ active organizations. These memberships include almost the entire cross-section of the industry for instance, O&G producers, drilling service providers, service contractors, engineering companies, equipment manufacturers, expert centres, etc. This rapid growth of SOIL is attributable to the offer of a new set of innovative application services for North Sea assets and has today allowed more coordinated E&P activities between UK and Norwegian shelves.

The active nodes of the SOIL-based digital infrastructure are termed *Onshore Support Centres*. These centres provide expert assistance 24/7 online and real-time basis. To enable such onshore-based support to offshore facilities, they are equipped with tabletop collaborative workstations, back-projected large VDUs, technologies for remote operation of for instance down-hole drilling tools, video-conferencing facilities, CCTV and other advanced technological capabilities for joint decision-making (e.g., VisiWear, Smart boards), supportive advanced technology to produce 3D images and to run simulations, etc.

The implementation of SOIL and Onshore Centres has provided the structural skeleton for implementation of supportive technologies and information solutions. At the current pace of development it seems that the width and the breadth of technology applications grow systematically. Principal technological advancements are visible in the use of, for instance:

- Fiber-optic based ICT-net and wireless communication capability

- Real-time visualization, 3D visualization, and simulation tools
- Smart sensors, intelligent transducers, and equipment with advanced functionalities
- Online diagnostic and prognostic engineering capability
- Process automation and real-time data acquisition techniques
- Online video monitoring and conferencing facilities, etc.

In general the trends of exploitation of technologies and ICT solutions in North Sea E&P environment today can be divided into three specific classes;

- large scale ICT net work-based digital infrastructures
- well equipped onshore centers and built-in collaborative technologies
- advanced process and safety technologies implemented in offshore assets.

The active use of this large-scale technological platform allows the acquisition of some core capabilities, for instance integration of geographically dispersed competencies, 24/7 connectivity, data-expertise integrity, easy access to distant knowledge, real-time information sharing, online communication networks, etc. This has 30-40 years of effects in terms of risk exposure and commercial benefits for major players on NCS.

However, the current operational setting and functional characteristics are still not fully fail-safe assured nor perfect in all senses. It obviously has brought a number of issues to be seriously considered further, for instance new forms of partnerships for cooperation, shared responsibilities and roles, contract redesign, risk-gain sharing schemas, security and reliability of infrastructures, etc., that are important to ensure fully-functional fail-safe activities. The biggest concern therefore is that the accelerated change triggered by the marvel of the technology and the success of technology implementation efforts may easily undermine the hidden problems, where ill-defined interfaces and increasing complexities of systems and data solutions can lead to unforeseen consequences, greater vulnerability, and greater risk (see explanations in von Glinow & Mohrman, 1990, Cox & Tait, 1998, Perrow, 1999, Duffey & Saull, 2003).

## **RAPID CHANGE AND CRITICAL SOCIO-TECHNICAL DIMENSIONS**

As highlighted above, digital networks, real-time online data exchange platforms, large-scale web-enabled information systems, equipment with electronic gadgets and advanced functionalities, diagnostic and prognostic techniques, sensor technologies, etc. seem to be the defining features of the new generation asset management practice in E&P industry. Certainly this has resulted in new operating organizational forms that are highly technology and information dependent (also see Mankin, Cohen, et al., 1996).

Ongoing developments on NCS target substantial advancement in production assurance beyond the year 2050 or so. The dedicated and reliable network of discipline experts and organizations, ICT enabled B2B transactions, active and dynamic sharing of process data and industry knowledge, online real-time communication capabilities, etc. are mainly dedicated to pave the path by 2015 to achieve the principal objective. Current digital infrastructure and other application technologies have already indicated clearly that E&P business on NCS systematically steps into new operational setting with highly inter-dependent virtual *Operational network environment* and *Collaborative partnerships* (also see Lipnack & Stamps, 1997, Tonchia & Tramontano, 2004). This by far takes a form of, what can be termed, an *Extended enterprise* that depends heavily on well-defined information and knowledge bases to retain necessary levels of integrity and a reliable infrastructure to allow information and communication traffic.

The industry-push and the technological-pull will continue to directly influence rapid developments seeking immediate commercial benefits without too much of risk exposure for all the stakeholders involved. Despite formal plans to achieve fully-integrated operational status by 2015, technology pull, organizational dedications, industry-wide commitments, and rapid introduction of series of programs, together with high oil price and favorable market conditions, have put the entire industry on a fast track to achieve excellence and world-class status in a much shorter time period. This seems to have triggered, what can be termed, an *accelerated change status*. Such an accelerated change occurs when there are:

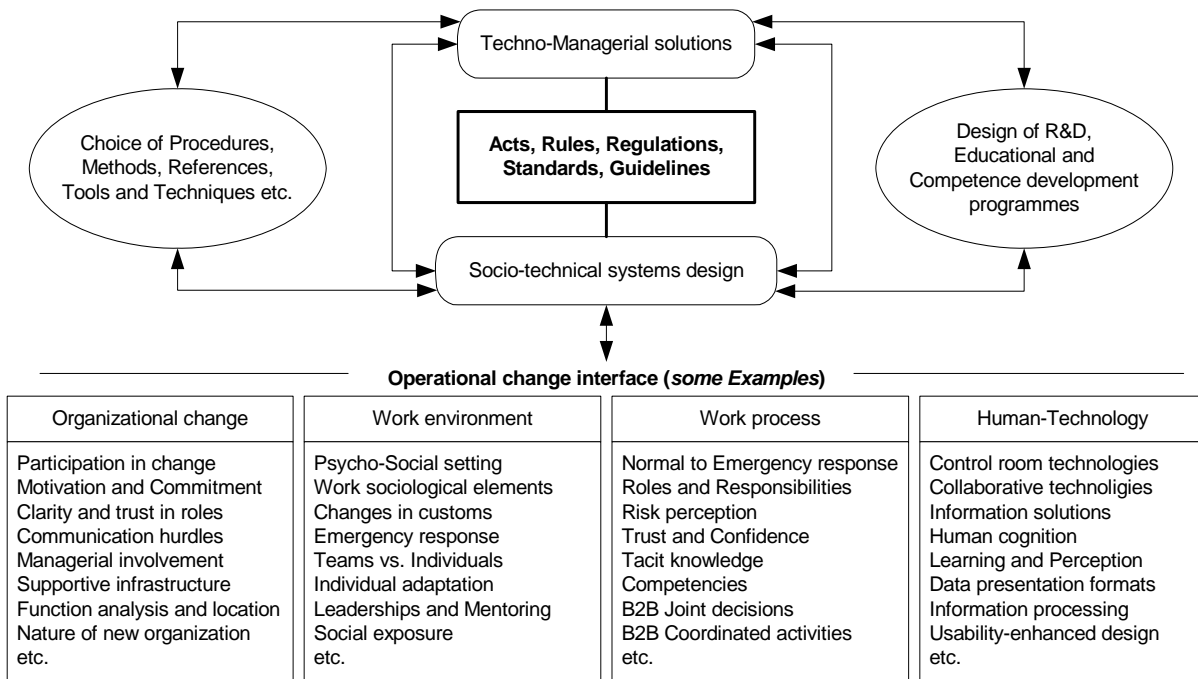
- high ambitions in terms of direct commercial benefits
- aggressive technology implementation efforts to stay ahead of competition
- shorter time-frames to implement highly ambitious plans
- accelerated programs to achieve the 'industry leadership' status, etc.

The biggest concern under these accelerated circumstances is that it can easily lead to complex and ill-defined socio-technical interfaces. If such conditions are subconsciously introduced, then unforeseen consequences, greater vulnerability, and greater risk are inevitable and the consequences can be too costly to bear. It implies that complex interfaces of the emerging socio-technical system need serious considerations to avoid commercially hazardous incidents with heavy losses. The industry has to recall some unpleasant historical experiences, for instance as discussed in Health and Safety Executive (1997), Perrow (1999), Duffey & Saull (2003), etc., and adapt a learning strategy to take necessary precautions to avoid any forms of repetitions of such failures and losses.

The rate of growth of technological applications, in most cases, is relatively far ahead in comparison to how quickly organizations can absorb such change and how safely people can adapt. The underlying issue here is that the current development trends, which has substantial faith on pure technological solutions, can easily over calculate human and organizational capacities and limitations. In fact in most cases human and organizational aspects are seen largely deviated from main-stream change and thus the pace of development of sub disciplines take place at different rates and scales. Since this setting can directly contribute to various levels and forms of complexities within an integrated environment, the E&P industry has begun to look relatively more seriously on a development path that will contribute to establish a more harmonized socio-technical setting. Authorities (e.g., Norwegian Petroleum Safety Authority) and political sources (e.g. Norwegian Oil Industry Association, Trade Unions, etc.) are very keen on this subject matter particularly owing to its sensitivity in occupational health, safety, and working environment terms.

The emerging socio-technical system, as a consequence of systematic growth towards IO, is in fact seen very complex. It involves different levels in the socio-political hierarchy, ranging from policy levels to more operational settings. It also involves, as aforementioned, different commercial organizations that need to play active roles in implementation of techno-managerial solutions (e.g., technology experts, application service providers, asset operators, service providers, etc.). The nature of vertical and/or horizontal interactivity between those different sources is a defining factor of the future of commercial operations. Despite the obvious complexity of the emerging setting, there still is an absence of a comprehensive overview and a deeper insight into the sensitive interfaces that is critical to mitigate operational risk. At the very socio-political level acts, rules, regulations, and guidelines represent important components to establish a well-defined top-down interface. Even though there is a vacuum in that respect between the policy-making and operational levels of the emerging system, the change processes at the operational level takes place regardless. These activities at the operational organization play major emphasis on the systematic integration of human, technology, organizations, and work processes (*i.e., full integration through H-T-O-WP interface design and evaluation*) as the basis to drive commercial activities. In fact the effects of such explicit or implicit integration is very synergistic, and has begun to place numerous demands on the need for more clear guidelines, procedures, recommendations, references etc. to help reducing the operational risk exposure. Such clarity in specifications, either in normative or voluntary forms, has wider ramifications across various sensitive change-dimensions. It is also very vital in the present context to harmonise various effects, and to ensure the quality and standard of the re-engineering processes (see Figure 3).

**Figure 3. Some critical dimensions of the accelerated change towards Integrated Operations (IO) on the Norwegian Continental Shelf (NCS).**



When the entire industry is heading towards an integration task across sectors where activities of key stakeholders are inter-connected to avert systems delays, for instance in responding to emergency situations, there is also a necessity to standardize some underlying aspects to avoid risks of misinterpretations and ill-defined practices. This is particularly so for data exchange processes in-between business partners, where web ontology, O&G semantics, and standards such as ISO 15926 are taken-in as part and parcel of ongoing projects and implementation activities to retain the desired level of integrity and consistency across various sectors of the industry. Also, the timely need of proper set of procedures, routines, and guidelines are also constantly raised to perform necessary analysis, design, implementation, and evaluation tasks professionally to ensure long-term safety and security of today's change processes. Furthermore, the industry has also commonly understood that it needs to acquire necessary level of maturity on non-conventional subject matters such as semantic web, human factors and ergonomics, web-based infrastructures, etc., through various forms of competence development measures. It implies that a range of parallel initiatives is in progress spearheaded by political sources, authorities, knowledge industry etc., in addition to technology implementation and re-organizational projects launched by major producers and their business partners.

**REALIZING FULLY-FUNCTIONAL AND FAIL-SAFE SOCIO-TECHNICAL SYSTEM**

The concept of IO is by far a very complex development scenario with a set of unique underlying risks. The entire industry is heading towards an ambitious future gradually embracing some genuine experiences from distinctive re-engineering processes. Undoubtedly, the rapid marketing of available technologies and the awareness of their advanced functionalities have marveled the major players of the industry. The fact that E&P industry by large is complex-technology driven and is mostly saturated with engineers and technocrats, substantially influence pulling of technology to make the operations better, faster, and easier. However, pure technological focus has its own dangers particularly in complex environments such as offshore oil production as highlighted by for instance Health and Safety Executive (1997), Perrow (1999), etc.

What the industry needs at the moment is to take every possible measure to avoid conventional socio-technical systems design practices. These conventional and ill-defined practices have a dark history of causing dys-



functional or mal-functional systems. Formally three such flawed practices (Table 1) have been identified by socio-technical system theorists (Hendrick & Kleiner, 2002).

**Table 1. Conventional systems design practice (see Hendrick & Kleiner, 2002).**

<b>Technology-centered Design</b>
Largely limited to ‘off the shelf’ or ‘cook book’ type engineering solutions demanding major changes within human and organizational components only at the usage phase.
<b>Left-over Approach</b>
Situation where owners, operators, and maintainers try to find solutions for those issues that are left-over by the technology designers.
<b>Mal-integration Condition</b>
When technology designers fail to fully comprehend the dynamic interactivity of socio-technical components within an organizational setting.

It implies that both the designers and users of advanced technological solutions under IO initiative on NCS have to walk through a cautious and a well thought through process, avoiding pure financial assessment of the integrated solutions standpoint but rather performing a holistic assessment of systems functionalities and their compatibilities especially from safety and security standpoints as well.

The ongoing techno-managerial re-engineering efforts, as mentioned above, will undoubtedly introduce major changes within the current work systems of major players on NCS. Owing to the fact that this directly challenges almost all the technical and managerial levels of organizations, a much broader criteria is absolutely necessary that seriously considers key characteristics of the emerging socio-technical system. Expert knowledge and adequate understanding of the complex dynamics of the system, which lively connects offshore-onshore work systems, is critical in systems design and implementation task to avoid the exposure to extreme operational risks. These issues have been discussed in proper details for instance in Sanders & McCormick (1993), Chapanis (1996), Clarke, Coakes, et al., (2003).

A fully-functional and a fail-safe approach to address these circumstances is surely the one which is more inclined towards a humanized and an organizationally oriented practice. It implies that the technology developers and the users need to adapt the most appropriate criterion (or criteria), at least out of the three choices highly recommended by the socio-technical systems theorists. The three specific criteria are; *Joint design*, *Humanized task approach*, and *Organizations’ socio-technical characteristics integration* (see Table 2). For more explanations see Hendrick & Kleiner (2002), Booher, (2003), etc.

**Table 2. More humanized systems design recommendations (see Hendrick & Kleiner, 2002).**

<b>Joint design</b>
Follows practice where technological and personnel sub-systems are brought together at very early stages of the systems design. Participatory aspects of experienced operating personnel from the user organization is a key component here.
<b>Humanized task approach</b>
Takes more early and cautious considerations of function and task allocation process in the development of the work system.
<b>Organizations’ socio-technical characteristics integration</b>
Early assesses the complex socio-technical characteristics of an organization with the intention of properly integrating them into the new work system.

It is more and more acknowledged today across the E&P industry in North Sea that a comprehensive overview of the new system is very necessary to define the set of sub-disciplines that are extremely critical to properly integrate human and organizational aspects to the re-engineering processes on NCS. In fact, the issue is that if such comprehensive strategies to overcome unforeseen events and incidents can prolong the time frame for integration tasks. Even though this may be the case, the argument is that such a systematic move will have substantial long-term pay back against a rapid accelerated solution that has substantial potentials to induce a stream of errors, ill-define interfaces, and thus unforeseen events. The costs of such events and subsequent 'ad-hoc solutions' or 'quick fixes' would be far great for the industry to bear and to live with.

## CONCLUSION

The NCS stepped into what is termed the 3<sup>rd</sup> *efficiency leap* from 2003 onwards targeting major commercial benefits from a rapid re-engineering process. This has resulted in an E&P environment that is highly technology and information solutions dependent, with direct implications at organizational levels and also restructuring the entire industry. The nature and scale of change is so large that there are serious concerns on the vulnerabilities and hidden risks of techno-managerial change. In fact the ongoing processes induce a new socio-technical system that is dynamic and is committed to 24/7 online real-time operations. This setting has a unique set of challenges in terms of proper understanding of the dynamics of the socio-technical system, defining critical dimensions, and thus taking necessary early measures to make the system fully-functional and fail-safe. This still remains a challenge for the major part of the industry, and there are initiatives and programs underway to address it particularly owing to the underlying sensitivity with respect to safe-guarding and securing the future of commercial interests and activities on NCS.

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