Re-Engineering a Tanker Ship Management System

Capt. Suresh BHARDWAJ
Vice Chancellor, AMET University, capt.s.bhardwaj@ametindia.com

Abstract The paper explores how technology, including Information Communication Technology, can be effectively used as the interface between the shore based tanker ship management and the shipboard management for performance optimization, and how tanker operations and maintenance processes may be reengineered using suited new technology in order to make operations more effective and efficient. *A Management Systems and Process approach* is utilized to identify the processes and reengineer them to increasing effectiveness and efficiency. First, modelling of the business processes has been undertaken in order to understand and communicate about the existing processes. The modelling is also the basis for optimization by re-engineering of the processes. Focus group interviews have been conducted in the Mumbai-based ship management companies. Here, the most radical reengineering opportunity was perceived to be the sub-process of "Monitoring of Ship's Fuel and Machinery Performance", which was then taken up as the area of main subsequent focus. This sub-process was then modelled and mapped out, the technological intervention needed was studied and applied, and the reengineered process was defined with its potential for increased efficiency and effectiveness. The reengineered process was then sought validated through review, verification and critical scrutiny for any weaknesses or blind spots at the same companies that participated in the focus group interviews.

Keyword*: Systems Approach, Process Approach, Reengineering, Business Process Reengineering, Ship Management, Process Management, Optimization.*

1. Introduction

1.1 Automation in Shipping

The shipping industry in general is not very responsive to change. It tends to play safe and rely on hands-on approach to management and operation, in spite of reliable technology having made inroads into and been integrated with safe ship operations. There are very many reasons for this: The maritime shipping industry is very competitive with average rates of return below many other industries with similar risks. [17]. Matter of fact, shipping economics exist as a separate branch of economics for two reasons: The one is the cyclicality of the shipping markets that also concerns the demand for shipping services and thus also freight rate fluctuations; the other is the idiosyncratic nature of shipping investment. The two are inextricably linked: Investing in ships could be classified as an astute, a brave or an insane decision depending on the state and the prospects of the shipping markets which rarely – if ever – fulfill the promises they seem to give. [18].

So also the fact remains that, the ship owners may sell their vessels and buy new ones or move them in and out of third party management, depending on fluctuating market situations, making it difficult to plan investment in technology; owners may also come from a conservative background which views technology with suspicion from the investment return optimization perspective. In the meantime, technology keeps changing, thus encouraging a "wait and watch" approach in ship owners' decision making.

Be that as it may, in shipping, just as it is the case in any other industry, an increased induction of the latest technology and automation is seen. Sophisticated systems and equipment with embedded software for fault diagnosis as well as multiple means for communication with shore-based units are seen being installed on newer vessels, particularly on those sophisticated vessels in the fleets of owners from high national income maritime nations.

1.2 Impact of Technology

A measure of the significance of a new technology is the extent to which it changes previous ways of doing thing, or changes our ideas about how they ought to be done. Some maritime innovations can certainly be described in this way as highly significant because they have altered traditional patterns of operating ships, and in some cases, they can also be said to have contributed towards an essential change in the relationship between humankind and the sea. [8]

The June 1995 incident of the passenger vessel “Royal Majesty” running aground with 1509 passengers aboard, near Nantucket Island on a voyage from Bermuda to Boston, was investigated by the U.S. National Transport Safety Board. This investigative report [13], concluded that, automation, when designed properly and used by trained personnel, can be helpful in improving operational efficiency and safety. However, when designed poorly or misused by undertrained or untrained personnel, automated equipment can be a contributing cause to accidents.

In another analysis of the same incident, this time from the perspective of the crew, [11] it was observed that, automation is often introduced because of quantitative promises: it will reduce human error; reduce workload; increase efficiency. But as demonstrated by the Royal Majesty, as well as by numerous research results, automation has qualitative consequences for human work and safety, and does not simply replace human work with machine work. Automation changes the task it was meant to support; it creates new error pathways, shifts consequences of error further into the future and delays opportunities for error detection and recovery.

While it was originally considered that the optimum ship was simply the most profitable one and that,[3] in the long run, competitive markets would ensure that this would be that with the lowest costs. However, in maritime transport, as elsewhere, there has been an increasing concern with the protection of the environment. Following number of well publicized disasters, this economic approach has been extended to maritime safety in general, which has to be factored in beyond the lowest cost principle. This development was accelerated by a report from a Select Committee of the House of Lords [5] which concluded that: “modern science and technology are not being adequately applied in many of the fields that affect the safety of ships, the lives of those who travel in them, and the marine environment; and that there are new developments in marine technology affecting the design, construction and operation of ships which the regulators constantly struggle to keep up with and constantly fall behind as technology develops.”

In the context of accident and incidence investigation, a school of thought, however, seems to support the idea of having more automation or computerization than what exists today, [2], to compensate for the erratic and fallible humans onboard, where it is opined that improvements might best be achieved by reducing or eliminating the human factor in incident sequences.

The above differing viewpoints highlight the mixed reactions to impacts of technology and automation in shipping.

1.3 Automation for Optimization

Of all things that can change the rules of competition, technological change is among the most prominent. It has the resulting ability to achieve low cost and differentiation through its value activities. [15]

Moreover, in a highly competitive global economy, automation has been an important general approach to improve productivity, quality and customer satisfaction. [10]

In the shipping industry context, it is appropriate to refer to the proceedings of a high-end workshop that was organized by the International Federation of Ship Masters Associations in Manila in November 2009, on the sidelines of the popular Lloyds Manning and Training Conference there. At the workshop, Andreas Nordseth, the Director General of Danish Maritime Authority remarked that there is no doubt that shipping has seen tremendous advancement in technology as a result of the owners investing in meeting the challenges in this competitive world. But it seems that we have not addressed the process of operating this new technology on board the ships that is leading to fatigue and consequential accidents and near misses.

2. The Objectives of the Research-in-Progress

The purpose of this research-in-progress is to see how technology can interface into the tanker management and its operations for improvement and optimization. This will also include the examination of the cooperation between organization on land and onboard the ship which is an integral part of Tanker ship Management system. In other words, this research project is an attempt at optimization of the Co-operation between Tanker Ship Owners' or Tanker Ship Managers' Technical organization based ashore and the management on board the ships, and the communication interface between onboard and shore-based units, leveraging the technological advantage, but at the same time, not exposing the ship to greater risk.

3. The Approaches to Research

3.1 Management Systems and Process Approach

A "Management Systems and Process" approach is utilized to identify the processes and reengineer the processes towards further optimization, [12], which here means increased resource efficiency and increased effectiveness with regard to specific goals.
For organizations to function effectively, the numerous interrelated and interacting processes need to be identified first. Often the output of one process directly forms the input to the next process.
The schematic identification and management of the processes employed within the organization and particularly the interactions between such processes is referred to as Process Approach.
Processes are charted to make things better, so that they in turn can do a better job as helping people to do their jobs better. Any improvement procedure requires to first identify the project, gather facts and break it down by preparing process charts , challenging the current method, developing improvement (eliminate, combine, change sequence, simplify) and then apply the improvement.
Process charts show us the big picture while allowing us to focus on the details. They give us fresh eyes and an opportunity to view work from different perspective and vantage point. All process charts follow the basic philosophy of flow charting. Process implies movement, and movement is depicted by line drawn from left to right. Standard kind of symbols are used to denote activity and words help clarify answers on what, where, when and who. [4]
Modeling the business processes helps to identify all fundamental aspects of a company and constitutes a powerful yet simple approach to understanding and communicating what really happens in existing processes. In this way, it represents the basis for a subsequent optimization of the company sectors or even re-engineering of the whole structure that result in cost and time savings. [12]
Processes are subsets of a System.
Systems thinking concerns an understanding of a system by examining the linkages and interactions between the elements of management that compose the entirety of the management system.
A Systems approach thus, uses two basic ideas. First, one should examine objectives before considering ways of solving a problem; and, second, one should begin by describing the system in general terms before proceeding to the specific. [1].

Such a "Management System and Process Approach" encourages organizations to analyze the needs and expectations, define the processes to enable contribute to the outputs, and also keep the processes under control.
It thus provides a good framework for driving improvements and optimization and increases the probability of enhancing the satisfaction levels of the interested parties.
The evaluation of the system is also then possible. It of course can vary in scope and encompass a range of activities such as review or Self Assessment.
The "Management System and Process Approach" thus focuses on the achievement of results, in relation to the objectives that result in Optimization.

Based on the above the research theme will be restated for the purpose of clarity in the context of Management Systems and Process Approach as: the development of an effective and purposeful system of management communication process (optimization of cooperation) between the shore based management and the ship board management in order to evolve an optimal management control strategy for the purpose of optimization of a set of objective functions, subject to a set of constraints.

3.2 The Tanker ship Management System

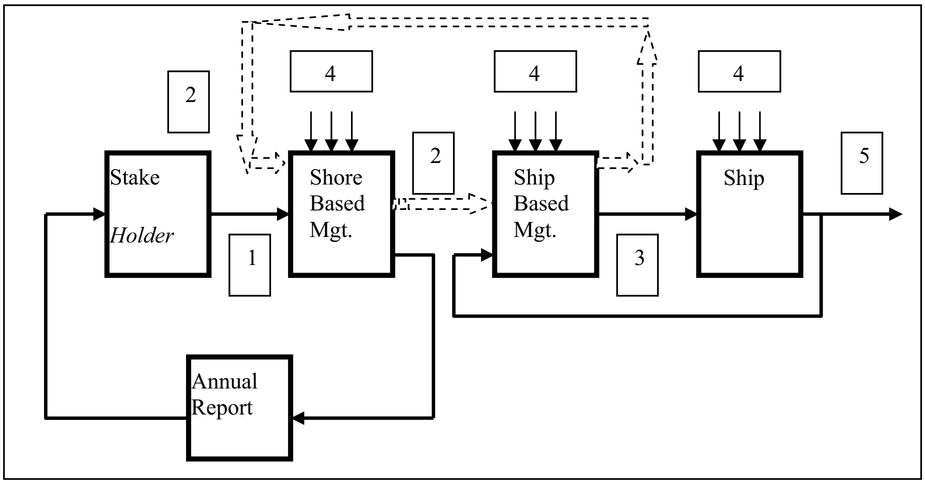

Fig. 1 Tanker ship Management System

The inputs, outputs and constraints as denoted by numbers in the figure 1 are explained below:-
(1)Expectations of the stake holders, (that defines the objective functions for process control)
Eg. Maximization of sailing time, Minimization of turn - around time, Minimization of port stay
(2) Management Communication Process (Work flow, cooperation etc. between shore based management and ship board management). The optimization to be attempted in the scope of this action research project is limited to this Process alone.
(3) Management control strategy for the ship; i.e. the strategy to achieve the desired stated objective function, derived from the stakeholder expectations.
(4) Constraints, e.g. (I) Shore based management constraints like Commercial (business commitments, etc.), Technical (Repair budget, dry docking schedules, etc.), Personnel (Availability of officers/other crew members, Flag state rules & trade union agreements), (II) Shipboard management constraints like weather, machinery/equipment limitations, regulations (SOLAS, MARPOL, ISM, etc.), piracy threats and attacks.
(5) Performance of the ship

From Figure 1 it can be seen that the "Tanker Ship Management System" is made up of several subsystems, like the stakeholder subsystem, the shore-based management subsystem, the ship-based management subsystem and the ship itself. Each of these subsystems has its inputs, outputs and set of business rules. All the subsystems are integrated to form the "Tanker Ship Management System".
This implies that, a small change made to any subsystem will affect other subsystems, as well as the Tanker Ship Management System as a whole. Therefore the management communication process comprising of the shore based management subsystem and the ship based management subsystem, which is shown in the figure with interconnections in dotted arrows(- - ->), and is the scope of this research project, cannot be viewed in isolation.
The aim to achieve increased resource efficiency and effectiveness with regard to specific output goals, which is the theme of this research project, is part of the process of working to increase efficiencies and the effectiveness of the entire Tanker Ship Management System.

4. The Methodology for the Research

4.1 Own Experience

Firstly, this research draws on the own experience of the author, who has been Chief Officer as well as Master of an 89000 ton dwt. Crude Oil Tanker, besides many other types of vessels. Subsequently, he has also been involved in the development and implementation of quality, environment, occupational health and safety management systems for 4 shipping companies listed below. This involved typically into consultancy projects over 9 months to a year, where in the complete process mapping of management systems in relation to the operation of ships was done with particular focus on the deliverables relating to quality, environment, occupational health and safety.

The companies were:

- Andromeda Shipping, Monte Carlo, Monaco; operating 5 oil tankers
- Qatar Shipping, Doha, Qatar; operating 9 oil tankers
- Pacific Basin, Hong Kong; operating a fleet of bulk carriers and tankers.
- Grand Seatrade, Hong Kong, operating 5 cape size bulk carriers.

These are international companies, and the first author’s work done on the systems of these companies was evaluated and then certified by highly reputed certifying agencies like Lloyds Register and Det Norske Veritas.

4.2Focus Group Interviews

Focus group interviews are being used to create primary data about industry experts’ viewpoints on the planned process which are to be reengineered for improved resource efficiency and increased effectiveness with regard to specific goals.

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Two rounds of focus group meetings have been held with the Bernhard Schulte Ship Management, Mumbai. This, company handles the complete Technical, Operations and Crew management out of Mumbai office for 70 vessels. Bernhard Schulte Ship management is a global leader in quality ship management and manages over 700 ships globally.

Additionally, two rounds of interviews were conducted with 2 Chief Engineers and 2 Masters of companies of Indian nationality but with vast global experience. These interviewees have had various ship management responsibilities both on board and ashore.

Further rounds of focus group interviews will be conducted as the research progresses.

4.3Macro level Process Mapping

As defined in the research objective, basic consideration in the systems approach to design of organizations implied dividing work into reasonable tasks (differentiation) while giving simultaneous attention to coordinating these activities and unifying their results into a meaningful whole (integration). For grouping activities the guideline followed were as follows:

Units that have similar orientations and tasks were grouped together, e.g. the shore-based individual management functions of Commercial, Technical and Operational Management, and the ship-based individual functions of Deck and Engine. (They can reinforce each other's common concern and the arrangement simplifies the coordinating task of a common manager).

Units required to integrate their activities closely were grouped together, e.g. the shore based management and the shipboard management. (The common manager can coordinate them through the formal hierarchy).

The research thus commenced as planned, with the identification of the processes and systems that constitute the Tanker Ship Management System as a whole, at a very macro level, as shown in the Figure 1 above. The process of mapping also took into account the author’s own experience as well as the small amount of available relevant research reports and industry data.

4.4 Micro level Process and its Reengineering.

Based on the initial focus group interviews, the most promising reengineering opportunity emerged to be in the sub-process of “Monitoring of Ship’s Fuel and Machinery Performance”, which was immediately taken up as a case study. This was because the members of the focus group interview concurred that the technological advancements that have occurred in this sub-process would yield the maximum positive results in terms of efficiency and effectiveness over the present process deliveries. The advanced process controls in this sub-process are now capable of on-line real time optimization; where this has been attempted it has been successful and well accepted, and thus can be implemented more widely. The focus group interviewed also affirmed the general perception that the advances in process control technology as well as information communication technology, which previously were on independent yet complimentary paths, has now converged to a great extent to be almost seamless. Moreover, while cost is a decisive factor in determining the extent to which shipping companies are prepared to invest in information and communication technologies (ICT) infrastructure, the new satellite communication technologies are providing an economical method of transferring data between ship and shore, with ship being another node in the corporate Intranet or Wide Area Network (WAN), thus providing seamless connectivity of good quality and high credibility. This technological development can be used to improve the effective management of the ship and the seafaring workforce as a virtual team. This capability may also be nothing short of a major revolution in the shipping after the sail to motor changeover.

5. Reengineering of the Process “Monitoring of Ship’s fuel and Machinery Performance”

5.1 The Current Process

In the current process, the ship’s chief engineer manages the machinery spaces from the control room and reports the performance to the shore staff of the technical management company every noon via the satellite communication in a specific reporting format. This report is scrutinized ashore, fed through the program in the office and any deviations from norms requiring attention is reported back to the ship. The ship takes the corrective action and reports back to the office.

The interested parties like owners and charterers then receive performance reports in their own specified formats.

The process map is as below in Figure 2, where for the sake of simplicity, the resources and the constraints are depicted in a horizontal row matching the activity box.

5.2 The Technology Intervention

As a consequence of automation, which is nowadays usually associated with information communication technology, the centre of gravity of a shipping enterprise has shifted away from the ship. Decision making has become increasingly remote, in offices ashore. Modern shipping depends for its day-to-day operation almost as much on communication and information as on more tangible inputs like fuel. [8].

Reengineered process with radical benefits and optimization can be achieved if a vessel is fitted with a fuel and machinery performance system, with capability of accurately monitoring fuel consumptions and transferring the data to shore based organizations including Technical Management on line and real time. Reference is made to the Product description of Kongsberg K-Chief 500 Marine Automation & Fuel Performance System [9], which states that, “as a tool for fuel economizing, the fuel performance system is used for monitoring of fuel consumption and assessment of the efficiency of the propulsion machinery. Performance parameters, as accumulated fuel consumption and propeller shaft power, can be displayed and printed for reporting.

Further, measurements and calculations can be based on continuous measurements made by the Distributed Processing Units. Based on these measurements, the following performance parameters can be calculated:

SHIP	**Technical / Operations Department Ashore**	**Resource**	**Constraint**	
Monitor and Control Machinery Parameters		Engine Control Room	Ship's Procedures	
Prepare & Transmit Noon Report in Various Recipients' formats		A) Format B) SES Satcom*	By 1400 ships time	
	Analyze & Comment Not OK	Tech. Management Software OK		
	Provide feedback To ship	LES Satcom*		
Action on feedback and report correction				
	Confirm the Corrective action			
	Record in History and for MIS reports.	Tech. Management Software		
	Transmit reports to interested recipients	Recipients' Formats	Reporting as per agreement with parties	

*SES Satcom – Ship Earth Station Satellite Communication
*LES Satcom – Land Earth Station Satellite Communication

Fig. 2 Process map (Current)

• Momentary fuel consumption for each engine, Total momentary fuel consumption, Hull efficiency, Engine efficiency for each engine, Shaft power for each shaft, and Total shaft power.
Vital data can be accumulated and presented as below:-

Fuel consumption and power output is calculated over the entire voyage period. Accumulated data includes: (a) Duration of voyage, Distance travelled, Accumulated fuel consumption for each main engine, Total accumulated fuel consumption, Accumulated propeller shaft power in for each shaft, Total accumulated propeller shaft power.
(b) Accumulated values can be reset by the operator. When doing so, the accumulated values are printed as a post voyage report. All fuel economizing measurements and calculations are available as a display window on the Operator Station.
ShipViewer
ShipViewer is a software package that runs on a standard PC connected to the K-Chief 500 system's Local Area Network. The computer can be installed anywhere on the ship. It has similar viewing capabilities as those found in the Operator Station, but without control functions. If installing the ShipViewer on the ship's administrative network, a Gateway computer must be installed to act as a firewall between the K-Chief 500 automation system and the administrative network.
Interaction exists between the process network, the administrative network and the Gateway. Communication principles for transfer of data from the system on-board to shore is also maintained.

Real Time Monitoring including raw data normalization (i.e., accounting for the effect of waves, wind and current) is possible. For example, minute-by-minute fuel consumption of vessels can be assessed against values in charter parties. Charterers have often been frustrated by discrepancies between fuel consumption day rates included in charter party and the actual performance, given the higher fuel costs and lack of transparency.

Safety and reliability
The K-Chief 500 is designed to meet the most stringent safety and reliability requirements. It supports redundancy at all levels including communication, process controllers, serial lines and power supplies. The built-in self-diagnostic facilities monitor the entire control system and include extensive monitoring of field circuits. Both the hardware and the software have been type approved by major classification societies.
The K-Chief 500 complies with the requirements of IMO, local maritime authorities, IACS and eleven classification societies. It is designed to meet the classification societies' requirements for periodically unmanned engine room operation. The K-Chief 500 is also developed to strict military quality standards."

5.3 The Reengineered Process

SHIP	**All Departments Ashore, and Interested Parties**	**Resource**	**Constraint**	
Monitor and Control Machinery Parameters		Machinery Control Automation	ICAN	
Maintain live on-line displays and history reports	Access		ICAN	
Record in History and generate MIS reports to interested parties	Access		ICAN	

Fig. 3 Process map (Reengineered)

- I – Integrity of Data, an assurance that data is consistent, certified and can be reconciled.
- C – Confidentiality
- A – Access Control

  N – Non – repudiation by Shipboard personnel

The constraints, ICAN, in any automated and networked systems is explained below [16]:
"Information Assurance (IA) is the practice of managing information-related risks. More specifically, it seeks to protect and defend information and information systems by ensuring confidentiality, integrity, authentication, availability and non-repudiation. These goals are relevant whether the information is in storage, processing or transit, and whether threatened by malice or accident. In other words, IA is the process of ensuring that authorized users have access to authorized information at the authorized time.
Integrity – Integrity means data cannot be created, changed, or deleted without proper authorization. It also means that data stored in one part of a database system is in agreement with other related data stored in another part of the database system (or another system)
Confidentiality – Confidential information must only be accessed, used, copied, or disclosed by users who have been authorized, and only when there is a genuine need. A confidentiality breach occurs when information or information systems have been, or may have been, accessed, used copied or disclosed, or by someone who was not authorized to have access to the information.
Access Control – Authenticity is necessary to ensure that the users or objects (like documents) are genuine (they have not been forged or fabricated).
Non-repudiation – implies that one party of a transaction cannot deny having received a transaction nor can the other party deny having sent a transaction."

5.4 Optimization Potential for this Reengineered Process

This reengineering would result in
(a)Transparency. The Charterer who normally pays for the fuel costs, can directly access real time fuel consumptions from the machinery and there is no need for reporting on the same either by the Ship's staff or more conventionally by the Technical Managers ashore, giving rise to doubts on covering up for inefficient excess fuel consumptions.
(b) Elimination of lot of paperwork and duplication of paperwork
(c) More time at hand to ships staff, that otherwise would go wasteful in manual checking of fuel consumptions, analysis of performances and reporting of data to shore based managers.
(d)Fuel savings,
(e)Reduction in off-hires and charter disputes. Charter disputes frequently occur on account of causes attributed to discrepancies in fuel consumptions against as agreed in the Charter party document.
(f) Relationship building, between the charters and ship owners / ship managers, which is a key component is shipping business. It is not a one-time transaction but a continuous interaction on which stable, long term relationships are built up. 'Trust' being inherent to relationships, comprises, perceived integrity, willingness to reduce uncertainty, expertise, congeniality and timeliness. [14].

All these factors are readily addressed by this reengineered process.

5.5 Validation for the Reengineered Process

The above process as well as its optimization potential has been verified and validated theoretically through a focus group interaction with the Technical Management of a Danish shipping company that carries out its Technical, Operations and Crewing management out of their Mumbai office. This team of Technical Managers comprise some highly experienced marine engineers who keep themselves updated with latest developments in their area of operation and have even studied the reports on this enhanced technology deployed in ships. New technology deployment always carries the risk for the first time users and the industry normally waits and watches closely the developments before self deployment which also then entails the question of BATNEEC principle (Best Available Technology Not Entailing Excessive Costs).

As further work to this research, ways will be formulated to subject the reengineered process to some further tests of validation and falsification, in support of the conclusion inferred from the above.

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