incremental
software for ship repair

# Management Information Systems for Ship Repair


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## Abstract

This paper outlines the characteristics of shiprepair, and the planning and management requirements of the business. Shiprepair is a business in which short term change and variability are the normal conditions, and this inhibits planning and control. Capture and accessibility of data are essential to successful management of shiprepair contracts.

The paper highlights the benefits of using computerised management information systems (MIS) and the obstacles to achieving these benefits. It then describes how the modern developments in information technology can overcome these obstacles, and how such developments can be exploited to enhance both initial planning of contracts and maintaining control during their execution.

## Contents

## Introduction

Shiprepair is an inherently difficult business to manage. Variously described as "complex", "dynamic", "fast-moving", "chaotic", the business of shiprepair is undoubtedly difficult to plan and then manage. Shiprepairers are often of the firm belief that processes of shiprepair cannot be planned in the conventional sense, and that any control is limited to short term management of resources.(Ref. 1). The nature of the work involved does make this a difficult argument to refute, at least with respect to some categories of work which fall under the heading of shiprepair and conversion.

Several categories of shiprepair work can be identified, as well as conversion to prepare a ship for some new service. A shiprepair contract can vary in duration from a few hours, to days, weeks or months. Repair work can be categorised in increasing order of scale and cost:

- Voyage repairs, where minor repairs are carried out with a ship in service, often during a stay in port. This may be remote from a shiprepair site.

- Routine docking, where the ship is docked for hull coating renewal, and for any other required underwater work to be carried out, when the opportunity is taken to make other repairs. As ships age these dockings include special surveys, which may result in steelwork renewals. Other major refits, where the ship is substantially re-equipped, may also be carried out.

- Damage repairs, where extensive work, particularly to the ship's structure, may be required. These are the result of groundings, collisions and other accidents.

- Conversion, where a ship is refitted for a different use.

During the course of these repairs, different classes of work are carried out, reflecting the diversity of ship types and of the equipment installed in them The work typically includes:

- Cleaning and painting, underwater fittings.
- Steelwork, replacement of corroded or damaged material.
- Machinery overhauls and repairs.
- Miscellaneous work, on deck equipment, accommodation and other systems.
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The planning and management needs vary according to the category of work and vessel type. Major conversions and refits are considered to be closer in organisational terms to new construction, but what planning and management systems are available to support the routine and emergency repairs? This is a particular problem for the smaller companies in the industry, which have limited management resources.

## Planning and Control of Shiprepair

Planning and control of shiprepair differs significantly from ship construction, and also from major refit and conversion projects. The first problem is that the forward workload is not certain at the time of commencing the contract work. A ship construction project, once the design is sufficiently advanced and assuming there is a well-organised production system in place, can be planned in detail with a high degree of certainty. A conversion, despite initial uncertainty about the condition of existing structure and systems, can be planned in advance. It can then be re-planned after the initial stages, usually repair of the ship when any additional problems can be identified. On the other hand, a repair contract, even where a relatively detailed specification is in place, and has been quoted against, is subject to change. Often the specification for the contract will actually be sparse, and the detailed work requirements will only emerge once the repair work is underway.

Second, in almost all cases, whether highly specified or not, there will be emerging work, as the contract progresses. This is because in many cases the specification will call for an item of equipment to be inspected and then repaired or replaced as necessary. If the work required is substantial, then additional jobs must be done. These in turn may lead to the cancellation of other, less urgent work, to allow the total cost of the repairs to remain within a budget total. Inspection of hull structure may lead to significant replacement requirements for corroded material in older ships, again the extent of the work being unknown until the contract is underway.

There is another complication for the shiprepairer. In the case of ship construction, there is an estimate for the contract which is then the basis for the contract price (almost certainly fixed). The estimate is based on specific measures of productivity for typical shipbuilding activities, based on past work, which the shipyard can use with some confidence. These may be modified to take account of variations in the ship or planned improvements based on new investment or methods. In general, however, the shipbuilder has a budget for man-hours, broken down by tasks, and can plan, resource and monitor the contract against these. When the work is completed on time and within, or under budget, the result is at least potentially profitable. If the work is over time or cost budget then there is likely to be a loss.

For the shiprepairer, the situation is far more complex. In the first instance, there are few routine jobs which can be used as a basis for productivity measurement. Work such as hull cleaning or painting can be based on the specification and area to be covered, although the actual underwater hull condition, which is the starting point, may only be clear when the ship is docked. However, for many items the workload associated with the task is variable. Then, once work commences, there may be variations in the tasks, which result in variations in the man-hours.

However, whereas in ship construction, with fixed tasks and a fixed price, any unforeseen variation results in additional cost with probably no redress, the situation in shiprepair is more complex. There is a clear need to try and manage each task within the initial budget, provided there is no variation in the work content of the task. This will apply primarily to tasks such as painting and dealing with underwater fittings, and the basics of docking and undocking. Such items as the supply of power to the ship in dock can be based on a tariff and measured. However, many of the shiprepair tasks do vary, and once they do so, then a number of different conditions may be found:

More work may be necessary within a fixed price, resulting in a loss. This is avoided as far as possible, by not fixing prices where there is much uncertainty in the scope of the task. Once a fixed element is agreed, the situation in terms of the need to maintain a budget is similar to ship construction.

More work may be necessary, but to be paid for against an estimate and agreed price. The problem is now still to manage within the (revised) budget. From a planning viewpoint, the enhanced task will still require to be completed within a fixed overall timescale. If there is a large amount of emergent work, then the timescale may be re-negotiated, but usually the ship has a charter or schedule to meet and the completion date is important. If the work is not completed within the agreed timescale, then there may be financial penalties.

More work may be necessary, to be paid for as incurred. There is in this case no problem for the shiprepairer, except to monitor expenditure accurately.

Other characteristics of shiprepair planning are similar to those of new construction, particularly with respect to maintaining the end date. The ship under repair has been taken out of service to enter the shiprepair yard, and is almost certainly scheduled for another voyage immediately afterwards. The completion date is therefore rigid. Even if there are changes to the workload, as outlined above, the end date must be maintained.

The management of a repair contract is therefore a case of maintaining the end date against that background of continual variation in work content and therefore resource requirements.

The response of the shiprepair industry in Europe has generally been to develop a highly effective infrastructure of sub-contractors, suppliers and casual labour. In other areas, where labour costs are lower, the pressure on managing resources may be less and some under-utilisation of resources, particularly people, may be acceptable.

## Available Supporting Software

The needs of shiprepair make particular demands on the management information systems. In the past, a lot of the management is conducted relatively informally, with decisions taken locally to expedite the work processes and the formal paperwork catching up later. To manage this situation there has been little available software which can deal with the turbulence of the business.

Conventional planning software is based on a network, but assumes in general that once a plan has been developed, and as far as possible optimised, every effort will be made to maintain it. Much work on ship construction planning is based on the sub-division of the contract into very small tasks (or work packages), of short duration, and then avoiding any variation in time or work content. (Ref. 6)

Therefore the critical difference between ship construction and shiprepair is that in ship construction any change in work or schedule is avoided if at all possible, whereas in shiprepair the expectation is that there will be change. Where conventional planning software is used, the overhead of continual updating devalues its use. At times, on a fast-moving contract, the planning system is struggling to keep up with actual happenings on the ship.

In order to manage the work as the contract progresses, the ability to collect accurate progress information, and to transmit this rapidly to those responsible for maintaining the contract status is essential. The information is also needed allow assessment of the forecast to completion for the contract, and therefore underpins any re-scheduling as the emerging work is identified. Almost real-time data collection is desirable to be able to manage the rapid changes of scope which are experienced.

There are procedures designed for job shop environments which allow variations to be managed. (Ref. 7) However, these are primarily intended to allow re-scheduling of job sequences within a resource constraint, whereas shiprepairers use flexibility of resources to maintain the contract schedule. Most job shops aim to maximise efficiency of fixed resources. Most other industry sectors selling services and repair facilities have non-unique products or are able to allow completion dates to slip. As an example, road vehicle maintenance generally can substitute another, similar vehicle if an unexpected delay to repairs is encountered. In shipping, almost all ships are unique, and substitution is much more difficult.

Other approaches to the management of the shiprepair business are based on accounting software. This provides an accurate cost outcome (subject to the input information being correct), but is essentially designed for historical cost recording. It is not usually designed to include the flexibility in updating, particularly variations in work scope and cancellations, that shiprepair requires.

## Software Requirements

There is a need for some form of hybrid system which is specific to the shiprepair problem. The characteristics of such a system can be specified, based on the factors which are critical to the successful management - in planning terms - of a shiprepair contract. These factors are:

The total elapsed time available for the contract. The time to be spent in the repair yard, and hence the delivery date, is in nearly all cases an absolute requirement, and is dependent on a critical path comprising the work items which take the longest times.

The dock time is a major element of the time for most shiprepair contracts. Ships may spend time afloat at a quay prior to and after docking, but the dock is the key facility, and maximising the numbers of ships through the dock is one measure of efficiency for a shiprepair yard. Again, there is a critical path for this segment of the repair, involving the main underwater items.

The activities which combine to set a critical path for a shiprepair contract are:

- Any major engine repairs, afloat or in dock and contributing to total time.
- Any major equipment installations, afloat or in dock.
- Any major refitting activities.
- Steelwork repairs, particularly underwater, affecting dock time.
- Cleaning, painting and any other underwater work affecting dock time.

The first requirement in planning a shiprepair contract is to create a preliminary schedule, based on several elements, including.

- The proposed arrival and departure dates required by and specified by the shipowner,
- The expected dock and quay times, using past contract data,
- The total estimated man-hours and the numbers to be employed on the ship,
- The tasks to be completed, particularly those which require sub-contractors and external services.

Of the tasks only a few will be critical, and a simple network can use these to establish the critical path for the contract. This will be developed without considering resources in the first instance. Provided the times which are identified, and the associated resource levels are realistic (that is, the numbers required can be obtained and deployed) then an appropriate combination of sub-contract and in-house resources can be used. The use of sub contractors, and casual labour in many cases, allows the planning to be done without resource constraints as a major issue.

Once the critical tasks are determined and the overall timescale agreed, the remaining tasks can be scheduled. Again, these may need external (sub-contract or casual) resources as well as internal resources. Account needs to be taken of interferences and dependencies between different trades and contractors, but in most cases, work can be scheduled as required.

There is a further need to look across all the contracts which are current in the shiprepair yard, and to take into account any enquiries which may be converted in the period covered by the shipyard planning horizon. The rapidly changing contract situation, and the possibility of a damaged ship requiring immediate attention, also contribute to the volatility of the planning situation.

Overall, the complexity of the shiprepair industry, the rapid changes in requirements, typically across several contracts and the use of external resources have combined to make planning a neglected aspect of the business processes. In recent years, changes in IT and related areas have produced some opportunities to re-visit planning, with some prospect of success in managing this complex environment.

## A Shiprepair Specific MIS

The specific needs of the shiprepair industry must direct the development of any management information system which is to provide real help. The features which are necessary can be summarised:

Marketing requires to provide the shipyard with a stream of "good" enquiries, that is where there is a good chance of a contract with reasonable profit.

Management of the client base. This is likely to be international, even for a small shipyard, and needs to track the companies, agents, management companies, together representatives and the ships that they require to be repaired. The database must be accessible and be updateable remotely, so a shipyard can respond to often rapidly changing circumstances.

Management of Enquiries. The typical repair contract is small and the success rate on enquiries is typically one in five. The result is the need to manage a significant number of live enquiries at any time, linking these to the client data base and updating their status frequently.

Man-hour Estimates are ideally based on some analysis of past performance, so that they can be described as "realistic", that is the contract, if won, will be profitable.

Materials and Supply Estimates. These are built up over time using past data, supplier estimates of cost, sub-contractor rates and standard tariffs. Rapid and easy access to past estimates and contract data can provide a valuable addition to the process. Tracking information is also very important.

The contract negotiations can be extended and include changes in specification and scope of work. Easy tracking of the changes and status increase the chances of a successful outcome.

Production Planning. Once an estimate has been converted to a contract, the estimate data must be converted into a work schedule, which is then maintained in an up to date form through out as the scope changes.

The schedule is often variable, as new work emerges and some tasks may be cancelled or reduced in scope. The basic scheduling is usually straightforward; the more difficult requirement is to maintain an up to date status of the tasks and the work required to be completed by the delivery date.

Progress Monitoring. The work schedule is also used as the base on which to record actual man-hours, and other costs and also to track progress. This allows the state of a contract to be assessed quickly, along with its potential profitability. It also allows easy comparison with the estimate to monitor changes.

Control of the operations is the main deliverable required. This ensures that the contract outcome is as predictable as possible and any potential problems, especially with timely completion, are flagged early so action can be taken.

Invoicing. The completed work schedule, with the hours and costs associated with each task makes the development of an accurate invoice more straightforward. The outcome can be compared with the estimate, extras highlighted and agreement can be managed more effectively.

Maintaining up to date and readily accessible information on the contracts makes the generation of draft invoices, and their agreement much easier, benefiting both shipyard and owner.

The data from the contract management process includes items required for other functions.

Payroll. Accurate man-hour recording against tasks provides the information necessary to support he payroll, whether this is internal or sub-contracted.

Purchasing. The estimated and then final costs of bought in items and services are available to support the purchasing  function.

Flexibility is essential to manage both large items known in advance and also the many smaller items which can emerge as necessary late in the contract. Again, capturing the data and maintaining the status is critical.

By building a series of standard processes around a central database an effective and integrated system can be developed.  With all data residing in one place, easy and flexible reporting is possible.  Current and historical data can be aggregated, allowing a corporate 'memory' to be built up.  The data can be consistent and thorough, preventing errors and trapping all costs.

## Real World Obstacles

There are however multiple obstacles to effective management of ship repair via MIS.

### *'Garbage In, Garbage Out'*

One of the main benefits of MIS is the reduction of administration effort - particularly true in small yards with limited resources. However MIS are only as current and as useful as the data entered. Frequently MIS permit swift and efficient reporting , but provide only cumbersome data entry procedures. Practice has shown that the quality of the data is inversely related to how painful it is to enter.

### *Winners vs. Losers*

Often those charged with entering the data perceive little value for themselves from a system. They view such effort interfering with their 'real' work, or worse, an irrelevance. Administrative staff can see MIS as a threat. In contrast those who extract information from a system can gain great benefit, and place ever greater reliance on it. This gulf in user 'buy-in' hinders the inevitable cultural changes required if MIS is to be a success. This is exacerbated when up-front costs accrue before the benefits appear.

### *The 80/20 Rule Does Not Apply*

Computer systems excel in accelerating repetitive and predictable processes. They are built focussing on these process, implicitly acknowledging that situations that fall outside those boundaries will be handled manually. This is not sufficient in ship repair where profit is usually the small difference between two large numbers. Ship repair MIS must aim for 100% coverage of the yard's business. Even a single error or missed cost can turn a contract's profitability. Every time a situation is beyond the MIS's capabilities, the system is devalued.

### *No Single World View*

MIS are, have to be, built against some fixed model of the business they manage. This can either be generic, in order to apply as universally as possible, or can be expensively targeted at a single customer's way of doing business. In an industry as flexible and changeable as ship repair, the former leads to compromise and the latter to large development costs. Furthermore separate contracts within an individual yard may need to be managed differently, with different processes enforced, and different flexibilities allowed.

### *Monolithic MIS & Big Bangs*

MIS expect to replace existing processes at the heart of the business. They are designed as the hub from which or through which everything else operates.

In contrast, yards' current systems can consistent of multiple discrete applications targeted at individual problems intermixed with primarily manual processes. These current systems are frequently home-grown spreadsheets and databases. Their replacement can be culturally tricky, with the only feasible deployment approach an expensive and risky 'big bang'.

### A Trading Community

Traditionally MIS take a static view of the world. They are modelled on a snapshot of the business at a single moment in time and create their data structures accordingly. This can be misleading and inappropriate. For instance, marketing data is often presented as an extended address book with a strict hierarchical structure of companies, employees and vessels. In reality a yard operates in a dynamic community in which relationships between companies, people and vessels are constantly changing.

### Single Source Fallacy

Within the electronic realm there has been a traditional separation between database data, electronic files such as spreadsheets and word processed documents, and, importantly, e-mail. The database itself rarely holds all the information pertinent to a contract. And this is without considering paper records.

### Share and Share Alike

MIS systems are frequently billed as the first step to an electronic marketplace based on free and easy transfer of electronic data. Ship repair relies upon sophisticated and effective supply chains. However Electronic Data Interchange (EDI) within ship repair has yet to deliver on its promise. It is hard to beat the efficiency of the traditional phone call to a favoured supplier. Phone calls do not have to contend with proprietary databases, hard-to-maintain harmonised product catalogues, and the security concerns of electronic commerce.

# Modern Trends To Overcome The Obstacles

Despite these obstacles, successful MIS have been introduced in the ship repair industry. In the UK the most successful examples are programs where considerable effort has been made to tailor the systems to the yards' requirements, generally over a long period of time to affect cultural change as well. Such costly effort has been funded either by the yards themselves or through collaborative ventures with government and/or other institutions. Modern trends in IT technology and software development practice are bringing this cost down.

## *Technology – GUI*

Systems have long been capable of the data processing requirements necessary in MIS. A bigger obstacle has been the interface to the user. Graphical User Interfaces (GUI) such as Windows have replaced unforgiving terminal-style 'green screens', but still frequently struggle to present an intuitive experience to the user, especially to non-IT literate users in yards with ageing workforces. All too frequently, GUI's reflect the needs of the software developer, rather than the needs of the user. They cause user confusion and distrust which hamper adoption.

The art of GUI design is only now maturing to a point where genuinely friendly interfaces are available. Techniques such as 'progressive disclosure' (where the aim is to show the minimum information necessary but always offer an immediate way to access further data) are now becoming common currency in the IT development community.

## *Technology – Data Storage*

The traditional separation between database data and other electronic formats such as documents and email is being eroded. Modern search engines can comb multiple formats, and can be installed on a yard's own computers. Next generation operating systems are looking to remove the barriers completely. Their aim is make available any data, from any database or file, immediately accessible.

## *Technology – Internet*

It is perhaps necessary here to distinguish the world wide web from the internet. The ubiquity of the web leads it to be confused as being the 'internet'. In reality the web is only a single tool that runs across the internet. Much focus has been given to web-enabled applications that offer a service-based approach to functional provision. Companies such as Salesforce.com epitomise this, offering Customer Relationship Management (CRM) to any company with an internet connection. The INTERMAR project is an apposite example, offering a web-based collaborative system for supply chain management for ship repair.

However web-based systems rely on a fast, robust, secure IT infrastructure that yards may not have the skills, resources or inclination to maintain. Moreover user experience of web-based systems is limited. Modern trends are to revert back to the richer, more functional, GUI's that require traditionally installed programs. Thus using the web to distribute data to users is not relevant to complex MIS. However the boom in web programming has encouraged the development of several other collaborative technologies that run across the internet. These are generally invisible to users but allow systems to be monitored, maintained, supported, and even remotely.. Effective remote support means the option of adopting sophisticated, tailored systems is possible even for yards with limited IT resource of their own.

### *Development Practice*

Notwithstanding these trends, technology has not been the limiting factor in producing effective MIS. The issue has been customisation. Every yard is unique so ideally requires a unique MIS. The core obstacle is the cost of developing such a unique system. There is a dichotomy in current MIS – either hugely expensive custom systems, or cheap 'off the shelf' products. This dichotomy is fundamentally down to development cost. Tailored MIS are expensive in order to cover these costs. Cheap MIS must be generic enough to apply and sell everywhere.

### *Agile Development*

What is needed is a means to bring down the development costs for custom-built systems. This is the objective of the 'agile development' movement within the IT industry. It suggests a combination of tools and best practice that can be used to produce software faster and cheaper. The core concept is an iterative development approach involving users. Software is released 'early and often' allowing immediate feedback, a more accurate understanding of requirements, and crucially, generating buy-in (or at least interest) with the future users.

This frequent release process necessitates a modular design of systems. This can answer the issue of 'big bang' deployments and their resultant cultural shocks. A system that is developed bit by bit is inherently useable bit by bit. Moreover each area of functionality can be developed to be just good enough, and no more. All of these factors allow an incremental, 'benefits-first' approach to adoption.

### *Open Source*

The single most important trend within the software development world has been the growth of open-source software – software developed and available for free. Thousands of programmers work for nothing producing software that can used by others within their own products. The open source movement is hard to comprehend but easy to take advantage of. It has made it possible for small development teams to produce software at vastly less cost than in the past. Open source has also reemphasised the benefits of collaboration, standards, and 'good enough' computing, all of which favour the small, cheap development strategies of agile development.

## Affordable MIS

The happy combination of agile development and open source is reducing the cost of development. They permit rapid and focussed customisation. Technology advances are supporting this and allowing for cheaper post-sale support and maintenance. Maturing design processes can smooth the cultural changes necessary when adopting an MIS, and lower the indirect costs such as training. Sophisticated MIS is becoming affordable.

## Summary

The benefits of MIS are great. However there are significant obstacles. The key is customisation, which allows a yard to tailor its MIS to its business and cultural needs.

Customisation has always been possible, but at a cost untenable to most yards. Modern improvements in software design and development are reducing these costs, offering the possibility of an affordable, tailored system for every ship yard.

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