CHALLENGES FACED BY A SMALL SHIP YARD IN INTEGRATING COMPUTER AIDED DESIGN AND PRODUCTION PROCESSES – A REAL LIFE CASE STUDY

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SUMMARY

Mustang Marine (Wales) Ltd is a small commercial boat yard specialising in the construction of aluminium and steel bespoke vessels of lengths up to 50m. In recent years, the company has experienced rapid growth. During this period the company has procured a number of commercially available design software packages and has successfully integrated them to generate vessel models with a view to automatic generation of BOMs for combining with an MRP system developed in house. The basis of the concept is to develop a low budget integrated design and production system suitable for a small shipyard. The paper describes the experience gained from this transformational process as a case study.

After the critical self-evaluation process, the company embarked on a three year Knowledge Transfer Partnership program with Swansea University in order to develop a customised solution for itself and embrace structural and cultural change in the way company operated without disturbing the processes that worked best for the company and/or their operational agility.

A low cost materials resource planning solution to capitalise on design information reuse, taking advantage of commonality between systems of otherwise bespoke vessels. The solution looks at capture of information at source and focuses upon its reuse throughout key areas of the organisation. The paper details relevant schemas developed and gives an example of how cost savings can be achieved through adaptation and integration of affordable software packages.

The future vision is to develop the system to embrace supply chain management and client asset through life management.

NOMENCLATURE

BOM  Bill of Materials
CAD  Computer Aided Design
MRP  Materials Resource Planning
PLM  Product Lifecycle Management
SQL  Structured Query Language
WBS  Work Breakdown Structure
KPI's  Key Performance Indicators

Facilities Scheduling, and Product Lifecycle Management (PLM).

2. CULTURAL CHANGE

Mustang Marine is undertaking a fundamental transitional change away from a small organisation run by a small select team of directors, to a professionally managed outfit. As well as looking after the high growth which is currently being experienced, they must manage this cultural shift. The top management were doing all of the work themselves, as the business expands they do not have the capacity to do everything. Where no processes are in place, the associated area becomes exposed under the scrutiny of increased commercial pressure and potential failure. It is by identifying and tightening these gaps that the company can improve their efficiency and business integrity.

Along with the change of software comes about a whole change of thinking. The experiences gained in this project give Mustang Marine an insight into what has worked best, so as to influence how changes are made into the future, and steer the company as to the best way of achieving their objectives.

2.1. THE BUSINESS DIRECTION

Mustang Marine has evolved from a family run business, which design and manufacture, bespoke commercial work boats.
For the company to expand, they needed to move from an entrepreneurial business into a process driven organisation. Management recognised that traditional ship building skills had been lost to our area of operation so a new way forward was needed. The UK still retained leading Naval Architecture design capabilities and so the company took a conscious decision to turn the business from “craft up” to “supervision down”. In 2003 Mustang Marine adopted Albacore ShipConstructor as its preferred tool in developing vessel structures [2]. Once the preserve of large yards this software was becoming more affordable. Mustang Marine have used this software to good effect in developing light steel and aluminium vessels collaborating with notable design houses and “productionising” their concepts.

In has become apparent that whilst the specialist software houses still have the edge for specialist applications such as Naval architecture functions and developing complex hull structure main stream systems have through development and collaborative initiatives taken a lead in outfitting and CAD/CAM production synthesis. To this extent Mustang Marine management can proceed to take further advantage of the eliminating the craft culture from the outfit of vessels. This will enhance product quality and create legacy products, in addition to providing information which may be packaged and used to assist the end user in the through life management of the vessel.

As Mustang Marine cannot standardise their product, to capitalise on the benefits of repeat work. They need to explore new areas to reduce the amount of rework involved in each product. One way of achieving this has been to identify commonality in the vessels produced. Although each solution is unique there are patterns in system configuration, preferred suppliers and best practice. To this extent the yard has sought to adopt standard components and practices to provide a common approach in developing bespoke vessels.

The first area for improvement has been through the development of a centralized database of parts. The contents of this database are established from best practice and experience and the ability to perform parametric modelling allows the reuse of similar systems in new vessels [7].

![Diagram of PLM, MRP, CAD](image)

**Figure 1:** Development of portal at Mustang Marine, each element is dependent upon the data generated in another software package.

A second business improvement area is to create a database to deal with Materials Resource Planning (MRP), here scheduling requirements are included along with suppliers. By knowing this information at an early juncture in the build, Mustang Marine has been able to reduce the supplier base and have greater bargaining power. Furthermore by identifying generic components the opportunity has arisen for comparative and competitive pricing between suppliers.

To aid with the aggregation of costs the company has invested in automated labour hours capture to enhance accuracy regarding the tasks performed and which is helping to identify key areas for production improvement, further driving cost out of projects.

Management also note that the output of the product process is the amalgamation of a significant quantity of data that will be of use to a vessel end user especially if they are maintaining fleets of vessels. The application of the so called 4th dimension of CAD i.e. definition of attributes can be utilised to develop product lifecycle management products in conjunction with the end user.

**2.2. STRUCTURAL CHANGE**

As the company grows, new specialists are brought in to enhance key business areas. Originally the small team of senior management would have done these tasks in amongst their usual work. When work gets broken down like this an individual no longer sees an area of work through every process in the company because of this subtlety and detail can be lost, and the next member of personnel has to retrace the paperwork thread to understand the current situation. This is why data capture and reuse is crucial to the success of a growing business. To relieve the pressures on top management, levels of authority and management structure need to be clearly defined, along with communication channels. Minor decision making is delegated to those with sufficient authority, but it is also known when a higher level of decision is to be required. This way Mustang Marine is able to respond quickly to daily issues and senior personnel has to retrace the paperwork thread to understand the current situation. This is why data capture and reuse is crucial to the success of a growing business.
managements can focus their attention on the bigger picture. Part of the key to this success is aligning each team member with the company’s vision and strategy. This vision is communicated from the board of directors to the senior management who set targets to achieve this vision. These targets are given to all levels of management from which the critical success factors can be communicated to every employee. This way through capture of these factors informed decisions can be made regarding the businesses strengths and weaknesses.

![Critical Success Factors](image)

**Figure 2:** Communicating company vision down to each and every employee.

2.3. **ORGANISATIONAL LEARNING**

As with many successful small companies, the initial success may often be down to the leadership of key individuals. Historically this has been a major contributor to the reputation quality and technical excellence which Mustang Marine proudly possesses. Getting the knowledge out of these individuals and empowering the greater workforce is a key objective for the organisation going forwards. This way the company can expand whilst still maintaining its high quality standards. The first element is to capture best practice right at the outset of design based on the knowledge gained in previous builds, this also has the benefit of a faster development cycle for young design engineers. A lessons log is kept against all new build projects, this way any potential for minor improvement is captured. Recognition of project cross over is of paramount importance, this way the company is minimising the amount of unknown technology with every project. Furthermore despite a project being unique, it can be looked at more as a product with configuration options.

3. **SYSTEMS ANALYSIS**

Mustang Marine specialise in bespoke vessels. Whilst occasionally they may build a run of two or three vessels, this is not always the case. Each vessel consists of approximately 5,000 unique parts, yet there are still significant patterns between builds even if the parts are not exactly the same. The challenge has been to devise a method by which to group and classify these items so as to identify build trends. It has been found that parts can be grouped together by the functions which they are there to perform, and by the system in which they are utilised. Through formalising this selection process the designer is helped in establishing which parts are needed in a more structured manner, and assists in reducing the risk of failure. The benefits of doing this can be several fold. For starters the design is more likely to be captured right first time, and secondly it is far less likely that items will be missed. A knock on effect of being right first time is primarily less chance of rework, this is an especially costly process and can also cause major disruption to build schedules.

Grouping parts together in a systematic manner, suits the way in which both engineering designers, and the manufacturing staff operate. It suits the way we think of a vessel and breaks it into distinct elements. It also provides a structured fail safe by which we can step through the operation of a finished system and can visualise whether it will operate satisfactorily. Furthermore it is then possible to analyse the system on a comparative conceptual basis with other vessels.

There may often be several ways of building a system to achieve the same end result. Despite two vessels being very different, by transferring the conceptual knowledge for previous vessels known to be successful, risk is eliminated from a new design. For example certain manufactured parts may have proven reliability, in which case it would make logical sense to use a component from the same range for the new system to become a yard standard.

The high level conceptual approach should be undertaken at the very onset of a new build project. Here philosophy of operation verses cost and performance is detailed with the client. By doing this at an early juncture and communicating the findings, there is less opportunity for the design engineers to deviate from the core specification of the client. In doing so the design engineers should be able to identify the similar systems from the past and utilise this information as a basis for the new design.

3.1. **CLASSIFICATIONS/ SYSTEMS**

In order for an entity to be managed effectively it first needs to be monitored. Due to the complexity and individuality of each build at Mustang Marine, it is not possible to compare projects on a like for like basis. As such a good work breakdown structure is of paramount importance. A common outlook at Mustang Marine is that everything can be broken down by into networks of objects which perform a given role. In other words every item aboard a vessel is part of a system of parts placed together to perform a task. Whilst on the surface this may seem very simple, due to the complexity of the interactions between systems it is not. There needs to be a central unanimous agreement over the breakdown of
the systems to provide complete traceability and consistency right through from the new build enquiry through to the drawings and purchasing departments. As an aside to vessel classification, it has become apparent that a system is needed for categorising parts. The aim here is to make the categorisation independent of the vessel system on which the part may end up. For example the system may be raw water cooling system and the item may be a pipe. The pipe would be classed as a raw material as it will require post processing, and the very fact that it is in the raw water system will define further criteria such as material and testing requirements.

4. **COLLABORATIVE WORKING**

In a small business, information can easily be stored in the heads of the few members and on paper lists. Individuals tend to have involvement in many business areas and can stay with a task through a large number of business processes. In a larger business this is less likely to happen and specialists are likely to be utilised in key areas. For this process to be successful the communication of information amongst an ever increasing team of people is crucial. As well as communication and delegation, management personnel need to have visibility of up to date information and statistics to assess the success of critical business tasks. To do this effectively, access to data and information is fundamental. The company are developing a central data repository with effective reporting systems. This way all users have access to the tools they require, and the directors need only monitor, allowing them to concentrate on the strategic visionary planning. This study looks at three key reporting requirements; these are Materials Resource Planning (MRP), Labour Scheduling, and Product Lifecycle Management (PLM).

By its very nature the commercial boat building is heavily reliant upon internal company collaboration where data transfer is key and is highly dependent upon specialised design software. When all levels of management were together in a single office building, word of mouth could play a key role, in communications amongst themselves and to the small team of production staff. Any issues and risks were generally widely known and communicated. However as the company grows and has spread across several sites, this chain of communication has become broken. To remain competitive in the industry software selection is key and is directly relevant to the impact on productivity and compatibility with the remainder of industry. When Mustang Marine collaborate with clients, design houses and suppliers, companies’ software’s often have issues aligning, as there is no industry standard solution and even so version control is another factor. The cost of these large packages targeted at the largest of corporations is uneconomical to Mustang Marine’s smaller business and often restricts how processes can be conducted [3].

In an ideal word, software packages are selected based upon their specific merits for their required tasks. As a result there is a desire to communicate between said packages through a central collaborative package [4]. The ethereal goal is to achieve communication between industry standard CAD software so as to drive directly into company requisition database to bypass the repeated data input. Provided that any part held in the purchasing database carries the same unique identifier as the associated part in the CAD database, and other relevant information such as run length or stock size. The ontology should be able to recognise the inclusion of a new component and populate the purchasing database.

With such an increase of data within the company sensitive information access and data integrity are two significant issues. Forms have been utilised to help with the integrity of the data, they enforce that certain information to be included and reduces the possibility for duplication, as many fields selected from drop downs. Drop downs further enhance the capability of reporting, as data is in distinct groups information can be asked of it, this is where the integrity of the data is so important. Levels of inputs allow some users to read only so as to perform analysis but not to corrupt existing data.

5. **THE BUSINESS PORTAL**

5.1. **BUSINESS PROCESS**

Simple business processes are already documented for Mustang Marine they cover normal working activities. As a small business many of the other processes were off the cuff and flexible to best suit the small company. One of the most difficult tasks associated with this project has been the definition and mapping of detailed processes and modifying these to embrace change when management have adopted different products and or standards. To map the capture of information required a skeletal structure has been established from which a detailed Entity Relationship Diagram (ERD) has matured. This defines the data to be captures and its capabilities for reuse. It also provides a clear communication method of the company’s requirements when specifying software.

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The ideal ethereal goal is to have a situation where all data is captured right first time and single sourced [5]. This data will be captured at the earliest possible juncture in the business reused and enhanced by addition of attributes thereafter. Admin time consumed in repeated input can therefore be eliminated freeing more time for data analysis to focus on the company’s KPI’s as disseminated from the overall vision. What is not specified in the ERD is the company’s workflow, including such aspects as check points and sign off. Good software integration should nurture the user through company procedure thus reducing the quantity of things the user needs to remember to do [1].

5.2. CLIENT INTERACTION/ PORTAL

A future desire for this business portal is to bring in client interaction. This will help with processes such as drawing approval and review. Particularly with client preference criteria, such as console layouts or cabin arrangements. It is here where 3D cad visualisation tools are providing an added benefit beyond their anticipated usage. Further future benefits include the ability to hold manuals and information for client equipment, service information including full BOM information for refit purposes and the ability to arrange dockside repair and maintenance packages to be arranged at the dockside when the vessel requires. All this provides an added benefit to the client as vessel downtime can be substantially reduced [6].

Figure 3: Outline skeletal database structure, below is the Entity Relationship Diagram Developed From this to showing the detail of the final solution in low resolution to protect the intellectual property.

Figure 4: Client review of seating arrangements made possible through 3D rendering, improving workflow through early sign off of concept.

6. DESIGN BEFORE BUILD

6.1. DE-SKILLING

Though hard to achieve with such bespoke builds, Mustang Marine has already seen 25% of hours come out of the build time through careful design of structure and utilising the specialist software tools available through ShipConstructor. It has become apparent that additional hours applied prior to build repay themselves at least two fold during build. It is hoped that similar gains can be realised in the remainder of the build through the use of specialise software for the purposes of outfitting. The shop floor personnel are provided with a kit of parts to build with containing all of the necessary tooling, thus reducing the time spent on the vessel and the efficiency of the work produced, allowing a reduced cycle time between trades.
A key element in reducing the lead time between securing contract and commencement of build has been the standardisation of Mustang Marine’s parts library. By providing a clear pallet of useable “Standard Parts” to younger members of design personnel, they know that the designs and layouts produced will be fit for purpose. Where “Client Specified Parts” have been detailed in the project contract, there is more risk to the company as they may be an unknown entity and it may take longer to re-draw and add these items. Mustang Marine utilise an internal parts numbering system which provides a unique identifier to each part, this way when the information is passed to the MRP system a link is provided for continuity of information, even though the categorisation of that item has had to change to suit the new system.
7. SOFTWARE INTERGRATION

No two businesses operate in precisely the same manner; their processes are a combination of industry best practice, auditable trails and bitter experience. Many industries have specific software’s, needed for specialist tasks. Hull plate development is one such example with commercial boat building [8]. Each of these software’s have their own data requirement. There is no one system to suit every business. Those which come close are generally geared towards very large corporations and cost vast sums when it comes to customisation for a company’s specific needs.

Arrangement and storage of data is a key decision for such a system. Where possible it is important that only one central point of information is chosen. Mustang Marine keeps all data in there centralised SQL servers. This way they can utilise much of the added value in Microsoft reporting capabilities. Standard Power Pivot tables are used and can be refreshed as required keeping critical information up to date and relevant and provide the capability to mine the cone for relevant information.

Figure 9: SQL data cone, data collected from various software’s stored in compatible formats for reporting purposes.

8. CONCLUSIONS

Managing growth as well as the necessary ‘cultural and structural change’ is a risky strategy for a small shipyard.. However without the cultural and structural change the company will likely become less competitive and this will be a restraint on growth. With the changes management will be able to achieve significant growth without a significant ramp up of back office costs to support the increased activity. Intelligent utilisation of commercially available software packages and integration between platforms has been identified as a key are in which efficiency gains can be realised throughout the entire company.

Every organisation is different and operates in a different manner, with unique processes and techniques developed over many years. As such to find a software package which aligns with how the organisation operates is unlikely. More over businesses morph and adapt with the times to remain competitive. Should lucrative opportunity present itself it would be unwise to be constrained by the current software and processes. Large companies often resort to having software custom built to help with their processes. Or may even be forced to buy customised programming tweaks to modify and adapt existing software. This is not a viable option in this instance as the investment cannot be justified in a relatively small company. The alternative option would be to use existing software. Here the problem lies in having to force the organisation to conform with how these software operate and if necessary change their processes. The company need to protect processes that work best and develop a customised solution so that the software works for the company rather than company changing its work practise to suit software requirements. One benefit of the smaller and younger yard is a lesser burden from legacy software. The company has a greater ability to flex and change as required. A software solution may only suit for the short term, it is highly likely that if the company continues to grow that is will inevitably outgrow its systems. However careful attention to software selection can maximise its useful lifespan. Mustang Marine has already realised benefits from such careful selection through the implatnation of ShipConstructor for structural development [9]. The plate development capabilities of this software and the ability to nest parts into kits has reduced production hours significantly in relation to the requirement for traditional lofting techniques. The further savings to be realised through streamlining the fitout of vessels in a similar manner will be equally significant. For this process AutoCAD Inventor has been selected for the benefits it can potentially offer through its content centre of parts and parametric modelling capabilities. The vision is that the benefits of standardising vessel systems may be realised. It is hope that there will be the ability to utilise the existing workforce more effectively and turn the yard into more of an assembly line.

9. REFERENCES


10. AUTHORS BIOGRAPHY

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