UNIVERSITY OF SOUTHAMPTON

FACULTY OF ENGINEERING, SCIENCE AND MATHEMATICS

Concurrent Engineering for Leisure Boat Design

by

[student name removed]

[student id removed]

An M.Sc. *Interim Report* Submitted for the Postgraduate Degree of

Master of Science (M.Sc.) *Naval Architecture*

Supervised by: Prof. A. Shenoi & Co-Supervised by Dr. A. Sobey

3rd May 2013

1. INTERIM REPORT OBJECTIVES

The Interim Report is an introductory study conducted by the researcher which includes vital and sensitive issues with regards to the project. This document is important since it has to be presented at the early stages of the investigation. This report includes the aims of the research together with some background knowledge on the vital topics for this study.

The next step, following the discussion of basic principles making up this research in the form of a summarised literature review, was to discuss the method of conducting this research. This included a methodology schematic diagram so as to clearly give an overview of how this study shall be divided. Furthermore, it was imperative to identify any obstacles which could present themselves during the course of this study. This was completed by making use of the *ISO 31000 Risk Assessment Standard*. Finally, a Gantt chart depicting the provisional programme of work was produced. This will provide an approximate indication of how the research should be divided for a three month period.

This report adds up to 10% of the total research which amounts to 6 C.A.T.S. This restricts the report to a maximum of eight pages.

2. INTRODUCTION

The development of an engineering design process is a valuable task within companies in the manufacturing sector. It has been shown that a focused approach on the design stage at the earliest phases of product design will increase the success rate of new products on the market [(1)]. The standard engineering design process in todayôs modern world is divided into sequences which when grouped together make up the design process. However, a sequential approach may lead to problems later on during the manufacturing stages of the product [(2)]. Therefore, companies must find new ways of designing products more efficiently. This is where Concurrent Engineering comes into play.

Concurrent Engineering (CE) is an important management tool, widely used in various industries which include the *aerospace* (NASA), the *aircraft* (Airbus) [(3)] and also the *shipbuilding industries* (Damen Shipyards Group) [(4)]. In many researches and journals conducted by various authors, Concurrent Engineering has been seen by managing directors as a vital role in the *design*, *manufacture* and *selling* of a product. But what exactly is Concurrent Engineering and how does it help in achieving desirable results to firm?

In brief, CE is said to be a *systematic approach* where all of the manufacturing processes, together with the employees making up a product, work simultaneously so as to improve the overall quality of the product being manufactured, whilst also increasing the profit margins for the company [(5)]. Once a CE approach is successfully implemented into a company, results from various researches have shown that customer satisfaction increases, together with the quality and also the cycle time required in making the product [(5)].

Companies make use of various principles which aid in the implementation of CE. This includes *Parallel Design*, *Software Infrastructure and Support* and *Understanding of the Environment* [3]. For this research, special attention shall be given to Parallel Design and the Understanding of the Environment. Furthermore, various management tools may be used to gradually and effectively implement Concurrent Engineering in a company. These include *Quality Function Deployment charts* (QFD), *Morphological Charts*, *Total Quality Management* (TQM), *Lean Manufacturing* [6] and *4th Dimension Concurrent Engineering.* Tools such as QFD, Morphological Charts and 4th Dimension Concurrent Engineering shall be used in this research so as to promote optimisation of the boatbuilding industry of leisure boats, particularly focusing on the design stage.

3. RESEARCH AIMS & OBJECTIVES

This research involves the use of *Concurrent Engineering* (CE) in the leisure boat industry. Companies make use of CE as a management and engineering tool that helps in optimizing the process of designing and manufacturing of a product. In this research, CE tools such as QFD, Morphological Charts and 4D CAD shall be used to select appropriate parameters which will then be optimised using a coded Matlab program.

During the primary stages of this research, it became apparent that the subject of boat building facility layouts and assembly lines required in building boats is a novelty, and hence such a subject shall be tackled during the course of this research.

This study shall be divided into the following arrangements:

- Determine most important customer requirements;
- Analyse these requirements using Concurrent Engineering tools such as QFD;
- After identifying the main customer requirements by the use of QFD charts, it is then imperative to search for different assembly lines and manufacturing systems of how the boat building facility layout should be divided so as to decrease unnecessary costs in building the boat;
- Once the layout has been selected, optimisation shall be conducted on the layout of the facility;
- After optimisation is complete, 4D CAD will be used to produce a visual 3D model of the plant facility.

4. SUMMARY OF LITERATURE FOR RESEARCH

A ship is a complex system. Building one makes the process even harder. It requires coordination between various departments of a company in order for the building of a ship to run as smoothly as possible. The design phase of a shipbuilding company is the first step which requires due consideration and large amounts of research from various technical personnel [7]. It is essential that quality remains the top priority of a company. Top management have to strike a balance between optimising of many parameters ranging from *costs*, to *material utilisation*, and also *manufacturing processes*, but at the same time, delivering a good quality product to the customer. The boat building industry is surrounded by competitors and requires high costs to run

and maintain. Therefore, optimisation in such a company is a requirement [3]. This is achievable by introducing CE in a firm.

The *design stage* involves the cooperation of various departments working together. It has been shown that when such departments communicate well and work simultaneously together, this will result in positive results. From various researches, it has been shown that when such a management approach is assigned, costs and developing time of the design decrease whilst the quality of the product increases which results in customer satisfaction [8] .

The design process is made up of various subsystems. These can be divided into the following engineering activities: *Product Design and Modelling, Material Selection, Manufacturing Process Design, Manufacturing System Design* and *Prototype Testing* [9] and can be represented in Figure 1.

Figure 1 is a schematic representation of engineering design. This Figure also symbolises how parallel design (which after all is a Concurrent Engineering management tool), may be used so as to decrease the time required to finalise a product design. Each rectangle represents part of the design process, and each and every one requires a certain amount of time to complete. For example engineers in the Product Design and Modelling stage do not need to finish off all the work before moving onto the second stage of Material Selection. By using Concurrent Engineering, it is possible to start the following process earlier. This will help engineers not to overthink certain parameters in their current stage whilst also finishing off the assigned tasks earlier. From various researches, it has been found that by using such a technique, the product will be manufactured quicker and therefore companies gain a competitive edge, whilst also improving the quality of the product [6].

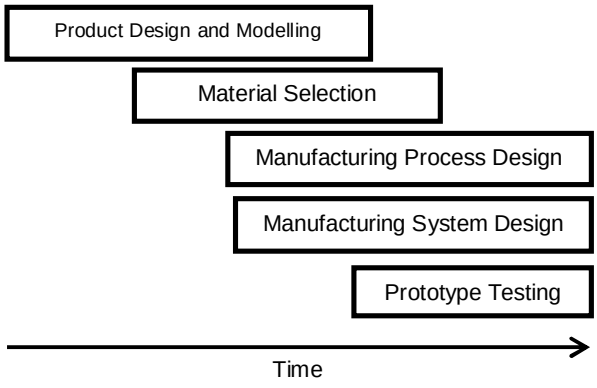

Figure 4.1: Representation of Parallel Design

Apart from Parallel Design, information with regards to the *Environment* both internally and externally is very important. A company must take into account the layout of the shipbuilding plant, and hence design the product accordingly. This helps in optimizing the plant where the product is manufactured. Once the plant has been optimized, it is then possible to produce a quality product with minimum costs and in the least possible time.

This gives rise to other research which is to be conducted in this study. This includes the different types of facility layouts which could be used in the boat building industry. A facility layout is an extremely sensitive issue which not all industries give it relevant importance, and may well affect the profit margins of the company

in question [10]. The planning for an efficient and optimised layout involves important logistical management which will help in reducing material handling costs. Companies who take the layout of the facility seriously may well embark on a competitive advantage. This results due to the fact that companies may finish production before other rival companies and hence release the product earlier into markets than other companies [11].

5. CONCURRENT ENGINEERING TOOLS

In this research, customer requirements shall be the first key factor to consider before moving onto the design stage of boatbuilding. It is essential to know exactly what the customer requires before designing the product. Once the requirements have been outlined, tools such as Quality Function Deployment (QFD), Concurrent Function Deployment (CFD), Morphological Chart, and Extended House of Quality (EHOQ) shall be used in order to establish a framework of what are the most important attributes as seen by the customer, together with how this will affect the design and production of the product [12].

These tools shall therefore be used so as to get a clear indication of what the customer *requires* together with how the product should be *designed* so as to have an efficient plant layout. Once this has been achieved, the plant may be optimised to get the best layout which makes the manufacturing process of boats faster, and hence delivers the product to the customer on time, which will in turn result in a happy customer.

6. OPTIMIZATION

The next section for this research will include the optimization of the plant layout, after analysis has been done using the CE tools mentioned in the previous section. Optimization is a vast topic which requires predetermined consideration on the outputs which are required to be obtained.

At this stage, it is important to discuss what needs to be optimized and why. For this research, optimizing of the plant layout so as to improve product design, could involve various decisions to be taken. The basic idea involves optimizing the most important machines or manufacturing processes that make up the leisure boat building process, and optimise their position relative to how the manufacturing process progresses. Furthermore, it is also important to consider other aspects such as the area available for optimisation and how such machines shall be positioned relative to this work area so as to optimise the available space as much as possible. This involves multiobjective optimization.

Multiobjective optimization includes the minimizing (or maximizing) of various objective functions (such as plant layouts) which are subject to a number of constraints. Alternatively, such a method may also be used to determine an optimal solution between two or more conflicting objectives [13]. Two different optimization techniques shall be considered for this research which includes genetic algorithms and neural networks. Both these optimization techniques fall under the *evolutionary computing algorithms*. Both these theories shall be further discussed, and the best technique shall be selected and hence used as the optimization tool to solve for the parameters mentioned in the previous section [14].

7. POST - RESULTS EVALUATION

A thorough examination of the outputs acquired from the coded MATLAB program shall be included. This will give an output of the desirable layout of the plant, together with other vital information which gives a clear dimension on what is required from the naval architects in the leisure boat design stage.

This introduces the next phase of this research. Fourth Dimensional Concurrent Engineering, is a management tool used as an Engineering Design Method which makes use of 3D CAD models (in this case a CAD model for the layout of the boat building facility shall be produced), together with cost estimates and schedules relating to design and managing of the construction project. Anumba *et al.* (10) describes how the use of Concurrent Engineering to optimise a facility has been found to be very effective and gave desirable results. This included improvements in productivity, decrease in the time from the start of construction up to facility turnover and shorter estimating times.

This 4D Engineering tool has been said to improve the project management of a plant through integration of data plus an additional visualising model (3D CAD model) [(15)].

8. METHODOLOGY DIAGRAM

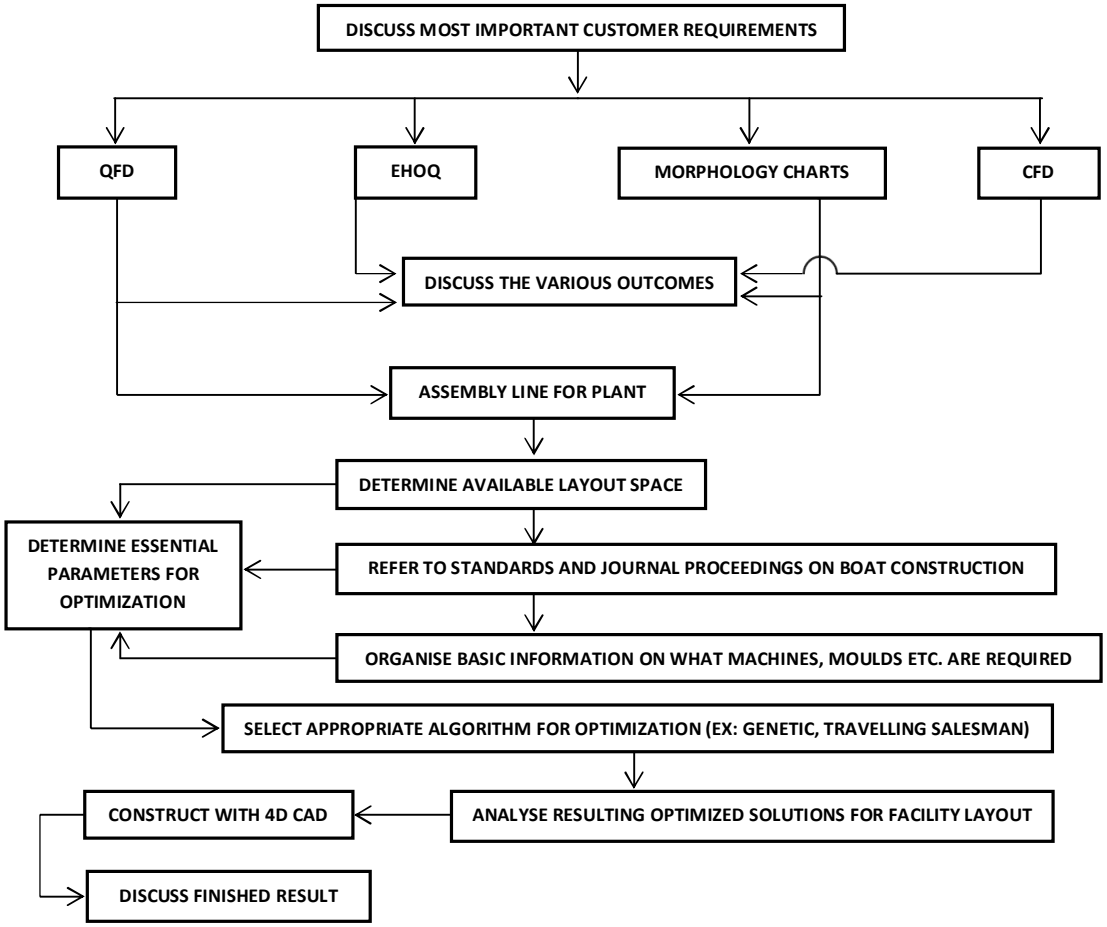

Figure 8.1: Flow Diagram for Methodology

9. MANAGING RISKS ENCOUNTERED DURING RESEARCH

"It's no good knowing that you've got a risk unless you understand what to do about it, even if it means doing nothing". [16]

Any Risks imposed on this research shall be conducted according to *ISO 31000*. This Standard has been recently updated in 2009 and goes by the following title: *Risk Management – Principles and guidelines*. This ISO standard offers various risk assessment techniques aimed in minimizing the number of risks in a project, or to have an alternative plan given that part of the original strategy did not follow through. *(Note: The following Risk Identifications have been numbered. Each number corresponds with the matching number in the Risk Treatment Section)*

9.1 Risk Identification / Analysis / Evaluation

1. This study requires a substantial amount of hours in front of a computer screen. Therefore, it is important to consider the Health and Safety Regulations so as to prevent any eyesight damage.
2. Room lighting together with seating posture are also essential. Insufficient lighting may result in eyesight damage, whilst improper seating position may result in back problems.
3. Like in any other research, human errors and problems are always prone to occur. These may lead to other factors which may cause problems in this research. For this study, some companies have been contacted in order to set up a visit at their leisure boat building facilities. However, some companies may find this intrusive and therefore would prefer not to give the author for this research the opportunity to go round the plant of their facilities. Therefore, an alternative plan has to be decided upon so that if such a problem occurs, an alternative strategy may be introduced.
4. As already mentioned in this Interim Report, Matlab will be used to code the genetic algorithms associated with the optimisation of the plant layout. This will involve advanced mathematics which could require some additional knowledge from a mathematics professor or lecturer.
5. Other risks could include that the algorithms programmed into Matlab are computationally expensive and therefore, some other algorithm has to be decided upon to get faster and more accurate results.

9.2 Risk Treatment

1. Five minute breaks will be compulsory every hour.
2. Proper Lighting together with a comfortable chair and good seating position will be used.
3. If none of these companies accept the authorôs request, then it is important to resolve into other ways and means to get round the problem. In which case, standards and other construction regulations shall be referred to and used for this research.
4. Apart from supervisors, and if the need arises, additional help shall be sought from mathematics academics so as to have the required help to code the Multiobjective Optimisation of the different parameters.
5. In such a case, other algorithms have been identified which could be of importance in the coding of optimisation. This includes the *Traveling Repairman,* and *Speeding Deliveryman* algorithms. These will also be reviewed as to check for the most efficient technique of delivering optimisation to the various parameters.

10. PROVISIONAL PROGRAMME OF WORK

Figure 10.1: Provisional Programme of Work (Numbers on Bars Represent the Amount of Days Allocated to Finish a Task)

11. REFERENCES

[1] J. SCANLAN, M. WOOLLEY, H. ERES, *A Metric-based Approach to Concept Design*, University of Southampton, 1998.

[2] R. SPRAGUE, K. SINGH, Concurrent Engineering in Product Development, *Concurrent Engineering research Center*, IEEE Design & Test of Computers, 1991.

[3] A. SOBEY, A. SHENOI and J.BLAKE, Optimisation of Composite Boat Hull Structures. In *Computer and Information Management Applications for Shipbuilding (COMPIT), Liege,* pages pp.502-515.

[4] M. WALDIE, (2013), *Damen & CAD Match to Speak on Concurrent Engineering.* Available:from http://www.shipconstructor.com/company/news-a-events/362-shipconstructor-expands-design-reuse-capabilities. Last accessed on 04/04/2013 at 9:30 a.m.

[5] BATH IRON WORKS CORP, *Report on Concurrent Engineering Implementation in a Shipyard*. Maine, U.S.A, The National Shipbuilding Research Program, 1995.

[6] A. SOBEY, *Concurrent Engineering in the Context of the Composite Leisure Boatbuilding Industry*, University of Southampton, Southampton, UK, June 2010.

[7] J. GUNASEKARAN, Design for Quality in the Shipbuilding Industry, *International Journal of Quality & Reliability Management*, Vol.10, Iss 4, pp.57 ï 63, November 1992

[8] A. CAPUTO, P. PELEGGAGE, Effects of Product Design on Assembly Lines Performance ï A Concurrent Engineering Approach, *Industrial Management & Data Systems*, Vol 108, Iss 6, pp. 726 ï 749, 2008.

[9] M. SCHIEDERJANS and S. HONG, Multiobjective Concurrent Engineering: A Goal Programming Approach, *IEEE Transactions on Engineering Managament*, Vol.43, Iss. 2, May 1996.

[10] D. SHA, A New Approach to the Multiple Objective Facility Layout Problem, *Integrated Manufacturing Systems*, Vol 12, Iss 1, pp. 59 ï 66, 1999.

[11] A. CANEN, G. WILLIAMSON, Facility Layout Overview: Towards Competitive Advantage, *Facilities*, Vol 14, Iss 10/11, pp. 5 ï 10, 1996.

[12] B. PRASAD, Review of WFD and Related Deployment Techniques, *Journal of Manufacturing Systems*, Vol. 17, 1998.

[13] MATHWORKS, *Multiple Objective Optimization*, Available from http://www.mathworks.com/discovery/multiobjective-optimization.html. Last accessed on 09/04/2013 at 13:09 p.m.

[14] R. MARKS, H. SCHNABL, Genetic Algorithms and Neaural Networks: A Comparison Based on the Repeated Prisonerôs Dilemma, Australia, May 15, 1998.

[15] C. ANUMBA, J. KAMARA and A. CUTTING-DECELLE, *Concurrent Engineering in Construction Projects,* New York, Taylor & Francis, 2007.

[16] C. EVERETT, A Risky Business: ISO 31000 and 27005 unwrapped, *Computer Fraud & Security*, February 2011.