

EUROPEAN BOAT DESIGN INNOVATION

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ABSTRACT

The European marine industry has a 26% share of the world market but growing competition from Asia and North America is threatening Europe's future market share, as they adapt their products more closely to consumer demands. A recent review of research has indicated that European boat manufacturers must be able to respond to their customers and offer exciting innovative products. They will have to learn to react quickly to changing consumer preferences and engage in continuous research and development. Design and manufacturing innovation are the keys to maintaining the competitiveness of the European boat industry in world markets. The opportunity created by the EBDIG (European Boat Design Innovation Group) project to transfer innovations from the automotive industry to the boat industry is expected to result in optimised design methodologies, leading to more cost effective design practices complementing and improving the knowledge and skills of small craft designers.

This paper reports on existing professional development training in marine small craft design and how learning from the automotive industry could help marine industry designers and manufacturers to adapt or adopt embedded practices within the automotive industry which will enable the European marine sector to understand and exploit opportunities to excite and capture consumers' imaginations and respond to competition from Asia and North America.

This paper also discusses key issues relating to design as well as manufacturing and quality for innovation transfer and skill development of designers. Some references are made to e-learning platforms such as www.egmdss.com (developed by Leonardo EGMDSS partnership including TUDEV) as well as a recent e-assessment platform, www.martel.pro (developed by the Leonardo MarTEL consortium including TUDEV) with a view how a similar platform could be constructed to transfer innovation from the automotive industry in design visualisation; ergonomics and telematics; and sustainable materials via 3 courses and a networking framework.

Keywords: Boat design, Design skills, Telematics, Sustainability, High technology applications in automotive industry

1. INTRODUCTION

The European marine industry has a 26% share of the world market but growing competition from Asia and North America is threatening Europe's future market share, as they adapt their products more closely to consumer demands [Lucintel, 2008-2013].

Design and manufacturing innovation are the keys to maintaining the competitiveness of the European boat industry in world markets.

Therefore European boat manufacturers' must be able to respond to their customers needs and offer exciting innovative products. They will have to learn to react quickly to changing consumer preferences and continuous R&D [Lucintel, 2008-2013].

The opportunity to transfer and combine innovations from the automotive industry to the boat industry, will result in optimised design methodologies, leading to more cost effective design cycles.

The EBDIG partnership includes an Advisory Group, made up of RINA (Royal Institute of Naval Architects), the BMF (British Marine Federation), and a HSC (High Speed Craft) ergonomics consultancy. The industry focus of the advisory group, will help contextualise the output of EBDIG to the needs of the European marine industry. They will be joined by industry & research institutions in each country. Delivery partners, educational institutions and small and multi-national companies representing the UK, Italy, the Netherlands, Turkey and France will contribute existing projects in, marine, automotive, telematics, ergonomics, design and e-learning to develop the EBDIG materials/infrastructure.

2. ORIGINS OF THE PROJECT

The automotive industry invests billions in research and development (R & D) however the marine industry has a smaller purse for investment. There is therefore, an opportunity for the marine industry to exploit the transfer of automotive techniques.

The sophistication and design philosophy - automotive industry standard - has not yet been adopted by the marine industry. A few small companies are starting to change this, however much more needs to be done to provide the skills to meet the increasing demands of the consumer in a globalised market.

Further to this is the need for greener boats although research into sustainable materials in boat design and manufacture is embryonic. The opposite is true for the automotive sector where vehicle telematics (remote diagnostics), ergonomics, high level visualisation representation and sustainable materials and fuels are common place - yet the European boat industry is worth over Euro 24 billion and maritime transport, represents 40% of internal European Union (EU) transport and carries 90% of goods imported or exported by the EU.

This project will thus transfer and combine innovation from the automotive industry to the boat industry in the four key areas of: design visualisation; ergonomics, telematics; and sustainable materials.

3. PROJECT AIMS AND OBJECTIVES

The projects main aim is to provide innovative professional development training and networking for marine industry employees by transferring embedded practices from within the automotive industry. This is expected to enable the European marine sector to understand and exploit opportunities to excite consumers' imaginations and respond to competition from Asia.

The projects objective is to use online courses and an interactive e-learning environment to transfer existing innovation in the automotive industry and education in ergonomics, design, telematics, materials and technology application within the work environment so that the European marine work-force develop world class skills and competencies to ensure the continued growth and competitiveness of the European Marine industry.

The project impact includes greater understanding and awareness of the needs of the boat Industry in France, Germany, Italy, the Netherlands, Turkey and the UK. Better trained boat industry personnel who are more aware of emerging technologies and techniques will enable the European boat industry to standardise and incorporate visualisation, ergonomics and telematics and sustainable materials in their continuing professional development programmes.

4. TRANSFER OF INNOVATION

Innovation will be transferred from the automotive sector to the marine sector, specifically from two

recent partner projects, European Global Product Realization (E-GPR) course (TU Delft) and European Automotive Digital Innovation Studio (Coventry University).

EBDIG will introduce marine industry employees to well established techniques in the automotive sector by training them in automotive industry knowledge and technologies to meet the marine industries growing skills needs. There are no such courses in the marine industry at present. The e-learning platform and its accompanying courses will be pilot tested on European marine industry employees nominated by partner/Advisory Group companies.

Transfer of Innovation will also occur between partners in terms of sector specific practices within types of boat design and manufacture. For example Coventry University has been populating the European Boat Industry for over 25 years with Industrial Designers, whilst the Institute of Maritime Studies in Turkey is supported by large ship builders. This will enable the partners to benefit from inter-sector innovation transfer and may result in new innovative products.

4.1 SPEED CRAFT CATEGORIES

EBDIG will examine a range of vessels including small craft to reflect the diversity of the European marine industry. These are as follows:

- Speedboat
- RIB (Rigid Inflatable Boat)
- Motor Yacht
- Sailing Yacht – 40 ft cruiser for instance
- Trimaran
- Super Yachts
- Inland Waterways Craft

The partnership is advised that while there are common innovative practices in the automotive sector that can be transferred to small crafts and that design skills are very similar when considering the design tasks nevertheless it would be advisable to narrow the range in terms of types and size of craft in this project.

4.2 PARTNERSHIP

Although there are a mix of boat manufacturers in each partner country, countries represented by a partner have been chosen because they specialise in a specific type of boat design and build. For example, Turkey specialises in motor and super yachts, France in sailing yachts and small craft, the UK, in large ships and super yachts, as does Italy, and the Netherlands in Lifeboats and small leisure craft.

This project will thus, enable country/boat specific expertise to be transferred. An example of this has been provided by Turkey, who after working with a Dutch partner, succeeded in building a leisure sailing yacht that required fewer crew but could hold more passengers using engineering methods from Lifeboats. The resulting boat is now in production in Turkey. The partners are reviewing the Engineering innovations in this project with a view to learn from the expertise developed in that project.

5. EUROPEAN DIMENSION

"The European industry is losing competitiveness as challengers from lower-cost economies have increased their share of world marine markets" while Korea made shipbuilding a strategic industry in the 1970's. [Collaborative product development consultants July, 2004].

China is now following Japan and Korea, and has plans to become the world's largest shipbuilding nation by 2015 and command 35% of the global order-book" [World Marine Propulsion, 2009]. Cox believes a European solution is required to this problem. He argues that as we cannot compete on labour price it is even more important that we concentrate efforts on creativity and innovation [2006]. EBDIG will therefore, develop training and infrastructure to empower employees of European companies to operate more innovatively and efficiently.

Operating at a European level provides opportunity to maximise the impact within the industry. The project partnership and Advisory Group are highly influential and well connected. The project will take advantage of this so that EBDIG is given a high profile from day one and is more speedily integrated into the working practices of European marine companies. Within the partnership, departments are working on a range of projects with large and small ship builders, designers and suppliers. These are ideal dissemination channels. Representatives from each industry sector will thus be invited to the EBDIG conference (including SAE-UK (Society of Automotive Engineers), RINA).

The sector needs to employ from an international pool of workers. EBDIG will thus enable participants to access a community of international Industrial Design practice. This will better equip them for international teams and provide the industry with the knowledge/best practice to adapt to meet the needs of culturally diverse teams.

As part of a European partnership EBDIG will benefit from experts in a range of disciplines, transfer innovation from other projects and access to different pedagogy from automotive and marine design and engineering. In Europe there are only 2

well established boat design undergraduate courses that focus on aesthetic design: Coventry University and Genoa University. Both of these Universities are partners in EBDIG. Given the global nature of the marine industry operating EBDIG on a purely national basis would add little knowledge and have limited industrial impact.

6. DISSEMINATION

6.1 TARGET GROUPS

The EBDIG project is aimed towards employees and managers working in the marine industry. As part of their training they will produce an E-portfolio, which may be accessed by any individual or organisation that are provided with the password. The participant will sign an agreement to this effect when they enrol onto the EBDIG programme. Word of mouth is also the best form of promotion - we aim to provide a high quality level of training so that the participants will spread the word amongst their colleagues. Recommendations such as this are invaluable for standardising a product.

In Italy and the UK the partners will work closely with the regional development agencies in order to disseminate EBDIG to companies and their employees. The partners are also working with the regional development agency's funding in order to offer the training to SMEs (Small to Medium Enterprises) without charge. This will provide us with a larger pool of participants to further refine, research and publish the work. TU Delft is providing participants for EBDIG from their E-GPR course. This is a huge dissemination opportunity for EBDIG, as E-GPR has been running in Europe and working for six years. We would therefore have access to hundreds of employees throughout Europe. EBDIG will also take advantage of EADIS (European Automotive Digital Innovation Studio) project which several partners in EBDIG were also partners in that project and hence not only have personal experience of processes in developing the EADIS course material but also in the dissemination process and strategy. Although EADIS was primarily concerned with vehicle telematics there are similarities between EBDIG and EADIS in course development as well as in application of telematics.

7. DESIGN CONSIDERATIONS

This project is primarily about transfer of innovation in design practice from the automotive sector to the boat design industry in Europe and ultimately about the developing and/or identifying design skills for designers within the boat industry. Boat design from an industrial design perspective involves defining and capturing opportunities that relate to the needs and desires of people. It is achieved through the harmonious and spirited integration of

visual, functional and user elements within manufactured forms or systems. Designers must examine the contemporary understanding of the term luxury in the context of boat design. In doing so they must research the trends in interior and exterior design aesthetics, to identify commonality and specifics of design language, across the full spectrum of boat design, from small craft with limited interior space to superyachts [McCartan, 2009].

Design cannot be considered without a good understanding of manufacturing methods and practices and a real appreciation of quality. Either the designer should have this knowledge or s/he should have access to good production Engineers and quality specialists.

The term design explains how ideas turn into real objects. Design in automotive terms is a discipline in itself. The automotive design, like any other form of design process, starts with the idea in the designers mind. It is then presented in written form, and at a later stage it is visualised and often sketched. These presentations or sketches, with a given standard, with rules and definitions, are then transformed generally into a set of technical drawings. Today, with modern technology these drawings are conceptualised and computerised hence the terms such as computer aided design (CAD) and so forth [Ziarati, 1991].

The computerisation has also helped to store and access information quickly and provides almost unlimited storage for information. These computer aided systems gradually became more integrated, for instance, combining design and manufacturing processes and other activities like cost became the standard. Once an idea is transformed into a set of technical drawings the whole process of manufacturing it and related procedures such as costing, testing and marketing it were up to recently part of what is known as computer integrated manufacturing (CIM) systems. CIMs provided easily accessible, consistent and secure data [Ziarati, 1994; 1996]. CIM also provided the integration of analysis, synthesis, simulation and modelling which go hand-in-hand with the evaluation and verification process in an interactive and iterative manner.

CIMs permit a project team to work together allowing information like finance and marketing to be added to design and manufacture more effectively. These systems allow the information coming in and going out to be controlled according to the given standards.

In recent years, intelligent computer integrated manufacturing systems often referred to in this paper as ICIMs or IMS have taken the place of CIMs [Ziarati, 2002]. These systems allow automation of repetitive tasks and allow information

to be accessed and controlled intelligently. This allows the designer to be more creative which brings improved quality and cost effectiveness.

The recent emergence of Market Driven Design and Manufacturing (MDDM) practice has not only integrated various activities such as design, material selection, production, finance, sales and marketing [Popova, 2009; C4FF TSB, 2009] but has identified a requirement for the intelligent assessment of the market for a given product as a basis for considering its design and production. The MDDM promotes the concept of problem definition and market assessment for a product as part of the idea generation and creative idea evaluation followed by further assessment of the idea and its presentation leading to a feasible solution. This process is a prelude to the conventional design viz., design specification, concept design, material and method selection leading to detailed design and its presentation and in parallel focusing on manufacturing methods and evaluation and verification. In automotive design the verification is always preceded by measurement and conformance to design as well as the manufacturing specification.

Even with all technological developments the main stages of design cannot be computerised. An idea still needs to emerge, be visualised or sketched and later detailed specifications are required which can only be generated through the human mind. In recent years there has been some attempt to develop an artificial brain primarily as a decision making aid to the human mind and to establish relationships among various sets of data. Data mining and extracting has also become highly automated in market search [Popova, 2009] and demand forecasting that are used as tools to decide which product to design and/or make based on market demand [Urkmez, 2008].

There are six generic design stages [Ingham, 1998] which have been put forward by TUDEV, one of the EBDIG partners, for possible adaptation in the project:

1. Determination of the Scope and Objective
This stage is often neglected but fundamental if based on market information and knowledge. What is the objective of the design and what is the scope for its realisation is considered in this stage.
2. Feasibility Study and Product/System Proposal
This includes a broad look at the major factors that influence the ability of the product/ system to realise the desired objectives. These factors could be related to any of the following reasons: technical, economical returns, non-economical returns, legal and operational, etc. and then to outline

solutions with sufficient details to enable a decision to be made as to whether it is worth going ahead with the project. For example, before going ahead and developing a new boat, adequate research has to be carried out as to whether there is enough demand for this type of product with the identified specification in the market that will enable enough returns justifying this project.

3. Product/System Analysis
This concerns the study of an existing or similar product/system for the purpose of designing a new improved product/ system. In this stage the benchmarking becomes crucial as basis of reducing risk.
4. Product /System Design
This is the stage where it should be possible to know what the product/ system looks like. The logical constraints and requirements of the new product/system are taken into consideration and given that there are a number of ways of implementing it on the physical level we could optimise the design of the product/system taking into consideration the view of those who intend to manufacture and use it.
5. Detailed Product/System Design
At this stage, detailed physical product/system specification, programme functions/routines specification, project plans and file structures are produced.
6. Implementation
7. The final stage involves:
 - a. The purchase and installation of the material and systems/hardware.
 - b. Prototyping or rapid prototyping.
 - c. Databases are created if necessary.
 - d. Operating procedures and manual are written.

This is the stage when the order is placed and the design is implemented and evaluated. The validation process is complete and if there are any other additional and .or regulatory requirements these have to taken into consideration in this stage.

7.1 COST VS. VALUE IN DESIGN

According to Mitra [1993] in a broad way of thinking, design should both satisfy the consumer and be simple and cheap. Design is affected by product type, cost, profit politics of the enterprise, demand for the product, current condition of components and pieces and product safety. In many cases, an improvement in product design increases the cost exponentially.

However, product price rises a little after a certain design. Figure 1 displays the effect of design level according to a service's or product's cost and value.

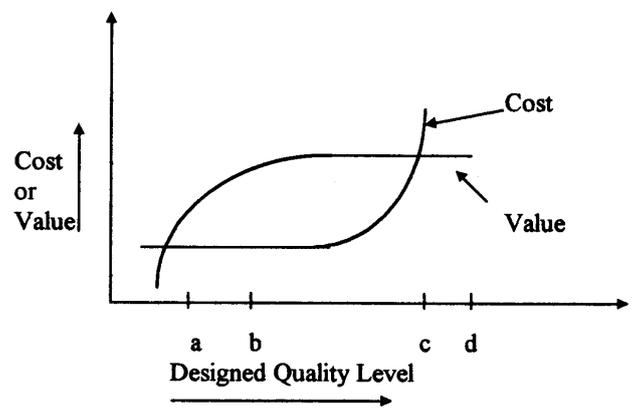


Figure 1. Cost and Value that Constitutes Function of Design [Mitra, 1993].

8. MANUFACTURING CONSIDERATIONS

All designers should know about the manufacturing practices. All manufacturing systems have a production plan based on forecasts, orders and so forth, as well as a Bill of Materials (BoM) which is a breakdown of a product into its constituent parts. There are several approaches to manufacturing. In its simplest form a product is designed and at the design stage the manufacturing processes are explicitly or implicitly indicated. Manufacturing processes such as MRP(Material Resource Planning), OPT(Optimized Production Time), JIT (Just in Time) and in recent years ERP (Enterprise Resource Planning) are different approaches used in manufacturing but invariably based on simple processes and requirements. MRPII (Manufacturing Resource Planning two) and its predecessor were generally a "push" system which means that although a forecast is generated at the start and a production plan is developed to meet the forecast, the forecast often was an arbitrary figure derived from pervious experience rather than an intelligent assessment of the market. The databases of MRPII primarily contain information about parts, components, work in progress and finished goods. The databases also include information about lead-times and relationships between various parts [Ziarati, 1992; 1994]. According to Managing into the '90s, [1989] an MRPII system works as follows: requirements are calculated in terms of quantity and time. These requirements are then transformed into a Bill of Materials files which break down a product into its constituent parts. Net requirements are then calculated by deducting available inventory from gross requirements. Finally a schedule is calculated with the user able to decide on variables such as lot sizes. The system then issues work orders to the relevant work centres [Ziarati, 1992; 1994].

The OPT aims to increase throughput and decrease inventory and reduce operating expenses and is defined in terms of three criteria:

- Throughput – the rate at which manufacturing is processed and hence the rate at which money is generated.
- Inventory – the amount of parts and finished goods in stores.
- Operating expenses/

According to Managing into the '90s [DTI, 1989] OPT bears some resemblance to both MRPII and JIT. It is not just a computer system but, like JIT, is a philosophy which concentrates on issues such as quality, lead times, lot sizes and machine set-up times.

OPT assumes that lead-times and lot sizes should not be fixed and are variable according to finite capacity at any given time. This is very different to MRPII which assumes infinite capacity but tries to set up lead time buckets and lot sizes. MRPII and OPT are similar in other respects. OPT is based on ten rules and these are stated in the reference given [DTI, 1989]. According to Managing into the '90s [1989], the goal of JIT is the production and delivery of the required items at the required time in the required quantity. JIT has been labelled a pull or demand driven system because nothing is produced until just before it is needed. Demand for parts and finished goods therefore pulls goods through the system.

In manufacturing the JIT is a risky approach because inventories have to be kept to a minimum hence there is a possibility of part shortages (delay in delivery) which could interrupt the entire manufacturing process. JIT is a philosophy and it could incorporate an MRPII methodology or an OPT approach.

All manufacturing systems irrespective of the overall approach are of two types:

- Batch production – down to one
- Line production – from a few to many

Both types of manufacturing are now computerised and often use computer integrated methods. The latest systems are taking advantage of Knowledge-Based-System (KBS) and other forms of Artificial Intelligence (AI).

MRP, MRPII, OPT, JIT approaches led to emergence of ERP (Enterprise Resource Planning). ERP systems encompass integrated manufacturing systems within an overall logistic model taking advantage particularly of JIT methodologies. What distinguishes ERP from its predecessors is its ability to provide a resource planning and implementation series of modules in supply chain environments. Usual models include production, costing, and so forth. The modern ERPs have e-commerce modules and some a forecasting module

[Ziarati, M. et al, 2002]. The ERP systems, according to Ziarati [Ziarati, M. et al, 2002] have no systematic capacity for learning, and hence rely on either a set of equations or human decisions.

A study of various computerised systems by Ziarati [1987] showed that the payoff due to the introduction of MRPII systems has been highly beneficial compared to other forms of computer aided systems. It was also mentioned that forecasting is by far the most important activity within the overall scheme of things. According to Ziarati et al [1992] no matter how sophisticated your ERP modules are if you get the forecasting wrong the cost to the company could be fatal. In the shipping industry the difference between right and almost right forecast could be bankruptcy of the company.

The modern concepts such as CIM and ICIM were briefly touched upon earlier concluding the section on manufacturing. The current ICIM with sophisticated forecasting systems have emerged in recent years [Ziarati, 2002; 2009; Urkmez, 2009].

9. QUALITY CONSIDERATION

Improving the quality increases the market share and decreases costs. Both the market share and the cost are the factors affecting the profit. When the quality increases, profit increases as well. Likewise, improving safety and suitability results in fewer faults and less service costs. Referring to his work with the firms producing air-conditioning units, Garvin (1984), revealed that quality and productivity correlates positively. He also stated that the firms working at high quality are five times more productive (unit/human-hour) compared to the firms working at low quality.

9.1 QUALITY DIMENSIONS

Quality has also a qualitative dimension besides its quantitative dimension like specifications and performance ratios. Generally the customers appreciate the quality of a product or service according to these dimensions. Garvin [1984] worked on the factors needed for a product or service of high quality and classified eight dimensions of quality:

- Performance: performance is the basic utilisation principle of a product.
- Features: the specifications are somewhat the reflection of the performance.
- Reliability: reliability reveals the possibility of defectiveness, going out of order in time, or a product not working effectively.
- Compliance: compliance means the assurance of the defined standards relating the product or the service, and the compliance with standards.

- Durability: durability is the usage of the product until it completes its shelf life.
- Serviceability: service capability is the service possibilities, repair time, easiness of repair, determining the complaints regarding the product, and taking care of them.
- Aesthetics: aesthetics express more relative concepts, such as the appearance, smell, and colour of the product.
- Perceived quality: the perceived quality is the views and comparisons of the customer regarding the product or the service.

9.2 QUALITY CHARACTERISTICS

To make the quality measurable and demonstrable, quality characteristics should be technically grouped. At this point, the customer or the consumer is to declare his expectations and the producer is to ensure quality. After all, quality is formed by the intersection of the criteria of both parties (namely the customer and the producer) put forward [Siha and Wilborn, 1985].

A customer who is satisfied is the one who obtained the expected quality. Otherwise, he loses his trust in the producer's quality and product responsibility is reviewed again.

9.3 QUALITY OF DESIGN

Establishments in search of quality have to consider certain quality types. Gitlow and Gitlow [1987] talks about three basic quality types to produce a qualitative product or service. These are: Design Quality, Quality of Suitability and Performance Quality.

Design Quality or quality of design comprises even the most trivial conditions of a service or product to meet the needs of the customer. This means that the product or service has to be designed so that it can also meet the insignificant wishes of the customer. Quality of design begins with market demand survey and sale and continues with determining a concept of quality of a product or service. Then, specifications are prepared for the concept of a product or service.

From the arguments put forward by Gitlow and Gitlow in 1987, it seems that the market demand survey, what was considered important then, has not been taken seriously by many companies and the design and production philosophy has been to some extent still based more on 'push' systems than 'pull' hence they must have ignored the suggestion made by scholars such as Gitlow and Gitlow. Today sophisticated online tools exist to search for market data [Popova, 2009; Ziarati et al, 2010] and concepts of value stream mapping [Tapping et al, 2002] and Hoshin Kanri [Tapping et

al, 2002] are applied in design and production planning in the manufacturing industry in general and should be encouraged for adaptation in small craft design building practices.

10. TELEMATICS

The project as implied earlier will review the development in telematics and wireless communication [Ozhusrev, 2003; Ziarati, 2002] which is highly developed both in automotive as well as yacht and ship building sectors. Some of the experiences learnt in automotive design of such systems [Ziarati, 1995b] will be considered for designers' attention and expected skills requirements.

11. SUSTAINABILITY

The topic of sustainability has now been well-understood in the design community. The diminishing resources and depletion of many mines throughout the world and considering the decreasing number of mineral discoveries the designers will have to become resourceful and search for new sources for their materials. The experience of concluding a recent Leonardo project called EADIS by two of the partners involved with EBDIG is expected to guide the partnership in carefully reviewing the areas of innovation for transfer from automotive sectors to yacht design and in parallel help the partnership to identify the skills a modern designer should acquire to ensure sustainability in the future. Manufacturing methods should also be carefully reviewed to ensure longer life cycles and re-usability of the materials after the products is scraped.

12. KEY QUESTIONS

During a brainstorming session at the Turkish Partner site, TUDEV, several key questions were raised. The Brain Storming sessions included 15 specialists in maritime education and training, 3 merchant navy captains, 2 naval captains, 2 sailing specialists, 4 yacht designers, 2 naval architects and 2 automotive designers. The key questions for the research posed and some of the responses are as follows:

1. What are the design and/or production specifications/techniques already transferred/in use from the automotive industry?

It was noted that sophisticated CAD/CAM systems are now being used in the industry albeit in either stand-alone or in cluster form with only a few interconnected nodes. It was noted that the level of communication automation particularly in wireless form is now wide spread in luxury yachts. Many buyers are becoming familiar

with ECDIS (Electronic Chart Display and Information System) and AIS systems and many are using GMDSS (Global Maritime Distress Safety System) in their yachts. TUDEV with several other partners were involved in the development of a novel e-learning platform for all vessel types including large ships. For more information refer to www.egmdss.com. In parallel TUDEV contributed as a partner to the development of a major e-assessment platform. Information about this package is given in www.martel.pro. EBDIG's own website is under construction and is expected to learn from the experience of successful projects in the past including those cited earlier.

It was acknowledged that modern manufacturing practices particularly those designed for one-off or batch or small stream production are applied in many progressive boat building yards. The one-off and batch production are using FMS (Facilities Management Services) practices and full integration of design and manufacturing processes are now common in boat building.

'Pull' systems are becoming common practice in manufacturing practice and most boats are either made to order or are made after careful consideration of the demand for them.

2. Which new methodologies and technologies can be transferred from the automotive particularly the luxury car design and/or production and marketing practices?

There were several discrete responses. One related to design practice specifically 3-dimensional CAD, mould making using 3-CAD modelling and surface modelling which has an implication in sculptural modelling and design of moulds for hulls of boats. Ergonomic techniques and access to controls and display units used in luxury cars was another important area for consideration. Mathematical modelling including animation and computer simulation used in automotive design practice were noted to be methods that could offer small craft designers tools and skills to develop and apply in the design of yachts and so forth. E-learning and e-assessment platforms used by companies such as Ford and C4FF (Centre for Factories of the Future) were thought to be able to help to promote this important technology and tool in the learning process and as an aid in assessment and re-

enforcement of learning. Lean practices and methods have not directly played a role in small craft design and production. The boat building industry could learn a great deal from automotive manufacturers in this respect. Market information gathering methods and use of data mining used in forecasting demand in automotive design and production was also an area where the yacht industry could learn from the automotive sectors experience such as C4FF's work with companies such as Land Rover and some of the suppliers through the prestigious TSB project [C4FF TSB, 2009] for example, Unipart, Trelleborg Industrials and Production software companies such as Preactor International. Logistics and material resourcing and transport on the shop floor are other areas mentioned [Ziarati et al, 1995a]. The Pipeline project of the Rover Group was thought of coming too late to save Rover from falling from grace in early 2000s [Ziarati, 1995a].

3. Which one of the following is the most important factor effecting yacht design, production and manufacturing concept?

- a. Luxury
- b. Cost
- c. Environment friendliness – Sustainability
- d. Easy maintenance – Sustainability
- e. Return on investment – Sustainability
- f. User friendliness

The most common response was the looks related to luxury, cost and level of user friendliness. But for more experienced sailors sophistication and availability of spare parts and maintenance was very important. There was no mention of sustainability when it was referred to directly and this was only considered important in relation to ease of maintenance and return on investment. There was no mention of environmentally friendly but most sailors prefer clean engines and do not wish to have noisy or polluting engines.

4. Can new technologies such as alternative energy generation and fuels for better emission be easily transferred from the automotive industry without sacrificing the customer's luxury requirements and without adversely impacting on cost?

The majority agreed that yacht engines are either not as sophisticated as luxury cars or that for application reasons cannot be made to be as highly responsive or fuel efficient. But the developments in developing high performance engines

particularly diesel engines are expected to make yachts faster and have a better fuel economy.

5 How can the new lean engine concepts used in automotive sectors be transferred to yachts?

No-one expressed any preference for lean engines but some foresaw their emergence in yachts. However, any depreciation of performance was considered not a good omen for yacht owners. Pollution from engines are now becoming a major topic and there is a view that regulatory authorities such as the EU will impose limits on CO₂ and NO_x and smoke emissions for water transportation in the near future in a similar manner to the limits set for the automotive engines. The work at Coventry University with C4FF's support in development of clean diesels was considered an important consideration for designers and boat manufacturers.

6 Which of the following is more suitable for the transfer of innovation from the automotive industry?

- a. Fast super-yachts for adventurous users
- b. Large yachts for family oriented users
- c. Yachts for continuous travelling all over the world without stopping for fuel
- d. Trawlers
- e. All
- f. None of above

No preference by any of those interviewed. But it was noted that 'a' and 'b' above are more inclined to expect yachts to retain their luxury aspects on their boats and facilities on board and if automation makes their yacht to perform better and fuel cost lower then they would be all for it. The c category was more interested in fuel efficiency and hybrid power units. However, the concept of hybrid was very different to what constitutes hybrid in the automotive sector. Diesel and wind power hybrid combination will in future lead to an improved fuel economy.

7 How can you combine innovations, for instance relating to the design, production or marketing, from the automotive industry to be transferred to the boat industry?

The boating companies were particularly interested in high technology and those having or interested in buying yachts were more interested in what is now available on the market in terms of AIS and so forth. The wireless and satellite technologies are

well known in shipping and yachting industries. To this end, both automotive and small craft industry are taking advantage of advancement in communication technologies however, concepts such as CAN network developed by one of the EBDIG partners are yet to be introduced to small craft design or manufacturing. However, LAN topologies are being used in automating control in small crafts and in security systems.

8 How could re-fit design concepts, such as modular structures, be used in yacht design?

This is where manufactures apparently believe there has been and will be a great deal of interest as it would make Group Technology (GT) a possible candidate for application in small boat production and will impact practices in design. Use of position sensors in cars and in Japanese ships is another interesting development. It was noted that GPS units used in cars will be used widely in boats and even ships as it would provide a good indicator of the position and passage plan verification using paper charts rather than more sophisticated systems such as ECDIS which on its installation on board has a 4-day course of mandatory training.

9 What are the two most important considerations in yacht design? Please identify/state;

- Looks
- Performance
- Quality, luxury, comfort, use of space etc.
- Materials both external and internal
- Features
- Cost
- Telematics
- Sustainability
- Automation -Level of sophistication,
- Safety features
- Any other – Please specify

The top requirement was quality expressed interestingly in terms of luxury, comfort and use of space followed by performance and level of automation. The safety features that were acknowledged are also becoming significant as well as reliability. Cost was an issue particularly for small boats. Terms such as sustainability and telematics were not mentioned as important. However, when telematics was considered as control and automation devices and communication systems it was thought to be important. The reliability was an issue and based on the

discussions that took place there is a connection between reliability and safety at sea in general, and in international waters in particular.

13. CONCLUSIONS

Design and innovation has become a key ingredient for success. There are people who refuse to buy a new house not because of its size or where it is situated, but because of its design. It was stated that a large number of people buy a car for a particular reason, for instance, reliability of Japanese cars in the 1990s led to their success in penetrating European and North American markets. To this end, the same arguments apply to boats where a particular design feature or quality dimension could improve competitive edge for a given design or boat building country/company.

This important yet unsurprising change now brings a sense of competitiveness to the boating industry meaning the boat manufacturers must respond faster and more effectively which of course brings with it extra costs. The opportunity to transfer designs and innovation from the automotive industry will result in optimised methodologies, which are expected to render the small craft industry in Europe as more cost effective.

The design of a questionnaire to seek the views of people in the automotive industry as well as those in the boat design and building community will offer marine industry professionals with the knowledge to improve their skills and understanding of the basic ideas as well as more sophisticated techniques developed in the automotive sector for application in their own industry. The argument here is not that the automotive industry has nothing to learn from the small craft industry but that this project is about making the yachting sector, in particular, become more competitive through rapid learning, benchmarking and rapid prototyping of the appropriate innovative practices in the automotive sector. This is expected to allow boat designers to visualise products and eventually this will result in a wide-range of boat industry design and/or production and marketing personnel being made aware of the latest technologies and techniques.

The project is about what aspects of innovation in the automotive industry in terms of design, production and marketing can be transferred to small craft industry. This is expected to help designers to learn also about how the shipping industry has adopted some of the innovation in this connection. The second issue is to develop the skills of yacht designers in aspects primarily concerning application of telematics, use of materials and the strategies for sustainability.

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