THE DESIGN PRACTICE

# MODULAR CONSTRUCTION IN LARGE YACHTS - an approach

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One of my earliest, lingering memories from childhood is the sound of the rivet guns from John Brown's shipyard no more than a stone's throw from my home. The relentless hammering combined with great crashing sounds as huge steel sheets landed on stone quaysides is both haunting and evocative. And when the yard horn sounded and the gates opened, out flowed a mass of humanity all running for buses and trams on their way home. Two things always struck me at the time, one was the number of people it took to build a ship and the second was how long it seemed to take. OK, so a long time has passed since the late 50's and early 60's when these thoughts first occurred to me. Heavy engineering has been given a blessing called technology, and construction systems and processes have been revolutionised.

My own professional involvement within the passenger shipping industry stretches back to the late 1980's, not nearly as long as many assembled here, but enough to have seen many developments and changes: the introduction of Computed Aided Design being probably the most exciting feature from a designers perspective. And a designer is what I am. My own consultancy, SPACE the design practice, supplies architectural and design services to various aspects of the passenger shipping industry, whether that be the luxury cruise sector, fast ferry and more recently the mega yacht market. We are also involved with other forms of high speed transportation systems and terminal facilities. But our experience is not confined to all things that float and many of our projects are land based. This varied scope offers us an opportunity to see ways of delivering design and construction from many perspectives and in many different cultures.

I have never seen the discipline design and architecture as purely something that is exclusively associated with the various aspects of the construction of a project. Delivering front-end thinking and the skills needed to empower clients in their markets is more where we should sit. Our central proposition has to be credible leadership and the creation of markets that are relevant to present and future customers. We need to be the spacemakers and the visioneers, both pragmatic engineers of the feasible, and creative strategists of the aspirational. In both guises we must make it possible for our clients to transit from mission to vision. We create, exploit, re-cycle and deploy knowledge; we glean it, clean it and help build business, visions and experiences with it. In this sense - intellectually, in corporate communications terms - our foundation and key asset is *knowledge*.

This paper is about 'modular construction within the larger yacht sector'. By looking in part to the cruise shipping sector this paper will explore the application of modular construction processes to the larger yacht market with a view to identifying whether benefits can be achieved in terms of improved manufacturing processes, speeding up production and increasing efficiencies during the build programme - or generally saving costs.

I have made a point at the outset of stating that I will be looking in part at the cruise shipping market as this is where my primary shipping experience lies. However, I shall also be reviewing other industries, both offshore and land-based, taking the knowledge created there and redeploying it within the context of large yachts: 'gleaning it, cleaning it and re-deploying it' to build these visions for our clients.

There are some words and phrases which seem to evoke an almost Pavlovian response every time they are spoken, and 'modular construction within the yacht market' I think may well be a good example. Love or hate the concept, there appears to be little ground in-between, especially at the top end of the market. Modularity seems to be seen as sitting well with those other odd bedfellows; prefabrication and standardisation. All commonly summed up by the words, *cheap and nasty*.

**So why am I talking about it today?**

Well, having spent almost 20 years in various aspects of the design industry, I have seen it and the business of design change as expectations and aspirations grew, and as technology and wealth emancipated those very ambitions. The design world today is very different from the one I stepped aboard back in the late 70's. And it isn't a matter of fashion that I refer to either. Fundamental changes and cultural drivers have taken us forward

and are continuing to drive us at an uncompromising pace. Organisations in any aspect of the business world which have not kept up with or taken onboard these changes have gone and will continue to fall by the wayside. Methods of delivery, whether information or construction, have changed beyond recognition, and so from where we stand now in the 'Funky 21st Century' we have to be clear as to the new ground rules for delivery and engagement.

I wish to explore, within the limits of this paper and the time available, the concept of modular construction within the field of larger yachts in its *widest* definition. I *do not* want to limit this to be merely a cursory look at hull manufacture or standardisation of components. I *do* want to explore and even propose that the industry has an better opportunity of powerful continued development, underpinned by sophisticated, cost-effective construction processes, if it were to adopt and embrace, explore and develop modular construction more readily than it has to date. So my definition of modular construction is a wide one and includes comment and illustration from many industry sectors with a view to locating appropriate parallels and alternative solutions which provide both benefits and advantage. (The term 'benefits' will be an issue which I will investigate as I believe that the future for any leisure and pleasure based industry player must include showing how they deliver benefit. It has to be a daily part of their sales and marketing initiatives more than ever before.)

So to start with lets define our terms:

**Modular Construction**

For clarity and appropriateness my definition encompasses the wider aspects of the definition and does include *prefabrication* especially when it comes to the interior components, as well as the fairly new area within land based residential architecture, namely the concept of 'transformable architecture'.

The American National Standards Institute defines modular construction or modular measure as:

*"A system in which buildings are so designed so that their dimensions are multiples of a given figure. Modular measure simplifies the problem of producing standard building components and materials that will fit together in a wide variety of applications."*

The very words "standard building components" are almost an anathema to many designers and builders within the super yacht industry and this issue is the spark which most often ignites the volatile debate surrounding a modular approach to superyacht and megayacht building.

But let's take it further. Modular construction is more than standard components, it is in reality a method of construction where the components are created

- off-site
- under controlled conditions
- transported to the place of final assembly
- in three dimensional sections, and
- installed on a primary infrastructure

All of the above elements, I would suggest, are in fact *benefits,* adding value to any construction venture whether that be on a building site or in a shipyard. Control of the means of production is after all the *holy grail* of the construction industry.

Let's take the concept further. If modular construction is viewed as being an off-site manufacturing process, are we not really talking about it as part of the wider aspects of prefabrication? Again, from an historical perspective, prefabrication has always been "synonymous with industrialised approaches to construction and with end products that have not necessarily met the expectations of customers or society", to quote one textbook on the subject. However, over the years we have seen increased sophistication of and intervention by technology, as well as its integration with other aspects of the construction process, which has allowed prefabrication to move to a new level of quality and performance - often because of the interest taken in the production process by both artists and designers.

Prefabrication should simply be considered as making buildings in factory conditions, indeed prefabrication is about:

- rationalisation not just standardisation
- pre-assembly, and
- modularisation

But that does not necessarily mean uniformity. Quite the opposite, if considered in its correct context and implemented as a fundamental aspect of the project process. Designed and controlled, it should be a prescription for increased:

- quality
- variety
- delivery, and
- efficiency

How? Standardisation or rationalisation, often mistakenly thought of as monotonous and of low aesthetic appeal, are really about adding *certainty* to a process that could and can lack *clarity and discipline*. They are about:

- improved predictability and quality
- increased efficiency
- systematic improvement
- social and environmental benefit, and
- ease of maintenance

All to be considered benefits in anyone's eyes.

Pre-assembly should be something which designers and architects champion simply because it is designed to help lift the quality of finish and workmanship and is generally not compromised by variability in performance of project site-based production in site conditions. Fewer defects should be expected, and the results should give:

- better control of risk
- higher likelihood of the client achieving value for money
- more robust design solutions
- safer working practices and less on-site problem solving, and
- fewer defects and lower maintenance costs

Surely this must be considered a win-win situation.

The great thing about pre-assembly in terms of the construction process is that moving the work from the site to the factory allows you to change the rules. This means that you can achieve a higher degree of integration of specialist trades than may otherwise have been achieved under less controlled site conditions.

I would contend, therefore, that pre-assembly is about optimising work: it is about manufacturing, not constructing. The distinction is important as one of the crucial aspects of manufacturing is the production of consistent quality at the lowest unit cost. It is also about implementing learning and development incrementally to the benefit of the end user – the procurement departments and final assembly points. The competitiveness of the environment occupied by manufacturing not only forces innovation but drives excellence through the continual need for product differentiation by the manufacturer against the competition. The burden of heavy investment in fixed capital goods is taken away from final fix and assembly venues and distributed amongst the manufacturers and suppliers.

With all of the benefits outlined above one would anticipate that construction industries in general, including the highly competitive and complex superyacht market would have adopted and improved upon every aspect of off-site production and prefabrication. But this is not yet the case. There is an almost bigoted stance which has been adopted in Europe to these new ways. Perhaps there are too many other vested interests which have conspired to preclude this new wave of innovation and keep it out of our yards?

Or is this the case?

The development of the super and mega yacht markets over the past decade has surprised even the most experienced maritime journalists. The ultimate designer accessory is the yacht. And more. It is proto-representative of 'lifestyle absolution', embodying in three-dimensions "Aspiration Achieved". It is the yacht with the "things which no other yacht has", and it is also about size. Yes, size *does* matter in this game. And as the scale and complexity of these creatures increases, changes have begun to occur with regards to where they are constructed. Traditional boat builders may be being superseded by the shipyards more used to building cruise ships and ferries simply because of the scale of the vessels being designed.

To quote Roberto Giorgi "today the normal builder of yachts does not have the facility to build very large yachts (almost all are busy until 2007) so I think it will be interesting for the large yards to enter this business. And it is the same with interior designers and architects".

And it is in these very shipyards referred to that alternative construction processes are most advanced.

Ships are still the largest objects set in motion by mankind. IBM in their paper on 'Solutions for Shipbuilding' are particularly clear in their thoughts about how things should be done. This is not a matter of opinion this is a matter of urgency. The modern cruise ship is at the forefront of this.

"They stand as tall as skyscrapers, floating cities that are the largest, most technologically advanced structures ever created by the hand of man."

"With as many as 1 million parts, the most advanced of these vessels dwarfs in engineering complexity even the modern jet passenger plane, with just 150,000 parts."

But in common with all industries, global competition is forcing the pace of change far more rapidly than some believe. The need for innovation has never been so important in a world where a competitor can copy your latest idea in a few weeks, days or even hours.

"The amount owners are willing to pay and the time they are willing to wait for new ships has declined. Being able to deliver ships faster and at lower cost has become a deciding factor in the competition for new contracts."

"Ship designs are being evaluated earlier in the design cycle, which maximises the sections which can be fabricated in existing robotic workcells, but considerably shortens available design time… working with subcontractors allows yards to leverage specialists who can produce the most advanced systems quickly and at the lowest possible price."

"Modular construction methods cut man hours 30–60 per cent but increase coordination complexity exponentially, requiring multiple enterprises to act as one digital enterprise."

The message is clear. The introduction of both sophisticated specialist offsite and modular production, combined with the highest trained and best technology, delivers competitiveness and product differentiation. Without this you are dead in the water.

Shipyards are not newcomers to modular processes. As far back as the days of the Liberty ships, many of which were constructed far inland and well away from the final place of assembly these vessels were built in sections, transported to shipyards and welded together. The first vessel, the Patrick Henry, launched on 27th September 1941, took 244 days to build. Once the design problems were ironed out, construction time was cut to 42 days, but in 1942, the Robert E. Perry took just 4 days and 15 hours to build from keel up. Although this is generally seen as a US concept, the basic design concept was taken from general purpose freighters produced by the Sunderland Shipping Company at Newcastle as early as 1879.

So the idea has been around the block a few times. Today the Block Build technique is the norm. With pieces as big as an apartments building, manufactured in one location and hauled to the assembly floor. Today in shipyards like Kvaerner Masa Yards in Helsinki block construction is a refined art. Although the yard throughputs some 25,000 tons of steel per year, the steel storage area is very small as Kvaerner operates a just-in-time delivery on an almost daily basis. Small teams of fabricators constructing the sequential blocks.

When it comes to the final outfitting the “company is very aggressive” about outsourcing. At this time, we are told, about 50–55 per cent of a completed ship cost is spent on contracts to buy parts and services from other entities that are better (and cheaper) at building and providing them than the yard. The most potent example of this concept is cabin supply. Pikkio Works, located nearby in Turku, employs around 200 staff and supplies various shipyards with pre-manufactured cabins. If you think that in a cruise ship around 50 per cent of the total deck space available is taken up by accommodation (cabins) then this is significant. The cabins are fully complete when delivered, including all furniture, bathroom fixtures, carpets and bed linen.

We at SPACE are developing our own cabin system. Funded by a British government innovation grant the project sets out on one level to create and design a modular solution of high quality, for all types of passenger vessels, albeit initially aimed at the cruise and ferry market. Our own commitment to modular solutions and manufacturing quality made the exercise almost an imperative as far as demonstrating to the industry what could be achieved. The first module is designed and we move on to looking at solutions for many other formats and sectors. The other driver for the project was to see if it was possible to introduce a newly developed, non-combustible material called Comfire to the passenger shipping sector. The materials key benefits being its complete non-combustibility, comparatively light weight and its workability as a material. We intend developing our ideas further with some of the key manufacturers within the industry as well as with potential end users.

Kvaerner are considering expanding their outsourcing capabilities for turnkey components to include galleys, laundries, gaming areas and casinos, right down to the bridge itself. So here is a modern shipyard, not only alive to the possibilities of the benefits of modular construction and prefabrication outlined earlier in this paper, but already actively involved.

Of course cruise ships do not necessarily have as many of the flowing lines and curves formerly associated with great liners and elegant sailing craft. One of the most used arguments against the modular or prefabricated route has been things like sheer line and hull contours that theoretically reduce the scope for modular cabins, which have always been constructed in place and made to fit the curve of the hull, as well as doors and walls made to fit the perpendicular. But again this is a matter of what IBM called “coordination complexity “ and where computer technology lends such a helping hand in the planning of pre-manufactured items. If a full size computer model of the vessel can be drawn on computer then there is no reason why every eventuality should not be pre-planned for and considerations like sheer, camber, curve, profile and quirk cannot be catered for remotely.

One naval architect in the yacht sector stated that “stock hulls are becoming more of a trend. Yachts used to be fine, narrow, fair hulls and faster than ordinary vessels. Ships are now becoming much beamier and a beamier, less profiled hull form gives a lot more room for prefabricated solutions in all aspects of manufacture. In many ways one of the least important items is the hull shape. The dynamics of stability can be got around with stabilisers after all. Hulls are just not as important as they used to be, especially in larger vessels. What is important is the onboard living experience and the individuality of that experience. No, the real driver is COST. And cost is why we should be exploring modular construction and prefabrication techniques in all their various guises”.

As Dr. Hans-Dieter Ehrenberg of Blohm + Voss in Hamburg states: “The competitive situation of the world shipbuilding market requires innovative solutions from yards, especially when situated in high wage countries.”

“This development tends to underscore the emerging importance of what one commentator referred to as 'software' (meaning the interior vision) over 'hardware' in identifying one company’s “product” from another’s whereas in the past the external appearance of ships was more strongly associated with the identity of the vessel’s ownership.”

I once shocked and appalled the marketing manager of one major cruise line and a senior surveyor from Lloyd’s Register by saying that the cruise industry had nothing to do with ships and everything to do with dreams. Cruise customers and many of those who buy large yachts are not necessarily afflicted by some sort of ship mania, indeed often the opposite. How she is on the *inside*, how she looks and feels, and the level of quality and finish is what gets noticed. The *experience* is why people cruise, collecting experiences and memories on each voyage. And it has a term: ‘yachtstyle living’.

But by the same token, if the onboard experience is an important aspect of ‘yachtstyle living’ and if for owners the individuality of interior spaces and the environment which that creates is a potent chemistry, then perhaps the key

to the successful introduction of modular or flexible construction techniques has to be proven to work for the interior spaces more than any other element.

I started off by suggesting that the industry had not really embraced modular construction and prefabrication, but that's not entirely true. There are many examples to be found where prefabrication within the yacht market exists, from Lürssen in Germany with their six key manufacturing technologies to Specialist Marine Interiors Limited in New Zealand with their 'box-in-box' technique. SMI states that "their commitment and passion is to produce superyacht interiors of a superior quality without compromise, and to offer substantial advantages in design and bottom line through revolutionary and innovative systems and the efficiencies of remote build interiors." Their basic technique involves creating 'box-in-box' solutions of modules which replicate vessel contours and interfaces to allow factory finish quality to be produced fast and cost effectively.

For SMI cost is a big driver in their approach, and rightly so. If we are to develop the industry then we have to make access to it easier. Cost effectiveness and efficiency is a route as is transparency of operating techniques and cost build up procedures. Demonstration of intrinsic cost saving approaches gives credence to and product differentiation to any player in the market over the opposition and it is something which I believe is being demanded by more and more clients and potential clients.

I mentioned earlier what I called the 'blessing of technology' and I meant it. Technology can allow you to remotely create any aspect of a built environment, pre-assemble it and ship it as a complete module or as a 'flat packed unit' which can be re-assembled on site. OK, so SMI may only be talking about vessels of around 50 metres but scale is not a limiter with this approach. Of course these vessels may be of high quality but they are not super-luxury. Perhaps the megayacht market demands greater interior responses than this. I believe the key to the whole solution working relies on sophisticated 3-D programming and construction software. Up-front thinking and planning is the key to success. Time is the final arbiter of all decision making processes and pre-planning the most important aspect of any construction exercise.

The requirement for unique interiors within the superyacht and megayacht market is consistently regarded by many as being the fundamental limiter to the full introduction of modular, prefabricated or standardised componentry to that sector. I hope that some of the procedures and examples already mentioned have rendered that objection invalid. The development of client particular and super luxury interior environments using unique floor plan arrangements, exclusive fabrics and other materials as well as customised furnishings and fittings are all elements which can be included as an outsourced and pre-manufacturable item. The specialist joinery items so often laboriously fitted in situ could be organised so much more easily if up front planning and full-on CAD technology were implemented in coordination with a real partnership of suppliers and subcontractors utilising the best approaches in manufacturing procedures.

If one looks at the number of elements within the typical build programme which are not seen as legitimate outsourced procurement elements, the scale of pre-manufacture within the cruise markets can be seen. And when you break down the interior elements into components this to is a very solvable problem.

Elements which can be either modularised or outsourced for pre-manufacture include:

**Build and manufacturing issues like**:

- hull blocks including infrastructure and services (subject to regulatory issues regarding interphases)
- cabins of any level of sophistication, finish and arrangement including fully fitted wet modules and bathrooms
- lift cars where deck penetrations are left open for ease of installing elevators directly into their shaft. These prefabricated units are installed with the lift car already fitted in the shaft and the whole assembly is brought to the yard pre-built
- galleys
- services and flexible piping (dependent upon regulatory issues)
- all cabinet work, panelling systems and carpentry final fix items
- flooring systems
- integrated mechanical and electrical runs
- smart connection modules
- ceiling systems

**'Software' issues like:**

- all soft furnishing including furniture is manufactured remotely anyway and when it comes to final fashion elements soft furnishings give the last distinctive edge to the interior architecture
- artwork
- accessories and sculpture

**Technology issues like:**

- building management systems
- power plants and drives capabilities
- TV/sound/mutimedia/internet/communications/and-wrap-around-luxury
- lighting and morphing technologies

The list goes on and on. If you really look at how we do things, is there any area where innovation and aspiration will not allow us to refine and redefine how we go about the process of modularising what we build, whilst at the same time maintaining a unique and still cost effective vessel for our clients?

**Every building sector has its own response to modular construction and prefabrication.**

Offshore platform and accommodation modules especially those working in extreme conditions like the North Sea or West of Shetland responded to the economics drivers of their quest and hence geographical location and responded with ever more complex sophisticated and streamlined delivery methods.

Residential housing. Japan has spearheaded the innovative use of prefabricated building components within the housing sector citing four key characteristics as tenets of the process: continuous 'flow-line' production; standardized production; planned production and mechanised production. These allow for faster construction work on-site, less skilled labour requirements, enhanced quality, improved working conditions, diminished affects of restrictions on-site and of course reduced cost of production. This is also being explored in the UK and the US for low-cost housing solutions for key workers in congested inner city locations.

Hotels are being designed like 'wine racks' with the various bedroom concepts slide in like bottles on a shelf. From the famous Japanese capsule 'sleep hotels' to the recent developments in the UK of the easyHotel and Yotel! brands and extensive activity in the USA in the low-rise motel sector, the opportunity and design flexes to meet the individual market requirements with the operators' key motivation being product differentiation and cost efficiency.

Transformation Architecture. This can mean many things originally simply the introduction of technology or the use of modular construction techniques to facilitate construction but more recently it has taken on a more dynamic meaning, namely the development of complex devices for modifying and customising architectural space on a day-to-day basis. Yachts are more difficult to modify on a regular basis as far as internal arrangements are concerned but technologies do exist which allow for many environments to be created in one space.

But one of the most interesting analogies to bear in mind is the global automotive industry where high end quality and luxury products are delivered on standard chassis with customised interiors and accessories which meet the individual needs and wishes of prospective customers.

**Conclusion**

It is not my intention to belittle the complexity of super and megayacht construction requirements. It is my intention to promote positive debate in extending all our thinking into what can be done when it comes to revolutionising how we do things.

In a recent investigation by the University of Nottingham on the effects of "Modular building services distribution on construction sequence, time and cost" one conclusion reached was that: *"In the manufacturing industry, the concept of 'design for manufacture' is a vital part of delivering efficiency and quality, and (the) construction (industry) needs to develop an equivalent efficiency and quality of 'design for construction'."*

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In other words look for improvements in processes and procedures which increase quality and diminish cost. Change how we define what we do from 'construction' to 'manufacture' thereby changing the way we approach how we design and create the spectacular visions which the industry is renowned for.

The Bauhaus talked of Art + Technology as a new unity and perhaps that concept is more relevant today than ever before.

"Current shipbuilding practice has reached a high state of development bringing together high tech solutions in engines, systems, construction methods, and material with economy of scale and series production. This allows an effective vessel to be assembled using a range of standard components and *yet be made unique* (emphasis added) by the embellishments of the designer and the artisan's finishing touches." - *Gordon Foley*

I started off by saying that this paper was all about modular construction but that is not really the case. This paper is really about change. A change that is happening now and which we all have to take a hard look at.

A few years ago we found a new group of billionaires in the market' keen to sample the delight of the ultimate luxury accessory, the Russians. But soon a new group will supplant them in terms of aspirations - the Chinese. The Russians have shown that they to can build yachts, but the Chinese may go further. It will not be their intention to be good at building ships, cruise or yacht, it will be their intention to *dominate* those markets. And they will not bring with them any hang-ups about traditional craftsmanship and techniques. They will bring with them the most up to date manufacturing techniques gleaned from the best in the business around the world. So should we not all be taking a closer look at what modular construction could do for us now?

If Roberto Giorgi is right then the big shipyards will be only too keen to take a piece of the yacht market - and they will certainly not be keen to give it back.

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**SPACE** creates the places and spaces where people work and play - innovative design solutions which challenge convention and reflect the current and future needs of our client's business and their customers

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