

## GLOBAL SUPERYACHT FORUM 2006

Conference Day 2 — 14th November 2006

### Construction Forum

Michael Eaglen	High Modulus
Jan Rozie	Yacht Glass
Ian MacDonald	Classic Yacht Refinishing
Wim Koersvelt	Icon Yachts

### Martin Redmayne

Ladies and gentlemen we're going to start our final session of day 2. For the last 24 hours we've talked about the incredible boom in our market, the amount of growth, the amount of new orders we're taking, the amount of deliveries that are on the horizon. It scares the hell out of me—how are you guys going to deliver that amount of work. Luckily I only have to produce a magazine every month, that's easy. Isn't it, Tork? Essentially this session is a bit of a mixture of presentations from two technical experts in the materials world and two experts in the actual construction world. Wim Koersvelt has embarked on a new career, heading up a shipyard called Icon Yachts and has some interesting comments to make. Ian MacDonald I've known for a long time and looks great on camera that's why he's up here. Ian is one of the finest yacht painters in the business and he's here to represent the quality standards issues of construction. Nearest to me on the right is Jan Rozie, a man that spoke at project back in '97 about the glass world, as glass is a major issue under MCA. He is Mr Glass, if you ever want to know anything, he's got a brilliant mind. Michael Eaglen at the end is one of these computer men who is incredibly good at engineering composites and is working for one of the finest companies I know, in New Zealand, High Modulus. Incredible business, who are doing some wonderful technical work.

We're going to start with Michael because he has a presentation on where he thinks the world of high tech engineering is going in yacht construction. The process is going to be 2 short presentations from Michael and Jan but then we're going to talk about construction methods, construction from the point of view of efficiency, speed of build, and modularisation, then open it to a discussion with the floor. Michael, can you start off please.

### Michael Eaglen

Gosh I can't see a thing. Good afternoon. I'm speaking today on the future of superyacht engineering from a composite structural engineering perspective. And there's a few things I'd like to pick up on that have been said in the forum and in some of the preliminary stuff for today's session about some of the benefits of technology to our industry. It's quite obvious to most people here I'm sure that technology has really moved a long way in the last 5 years, or 10 or 20 years. I guess that's particularly obvious in the composite world, but it occurs in all areas of the yacht construction field. Computer aided design in its many forms is the cliché but it's really driving all of what we do in design, whether it be finite element analysis, computational multi objective optimisation, leading through into CNC machining, and also all the information sharing side of what we do is various national design teams. We're involved in a lot of projects at the moment where we have more than 5 nations represented all over the world in the design team, and the way we share information

through that process is pretty important to making sure that any of us can make money at the end of the day, because it has great potential to be a very time consuming problem. All this new technology drives improved processes for us and improved accuracy of everything that we do is a really big part of that, quality is hard to measure but in each specific area we can measure it and I don't think many people would question that this technology enables us to improve quality a lot. Clearly faster production is a very major outcome and we'll see later on today some of the things that some of the top builders are doing in terms of shifting the construction process along and producing boats faster. I talked about quality and really the quality in most cases is improving a lot. Also the performance of boats is massively moving. We're involved in some very high speed motor yacht projects and very high speed or high performance sailing yacht projects, superyachts and racing boats. That's just moving on faster and faster, and in fact the cost effectiveness despite inflation effects is also moving along very quickly. We're actually able to achieve things very much more cost effectively now than we were able to 5 years ago. Composite materials in particular is a huge research area; there's a lot of collaboration now between the key players in the marine composites area and those in the aerospace and automotive industries. And that's very significant, it's always been there, but it's increasing. We're ourselves doing some major research projects with some of the big aerospace companies and some of the big airlines in composite materials research, interestingly enough in both directions. We're learning a lot from some of the analysis they're doing, we're using a lot of the analytical processes that they've used, a lot of the finite element software that's been developed for those industries but also we're sharing a lot of our knowledge about more cost effective and more time effective build processes to trickle up into the aerospace industry from the marine industry and I think that's certainly very enjoyable for us and I think does a lot for our view on where the marine composites world is relative to the rest of the world. We obviously see a lot of trickle down from the Grand Prix projects, the America's Cup, the Volvo Ocean Race, the high speed motor yachts, the offshore racing power boats. Those are the projects that we use to push the boundaries, to understand more about composite materials, to justify the R&D programmes. And very very rapidly those things trickle into the superyacht field first and then into the production boat field, and we're involved in all facets of the marine industry and we see very very strong trickle down into all areas. In fact I think it's probably in the production boat market where we see some of the greatest benefits of the high end analytical processes because when you're building 1,000 boats you can really make a big difference by saving \$50 per boat, compared to building one or two boats. There's a lot of revised analysis of loads in boats. For a long time we've been using load prediction formulae which were generated in the 50s and 60s and based on metal boats and they've worked pretty well for us; we don't have a lot of boats that fall apart and those that fall apart are not normally falling apart because we don't understand the loads. So in most cases we haven't had problems but as we push the composite materials further and further it requires us to understand the loads better than we've had to understand them in metallic boats and there's quite a bit of load analysis being done in sailing boats and in power boats, to understand better what loads we're really seeing. And the composite materials industry is a very rapidly growing market in the superyacht game. A lot of metal boat builders are moving to composites for all sorts of reasons. In the computer aided design side of things the virtual design, the designing everything in the computer before we build it is a very hot topic and a very fertile area of development. The automated exploration of design options through computational optimisation routines is really a very very significant development and quite recent. I've been involved in organising a conference in New Zealand that's been running since 2002 called high performance yacht design. It's a yacht research conference and in the 2006 edition we were quite taken aback by the amount of research that was being presented in computational optimisation and I remember

coming out of that and saying to my colleagues at High Modulus hey, we need to take notice of this computational optimisation, we've been doing manual and semi computational optimisation for a long time, we really need to take notice of what automated processes are coming on stream. I said you know, it's not going to happen overnight but it is going to happen reasonable quickly, maybe 5 years. Well 5 months later we're doing it, we've completely turned our design process upside down and we have computational optimisation right in the very front end of the concept design stage. It's a pretty big deal for us and we think we've been leading the industry in the way we design composite structures and to have such a big change in such a short period of time is frightening. Fortunately the software, the experience, in the aerospace industry has really helped us to adopt those processes without turning our entire process into a shambles. The ability to build the boat virtually in advance has really changed the way we fit out our boats; the time it takes to build a boat from start to finish and really the quality of the boat we produce at the end of the day. So what's the downside? Does it make it more expensive? Does it make it take longer or does it reduce flexibility. It doesn't, or it doesn't have to. But it can, all of those things can be a problem if we let them. We need to remember what the end goal is. It's been suggested that in the future this technology will reduce our construction times dramatically and we're going to see that it's not just the future, it's happening now. Quality and reliability will improve, increased automation will reduce labour time and the designers will start adopting new approaches to their design process, visualisation and planning will eliminate changes and the owners will have to make their decisions earlier. Just push the button and the boat will be made? Perhaps not. The engineers love it; they go better, faster, brighter, more predictable processes, lower risk, higher quality, all these are things that we strive for as engineers and as boat builders, in the industry as a whole. But if we look again, the craftsmen will be replaced by machines? Will they? Designers will have to adopt new approaches. Is that good for the design or is that just good for us as engineers and boat builders? And the owners will have to make decisions earlier. It's really turning the whole creative process upside down. I think it can be a very very good thing but we need to ask the question—where's the fun? Because why do owners build superyachts? There are plenty of boats out there for sale, if they're in a hurry for a boat they just go out and buy one. Are they looking for technological improvement? Do they want a boat that's technically better than all the others out there? Not often. They want to do it because it's fun. They want to do it because they want to create and they want to be involved in what is one of the most amazing creative processes that's available to us at the moment—creation of a superyacht. So if it's a pushbutton solution then what type of custom boat is it, and given the advancements in other technologies is that solution necessarily the best solution anyway or should we be retaining some flexibility. And I think the good news is that the technology enables us to retain flexibility in the areas that matter. A lot of concurrent design through integration of the design team, the rapid tooling processes that are available for composite materials, for composite construction, some of the items that are critical to the owners, we can leave quite late at times. And the things that are critical to the operation of the boat we are can bring forward in the design process and if we properly understand that design process then we can really make a better boat, a better process for the owner. Keep the owner focussed on the things that actually bring value to him or her. There's a wide range of processes available to us and that can be very helpful to us and if we plan our process and we establish which bits can wait and which bits have to be done in the front we can leave aspects of the final form until quite late and we'll hear I think a little later about how we can do that. Things like communications masts, we can work out the guts of what we need but the styling of them or the final details in terms of which electronics are going to be involved enable us to actually improve the boat we're doing by leaving some of those aspects until later on. So I think we're in a tremendously exciting period and it's only going to get more exciting.

Composite materials certainly enable us to do some things that we can't easily do in other more traditional materials and the technology that's opening out and the attitudes that are opening out really are going to make for some tremendous boats and I hope a tremendous experience for our owners, because ultimately they are the people that we're serving.

## **Martin**

Michael thank you very much. I'll throw the floor open after Jan has said his piece.

## **Jan Rozie** Yacht Glass

Good afternoon. I'm working almost my whole life with glass bending and the future for glass is, especially in the yacht industry, a very good one because most ships at this moment which we see at our table are pictures from steel; everyone works with glass and of course glass you can work and do a lot with it. One of the things which is very important is the breakage of glass. The developments in glass in the last 20 years is so enormous that the newest technology is the chemically toughening, it's an old technique but these days it's used specially in the yacht industry and in the car industry and the breakage was one of the biggest issues by the designers, because we have curvatures and you have flat windows it is always a big issue for the classification. Because we test a flat window, a flat pane, and you make it 12:12:12 and you take a size from 3metres x 2metres it will wobble, but when you have a window 6:6:6 and it is curved then it don't wobble because then you have a very strong surface which can absorb a lot of force. And that is the future. The most designs from architects have curved forms, organic forms, so when you have windows which you want to have very large then you need curved surfaces and that is one of the tests which we are going to do at the end of this year where we want to test flat materials in the same size and same thicknesses, the same layers inside, and we make the same tests with curved, in the same size. So that we can find out and can prove that a curved glass, the same as used in the car industry, is much stronger and can absorb much more impact. Because the new designs which you see is what the car industry is assembling and my ideas are also that the most companies which I know and work with are building parts; first it was little parts and now they're making bigger parts, assembling them together. No-one brings a little piece, the components are bigger and bigger because everyone wants to have a yacht in 3 months. So the future for glass is also in ceilings of glass but it's all toughened, specially toughened, chemically toughened glass and the breakage—and that was one of the most important issues—in the last tests this year—was that when you have a breakage in glass which is normally chemically toughened you have a hole in your ship. So every half year there are coming new products on the market, special layers, special glues, all kinds of window constructions, the glued in is at the moment 80% of the building in situations; the clamp in systems are only used in the lower decks. So you see that a car and a ship are almost working in the same situation. The problem is of course we see that with some systems on very large yachts many architects send us drawings where the filler is a problem because it takes a long time and they want to speed the delivery time so for those ships we have designed glass walls and those glass walls are infiltrated with systems, photovoltaic systems so that you even have electricity from the sun. Then we have switchable glasses. In the near future many types will be switchable in different kind of colours and that is also the same with mirrors and all kind of materials because glass is a very ecological material. You can 100% reuse it and can control light with it. Another thing is, and I think it's very important, that you can translate also in your railing systems glass paints, you can bring light into those systems and it will be also possible in the future that you can have movies which you can watch on your

windscreens, because glass is one of the oldest materials that we use in the building industry, in ceramics, and what we want to prove is that the curvature and that is the shape of the glass, is very important for the stiffness and the laminate, what we do with it is, we have tested laminates, very thin laminates, the same as in the car industry it was 4 layers of 3mm glass chemically toughened and they can absorb up to 290 kilonewtons on the square metre. So the material is very strong and how thick it is, how heavy it is, and how more complicated it is and how more time it takes to build such systems. The most systems for yachts are all one offs; we make for every window one mould and that is normal in the glass industry but it would be possible to make more complicated shapes with our new technology. You see it in the times that people make wooden moulds from every window or every system, these days you have photometric systems. You can work in New Zealand and over the internet you can get all your data wherever you want in the world and they can work with the data; they can work very precisely and you can reproduce those systems. So our opinion is that the new technology in the glass industry will give the architects very very interesting things to work with, with bigger panes in a curved shape and I would like you to read that in February—we want to make some advertising where the new shapes and the results of the strength are reported. Thank you very much.

### **Martin**

Thank you. I can't imagine designers having bigger panes than they already do but anyway. Wim do you want to come to the podium or sit there and talk?

### **Wim Koersvelt**      Icon Yachts

I stay seated. I wasn't prepared to deliver a statement or a speech or a paper but the things that I heard could have been said by me, especially the things that you said, even though I am not working so much with composites at the moment. Like Martin said, I'm in the process of organising a new shipyard here in Holland that can build yachts starting with a pair of 62metre yachts and we can build up to 150metres in a covered dry dock facility. We'll be able to lift 4,500tons, that's all being organised and under way and the interesting thing for me was to almost have a midlife not crisis but career change is because the challenge was to build these boats in a way that would make use as much as possible of modern technology, in other words whereas in the old days and still at many yards the man in the blue overall with 40 years experience would build something very pretty, nowadays there are quite a few young guys, much younger than me, who have computer skills, who have experience and yes, we are actually virtually building the boat. We have been—this 62metre concept we have over the past year and a half been building virtually. We have not started our steel construction, these are big steel aluminium boats for the time being, the repeat boats will probably be composite because as was said, composite will probably be 20% cheaper to build than aluminium and also 20% lighter. But we are virtually building the boats and we postpone actual fabrication of the steel until every bit of engineering, every item that needs to be welded, will actually be on the drawings. And when the drawings go through we will do this with Central Steel in Holland, a company most people will know, when the steel fabrication drawings for each individual building kit, for each section—average weight maybe 50—60 tons, when they will be released every item that needs welding will be in that boat. That includes every penetration, every foundation, everything will be in the boat. We think we've calculated tremendous time savings as a result of that. We go a step further; every system in the engine room or technical space is completely designed in 3D, we have the virtual man walking in engine rooms and technical spaces and operating the systems, changing filters, to see if we can make this work. The systems after they have been engineered there will be feedback to the structural engineers to include

the foundations embracing whatever you need in steel, already in the steel drawings before they are released for production. The technical people who will install the engine room will actually, while the steel work starts, they will start at the same time—this is where some of the time saving will come in—they will prefabricate complete systems. A nice example is Hydroelectrical Marine we all, most people will know, they deliver you a complete assembled freshwater system, reverse osmosis multiple units, filters, backwashing, we have actually gone so far as doing that with every system in the 62metre yacht. It takes the fun out of boat building, I was just told, but I don't think so. Because you can go through an optimising process. In the last let's say 4½ months ago this steel fabrication drawings of this hull, 400 tons, were ready. Most builders would have started building. We decided not to. We will start cutting steel like I said mid December. In that period we have been able to do, I could write a page full of changes, where we could make small adjustments, some quite large adjustments. To optimise the balance of the boat, the trim of the boat, we could change some of the structural elements, we can more efficiently install pipes and ducting. We had a very good example where we moved the bulkhead under in the stern of the boat so one could actually—an engineer can actually go in there under any circumstance without too much problem; his steering systems on the boat, get and reach everything. So virtually building the boat will enable you to optimise and improve. The pipe systems are completely designed in 3D, again necessarily so you can make your proper penetrations in the metalwork but every drawing, every pipe from 50mm upwards is designed but always in the back of the mind who is going to build them and how is he going to build them. So very often, you all know, pipe systems have many bends, many shapes, many forms, the design of these pipe systems have been made in such a way, always keeping in mind the possibilities of the bending machines that are going to be used to make these pipes. So whereas very often the normal way is assembling pipe systems with flanges, knees, elbows, little pieces, sometimes 10 or 15 welds on one metre, none of that will happen. Meaning again that when the steel hull is being built the people that have to build the pipe systems can actually start work and when this vessel arrives away from the steel company, the steel manufacturer, she will be painted inside and out because there is no more welding. People say ha, all your brackets, all your pipes, there is a choice made of a rail system that will hold pipe brackets for any kind of pipe dimension and hull configuration that you want. The hull will be insulated, the dirt work on the paint on the outside will get done, then the vessel will actually be moved into an assembly site where these prefabricated large components are going to be installed and believe it or not, we are keeping the superstructure away, we're going back to a bolted construction, the superstructure can be set aside in another location so people don't have to climb to the 6th storey to reach it. The superstructure will be prewired and cable trace etc will be installed, hopefully if Jan is on time his windows will be installed and when we are finished we are bringing in large prefabricated components in the vessel, in preplanned openings, In adjusting time principle the superstructure will go on in a clean aircraft factory quality environment and I would say that is the future, and this can only be done on the basis of very thorough good engineering, good planning and virtually building the boat with knowledgeable people before you start building them. Anyway that's my contribution, Martin. Unprepared.

### **Martin**

Wim, thank you very much.

### **Wim**

I should add one thing. If anyone is interested in this approach to building, check the internet—the Toyota production system. There is in 1938 the principle for putting in

an industrial environment something together is being laid. Timing, of course, we're building a new factory, a new shipyard, a new facility, we don't have to overcome ingrained systems with people who've already worked there for 40 years so we have an opportunity and we figure once our systems are in place we think we can build a 62 metre yacht with 6 decks, 1200 ton vessel, properly equipped, in 13½ to 14 months from start to finish. From the moment that the first steel is cut. That's the target. That might be of interest.

**Martin**

Wim, thank you. Ian, do you want to add anything to this conversation about the yacht building world, construction?

**Ian MacDonald**     Classic Yacht Refinishing

I don't know if I can. I'm pretty much computer illiterate and it sounds like a computer is taking over my job. So I don't know where I'm going to go.

**Martin**

Well what do you think of this idea of the future, from your classical yacht building and your background.

**Ian**

Well, based on the present problems the industry is facing which are, to my mind, going to be very difficult to overcome, the labour shortages, the industry has basically outgrown our ability to perform. I don't really see how computers are going to solve all those problems. What it sounds to me like is that production boat building is getting into large yachts and I'm not sure that the owners want that.

**Martin**

OK, Wim?

**Wim**

I disagree with that. Production boat building is not coming into—well, to a certain point yes, you are going to try to repeat something you've already done right before, and every builder has been doing that for ages. The way we're approaching this, we certainly will try to repeat some of the engineering money that we have spent on getting organised over a number of vessels, this is part of the business plan. However the interesting thing is for instance on this 62 metre platform that we have we can build any superstructure, we can put any exterior styling on that boat, we can give the client any interior that he wants. OK he cannot move his galley from the main deck down below because crew technical and service areas have been very very well planned and there has been a lot of money spent in optimising that, but instead of having to spend €2 million in engineering we only have to charge to the first and second boat 250,000 on engineering. So we have to calculate some extra money for customising, the guy will save €1 million, €2½ million and he saves time. Time time time. And people will still get a custom boat, we will be working on a basic interior box into which the systems fit, into which have been engineered and with modern rapid prototyping especially in the composite industry we will be able to put from any designer, any styling on that yacht to make a custom yacht the way the client wants it. And with the possibilities of glass which of course we are working with

Yacht Glass the possibilities with glass you can still make a custom yacht. The difference is that the old hands, and I'm also finding myself to be the oldest in the room very often, you have to put your knowledge in the young guys and the things that you've done with your own hands you know, I've ruined my knees on the loft floor but if now you can talk intelligently with a guy working with a computer but you understand what he's doing, you can motivate him and you can tweak him, then it's the best of both worlds, and so custom boat building will not change, it will just go faster and better and higher quality.

**Tork**

Wim, I took your advice and looked up the Toyota Production System. I'm quite interested—how did you come to use a system which was designed for mass production of cars in many many unit quantities to the production of a short production platform yacht?

**Wim**

Anyone that has ever studied manufacture will have come across the Toyota Production System. But the Toyota system is really an approach to dealing with a manufacturing environment. Mr Toyoda actually started with building sewing machines after World War 2, and it's an approach, it's not easy to talk about the Toyota system because I still have a lot to learn there, but it is an attitude that has to be present in a manufacturing organisation. The organisation is a learning organisation, it's an organisation that always has to improve, the terms lean production, just in time, it's all coming out of that by having studied for the last number of years just purely as an academic exercise; I learned more, I read books—and all people that write about it, and there have been a tremendous amount of books written about that, they all agree that the approach is applicable to any industry.

**Tork**

So really I'm here and listening to you and it suggests that it is actually as much a philosophy as it is a technical approach to manufacture.

**Wim**

You know me a little bit, yes there is a philosophical aspect, and how do you deal with people and how do you motivate people, how do you ask people to become involved, it's another thing; an aspect is also very practical. When we started with the Icon project we talked with some of the people that would traditionally be called subcontractors; we call them co makers, we've established a unique relationship with them, we're almost in the process of evolving but from day one your critical subcontractors are involved and have input in how you are building the boat. Yes, we've done it with 7 critical people, we have to now expand that group because for instance we have not reckoned enough with the possibilities of glass and we've started on a larger vessel for planning for 2010—2111; we have to take more people on. Yes it is a philosophical approach but not only with your suppliers, also with the people on the workshop floor because you want them involved. Everybody always has to look up. Continuous improvement is another one of those terms. Some story I read, some email comment about Mercedes Benz— I read something that says Toyota builds a Lexus in the same manhours that (I cannot verify it, I hope someone challenges me on that or puts me right) Mercedes requires for correcting mistakes on the M Class. That's pretty much of a challenge.

**Martin**

Ian. How long does it take to paint a 60metre new build? Number of months?

**Ian**

A good question. It depends on everything else going on around you. In an ideal world I personally don't think it can be done in under 5 months. Again, it's depending on the fairing and everything else involved. So Wim how are you coping with paint in a 13 month build?

**Wim**

It's not very nice of you to say that. We also had a little bit of a talk about that beforehand. We are investigating—I'm quite sure one of the larger German shipyards is also involved doing that—there are coming on the market some automated sanding, application of primers, application of heavy heavy fairing compounds, I'm going next month to see that in a facility, because I don't believe it can be done. Milling of this fairing compound, of course people that are doing tooling they understand that it is possible. And then the application of the paint and there are calculation models that say you can from the moment the bare metal hull arrives at your factory or at your paint shed, 33 days later you have a painted hull. With four people; the manufacturer and the people doing the calculation models they claim two people, we looked at that critically, also with a paint applicator and he figured for some of the detail work you still need some touch up work by some of the men or women, and the claims are there that in a controlled environment you can paint a 62metre hull in 33 days where after that 33 days there is 15 days of curing involved, so 15 days of dead time, changing toolheads, etc etc. It's not there yet, I really didn't want to talk about it, but you pushed me into it and now I did. Anybody that has visited shows or read magazines they know that this technology is coming in. I understand one of the builders—and I hoped someone would speak up—in Germany that builds yachts over 100metres has actually also purchased one of these systems which of course each has to be custom made to suit your purposes. But it's a robotised system that maps the surface of the hull, compares it with the files that you have in your computer, the system will then identify the fairings, calculate the shape that is closest to the original shape with the least amount of fairing, applies the fairing where you want it. And with a certain thickness over—I've seen the samples and it's a moon landscape but not so bad. And then mills it down to a surface that is equal to the side of this cup, so smooth that it has to be sanded before you can apply the next layer of paint. So. I'm hoping this will work because for any builder 5 months is optimistic for a 62metre boat because you have to have some contingencies. I think 6—7 months is quite realistic and you have to figure all the things, the dust and the dirt and the scaffolding and my god. You know, if you can get away from that it's worthwhile investigating it. But I'm sure it's going to happen. If it's not this year, it'll be next year. We're trying to cope with it in that way, hopefully.

**Martin**

Thank you. Ian has a rebuttal.

**Ian**

It's an interesting idea that robotics is going to take over the painting world; I think most of us would applaud that. Especially employing a lot of painters. I said a

minimum of 5 months. I tend to agree with you on 6—7 months and probably 12 months is what's happening out there, plus several redos.

**Martin**

Is that because of a shortage of labour force?

**Ian**

Well I can speak for the States—I don't really know Europe except talking to friends in Europe. In the States we have a huge manpower shortage. There's no training systems, we actually try and train our guys, people try and steal them—so that just shows you how the shortage of labour works. It's very hard to motivate people to run a piece of sandpaper all day long. Almost impossible at times. So there's a lot of issues there. So robotics is certainly interesting. What I don't see is how robotics can replace our present painting system. I don't see how the paints have the ability to operate under robotic conditions, the cure cycles and all the variables that come into it. And I don't think that the structures we're presently working with lend themselves to robotics either. For example some of the complex shapes. Now if you're talking repeatability then obviously we all know robotics comes into play. And I guess from what the panel is saying, we're going towards repeatability, which to me is production boat building any way you look at it. If that's what the owners demand then that's the way we're going to go. I still think that the arena I'm in and which I've enjoyed for a number of years is actually custom building. I think that's really what this forum's all about. I think we're in the custom boat building business. Not robotics. I don't see it working. The fairing, the fillers, aren't capable of being robotically applied; the structures that we're building aren't close enough to allow robotics and there's no repeatability there. Every boat is different. I don't paint 2 boats the same.

**Martin**

Thank you. Wim? I think the question there is who's driving your project? Is it owner driven or your dream?

**Wim**

When we started of course there were some owners involved; but it's also a little bit driven by my madness—I'm a yacht builder. I like doing this. And you have to make it fun, not do the same thing over and over again. You have to look at possibilities, how can you be better, and if an opportunity presents itself—I mean these robot fairing and filling and machining systems are being used—there is a production line building military aircraft that you're not allowed to go inside of, but they've been doing it, and this is where this technology comes from. They're doing some military ships in Alabama where they are using this, Donald Blount (maybe someone here is from Donald Blount?) and I hear are doing some things also in Norfolk for the military. Maybe you should jump in and do some of the work that's being done with making one off moulds. I mean it's very easy, we've done calculations with a company in Holland where we were talking about building superstructures for these large yachts on a one off basis; we talked about making moulds out of certain blocks of a certain material that would be machined and joined together and we would make a one off mould in a very complex shape. And more complex than you could do with metal. So if you can do that, then scanning a hull, even on a repaint job, scanning a hull or a superstructure with scanning equipment which is all available and used elsewhere, then seeing what that shape is and then somehow sanding on the basis of that shape and applying paint in a way that no painter could ever be so consistent. When a

painter has to go down a 63metre hull by hand, by the time he's at the end he's got a muscle like that! And this robot is just a dummy, he'll go on 24hrs a day at the same distance, at the same speed, it's probably higher quality.

**Martin**

Have you seen the size of Ian's arms?

**Wim**

He's the boss. He doesn't do it himself any more.

**Ian**

Can I just interject. I mean at the present time fairing is the key. The surfaces aren't straight enough. And we're talking about eye straight, not putting a board on it—there's a lot of skill in getting there. To compare aircraft to yachts to me isn't a comparison at all. There is no fairing on any aircraft—never will be. It's just coatings. And if you look at the coatings even on the corporate jets they're not up to the standard that we would have to meet on a yacht.

**Tork**

Actually I was just looking it up and it's not a paint, it's an anti radar coating that's about this thick, sprayed on the B2 bomber. That's what Wim was talking about, I just found it on the internet here. So it's actually not a paint, it's a thick squidgy coating.

**Ian**

Yes, you know, but we understand that—you can do it with aircraft, you can do it with cars. They're doing it. The finish on a car, even a high end car, isn't the same as demanded of us on a boat. And that's fact. And I understand about the fibreglass. But when I've dealt with fibreglass even with High Modulus and everybody else, we see a lot of irregularities there, a lot of imperfections, they're not straight, even after all the computers and everything else and the fibreglass moves a lot, and I think as we get to bigger boats we're going to see a big problem with that. I don't think the resins can take the heat. That's my unexpert opinion. Noticing it in a real life situation.

**Michael**

Yes. A few things to pick up on there. I guess the first one is on the custom v production side of things. I think we have been doing a lot of custom one off boats.

**Wim**

On a steel boat the temperature changes are also of course very critical and while we were looking at this, while we were investigating this fairing robot, the controlling temperature in your process is something we were also worried about, because you're doing that in an environment where it's maybe 20° or 22° and then this boat goes outside. Hull no 1 is scheduled to be doing sea trials in February 2008—it'll be interesting to see what happens to the metal. We've all seen this year in Holland when temperature has an influence on things; you can be 100% perfect at 20° and maybe not so perfect at 40°.

**Michael**

I think we're quite lucky in that respect in composites that historically composite boats have been regarded as inferior cosmetically and I think that's not fair on composites and is probably to some extent the fault of those of us who've been designing them. But I think we've come a long way, as I said before, we will actually be seeing composite boats outperforming the metal boats cosmetically because of exactly that effect, that the thermal expansion issues that we get with any material is really what drives the cosmetic performance. And we can have a boat that's perfect, coming out of the shed, and see things change on us very quickly. Normally we tend to think that happens worse with composite boats but I think the work we've been doing with the resin manufacturers recently is shifting that quite quickly. And I think we're making a lot more progress than the metal world in that sense.

**Martin**

Thanks Michael. So I'm open to the floor now. We're trying to produce a business now that goes from never on time to just in time. Looking at quality issues, looking at standardisation, and now producing 60metre production boats. I'm not suggesting that Icon is producing production boats. But where are we heading as an industry, to make sure that this order book—can we deliver it on time? There's a few people out here who I'm sure have an opinion on the world of construction. I know Bill Blount should be out there somewhere. Bill, do you have a comment?

**Bill Blount** Donald Blount & Associates

I came in a bit late, heard my name mentioned there. I have a quick comment, going back to the fairing and there was a comment made about bulwark shapes. We own a large robotic CNC machine, we produce a lot of patterns for the marine and aerospace and transportation industries. And I can assure you at least from the geometry that anything the yacht projects require—they're really easy projects. It's the transportation industry projects that provide many more challenges for us to hit. So at least on the shape of the projects the motor yacht ones are easy. As far as the limited production tooling that's been mentioned, many of the projects we do are military related; I can't talk too much about them other than to say that we've done wingspans almost approaching 150ft in length, we've done hull tooling in the 90ft range. And we see this as an ever increasing portion of our business, cutting straight to what we refer to as a female or limited production mould. I think many of the yacht builders, even the metal yacht builders, will start to embrace this technology as they start doing unique deck structures that have compound curves; to go into a one off may prove to be a more economical and time saving approach to produce these shapes.

**Martin**

Thank you Bill. Any hands going up?

**Fredrik von Heland** Fagerdala Marine Systems

We have experienced some of these things in our company; we bought a robotics system 44metres long, 11 axis robots, that was said to be able to do mapping, all these things, fairing, sanding, painting, everything. It cost us quite a lot of money and if anyone wants to buy it it's for sale. Special price today. We use it now, it's too complex, it was doing too many things, we lock it now and we do small plugs up to 15metres in one go. We can't use the whole line because accuracy is not enough.

The sanding is a problem, we can't get a yacht finish out of it. We bought it to see if we can use our fairing system; we use it on metal hulls, aluminium and steel, we glue PVC foam sheets on and we do all the shaping and the hard work in the foam since it's a very porous foam, between 40—120 kilos density. We saved a lot of money on that and then we laminate it 2—5mm depending on what area, and then we use fine fairing on top, spray fairing and sand it to a perfect finish. So all the heavy work we do in the foam and save a lot of time and it's very clean because most of the time we use cutting tools, like planers and routers. We add as much foam as we want, we don't have to do any curves or grooves in the metal, we do everything in the foam. And we get away from the problem with heat on the metals, since we insulate the metal from the outside so the metal always stays within 2° of the inside temperature. So we always keep 18—22° on the metal surface, even when it's 10° below freezing and up to 80° on the outside, without any buckling, so that's quite nice. We avoid insulation on the inside since the foam is so much more efficient we want to have at least 25mm of foam covering the whole boat, decks, bottom, superstructure, everything. So we are building a fridge. We put the insulation on the right side of the metal so we don't have any condensation on the inside. It's a completely dry boat. Soundwise since the glue we use always stays visco elastic because we stay within the temperature on the inside of the insulation, we take away all resonance from the structure and we get a very quiet boat. Timewise it's quicker than fairing, since the work we do in the foam is so much quicker. Long boarding we have to do before the top coat comes on, of course. But as I say, we try to do all that heavy work in the foam, since it's so easy to shape. And so we don't need any more double bend metal structures, we can do all the double bending in the foam. It saves a lot of money also for metal structures. In the end it's a win win situation. Time, money and maintenance also for the future; we never have any cracks in the structure, since we have a laminated surface. We never have any corrosion since we completely cover all the metal surfaces and aluminium surfaces from the elements. So it's a way to make things easier and better.

### **Martin**

What is your build time?

### **Fredrik**

Per square metre? We calculate, depending on what surface, if you're going to do overhangs and bumpers and fenders and all these things sticking out from the boat, it takes a bit longer time, but it's very quick because we prefabricate them. We can do all these things with the robot of course because they are smaller. We glue them straight on to the first foam layer. But in average you can say about 13 hours per square metre from bare metal to top coat. That's about what we calculate. Then it's just the amount of people you put in. But of course the tricky thing is to do the first layer, to glue the PVC foam on, because we can't have an endless amount of people there. But after that it's quick, and that you can do it already in the very early stage. You can even do it in sections, if you're building in sections you can put the foam onto the sections before you weld them together, you just leave that gap for the welder. Then you fill it in. So that's a very very time efficient method. We think.

### **Martin**

Thank you.

### **Michael**

Maybe one day we'll convince you to leave the steel out altogether.

**Fredrik**

No, because what we see as a problem, because we build a couple of complicated GRP boats and it is still a problem with all the fittings, all the foundations for engines and these things. That's a weak point and people still want to have metal, I think. You just build a simple hull, it's a very low cost in the big total—the low cost will be in the hull and the superstructure. If you see the big composite boat that we built up in Sweden for the Navy they still have a big problem with the full sandwich 80metre frigates and they have big problems with the inserts and everything. They break and crack and they still have a big problem in the fairing—they had to put so much insulation in the boat they don't win so much in weight any more. So of course it's nice with GRP I agree but some people still want to have a steel hull.

**Martin**

Thank you. There's another question I believe, someone in the middle.

**Frans Verbaas** Lloyds Register, The Netherlands

Actually the process you just described is quite exactly what I sometimes recommend to clients to indeed go to a simple steel alone structure, plain sheaths, build your structure apart from that so have good fire integrity etc from there, and make all the parts in just a composite or sandwich construction that you just glue on and then make a nice boat out of it. And even have the possibility of to change a certain part, you just rip it off, put on some new pieces of foam and there you've got a new shape of the head or something. So in general I think that more or less confirms what I want to say. One other thing is a point in FRP construction which I see sometimes in yards coming out now for refits particularly if people want to put on an extra deckhouse layer or just want to cover the sun deck partly, then they want to do it in FRP for 2 reasons. You see there is a conflict coming up there with the windows that are there, which is generally if you put on large windows, they are designed to have to be properly supported originally. Now it is very difficult to make an FRP structure so rigid that it can support large windows correctly, so that is something to keep in mind, that you have to be very careful in designing it, rather than just a piece of top house, which is structurally OK but still deflections can be such that the windows can't follow the deflections.

**Jan**

Well, that is a very interesting question and also an issue, because we never tested glass in fibre constructions. And what Mr Verbaas said is very important because glass has to be supported by a solid frame construction. We never tested it because—

**Martin**

What is the typical weight you're talking about for the future? These big panes?

**Jan**

Well the big panels, the biggest panels which are now on the market in yachts that will be in the bridge—we're making now for a New Zealand company are almost 3000 x 2900 for bridge windows, and then come the problems because then you

have 50mm thicknesses so the problem is that when you look through the glass and it's built at an angle from 5° so you look through a wall of glass of almost 40cm so that is also an issue. But I think it would be very interesting; I will test it, we have a laboratory, because especially by high forces. And one of the things that we are going to do now is more for impact, because 6 6 6 8 8 8 it is all very nice but impact, when you're on the sea, everybody likes to stay alive, so when you have a piece of paper that says this glass can absorb 200kilonewtons and then you've got to swim to the coast! So what we want to do is proposal to make impact on glass, that you say when you build a ship or when you make designs they just say you've got to put a weight on it. In the normal building industry it is a standard, that you make something like that. It's a building standard and so it is not very complicated to put that into the rules for a ship, because there are skylights, we have now a design for a skylight from 8metres round; that is like a ballroom floor, so when water comes inside I think the ship will be gone. So you have to stop the people and be realistic, because glass is very strong, it can absorb forces like steel but it isn't steel, and you can see the difference when you take a stone and you throw it on a glass pane and then on a steel plate. Then you see the difference. So I think that is a very big issue, it's a very simple test, you can do it at home. But I think it is an issue that is for next year, my hobby, that we want to say for the yachting industry also for my colleagues, to test what the difference is between flat glass and curved glass, that we can find a figure out of it, and impact. Because I think it's very important, because there are hatches on sailing ships, 120 x 120cm, 1200 x 1200 and you have 6 8. When I put normally the standard, the standard P5 is 3 bullets steel balls from 4.5kilo, put it on glass, from 6metres high. So when you want to lay down Martin, next year we make such a live show here! And then you put from the ceiling, 3 bullets, for when you lie down.

### **Wim**

I think I go back to the question of Mr Verbaas, I think he mentioned that the composite structures into which these very very strong high quality glass panels are fixed cannot be made stiff enough to properly support that panel. I think that was the point that was raised. Am I correct?

### **Jan**

Well it's not so much that it cannot be made, but you have to take care that you make them stiff enough.

### **Michael**

Which was exactly the point that I was going to make. I think that when we design based on classification society rules we as an industry tend to be quite focussed on strength; strength is not always the end goal. It is absolutely possible even quite easy, to design a composite structure to be stiff enough, for example, people are quite happy to build aluminium superstructures and see that they are stiff enough to support the glass; well laminated carbon fibre is the same stiffness anyway. But even in glass we can easily do something which is the same stiffness. We just have to know that it's necessary to do that. And so really I guess that the end answer to the question, or to the point, is specific design, engineering. We don't just guess stuff, it's important to actually know what it is we're engineering for and it's not just about strength. And when these guys are talking about acoustics, vibrations, stiffness to support glass, it goes a lot further than just making sure that the boat itself doesn't break.

**Martin**

Frans, does that answer your point?

**Frans**

Yes, it answers the point and I fully concur again.

**Fredrik**

I forgot to mention one thing, when you start to speak about stiffness for glass, there is one nice side effect with this system that we use—we increase the panel stiffness tremendously, everyone that knows about sandwich understands that. In the tests we did we had a 25mm of foam and 4mm of aluminium we increased the stiffness, local lateral stiffness with 2 and 20 times. Not percent, times. So I don't know how many percent that is, but it's a lot. On a 5mm steel plate we increased 13 times the stiffness, and that means that we can use very very thin metal structures to get a stronger boat than a normal one. And we're running through this with the class for the moment and we will soon be done. Another month and then we're done. So we can start to build really light superstructures and also hull.

**Martin**

Thank you. Any further hands to raise before we break? Frans again and then there's one in the middle.

**Frans**

Just one more question. How is it that with fire safety, because generally if we have a steel aluminium deck on the outside it need not have insulation, but if when you lock it up in a sandwich the heat can't be dissipated, so it may just as well end up with the fire between steel plates and actually under the laminate?

**Fredrik**

The core material is injected so that it's self extinguishing. So you need an open flame to keep the fire going, as soon as you take the flame away it dies from chlor gases. Which is not healthy but —

**Martin**

You die in the process of suffocation.

**Fredrik**

No, but I mean it dies, instantly, so the chlor kills the fire.

**Michael**

I think it's important to note also that composite materials are not really not as bad in fire as everybody thinks they are, and as we do more and more large composite boats we're starting to really learn the truth about the performance of composite materials, there's a lot of research going into phenolic resins and things as well. We can even with full composite boats meet most fire requirements, and the insulation that we've had to apply in the past, and I think that the Swedish frigate example is a

very good one, that situation is changing very quickly and we're able to reduce quite dramatically the amount of fire insulation that we need to still achieve good fire performance. So I agree with what's been said, that it certainly can be done, it's not a problem, we just need to know what we're aiming for.

**Martin**

OK. Celine, can we hear from you on the other material, aluminium?

**Celine Renaud**           ALCAN Aerospace

Yes, I just want to make some comments about the technology transfer between aerospace and marine, because we are producing a lot of aluminium for the aerospace industry, for the transportation industry and for the marine industry and we have many different solutions for problems of fatigue, or painting, of temperature, of everything. We have many different solutions coming from the aerospace industry and we are used to propose that to the marine field but usually the problem we have is the problem of cost, so we have very effective solutions but there is a huge gap between the cost that the aerospace industry accept and the one that the marine field accepts.

**Martin**

What is the difference, in percentages?

**Celine**

Oh. I'm not sure, it's worth to say that. It can be a few percent and it can be 500%.

**Martin**

It's like yacht brokerage.

**Celine**

The main problem is usually the cost.

**Michael**

Absolutely. I agree. Some of the aerospace solutions are right up there in cost and in a high performance race boat or high performance race motor yacht project we will see maybe people are prepared to spend €100 to save a kilogram; in the aerospace industry that's often \$1,000 or more, in the satellite industry it's \$10,000 or more. Dollars or euros. Certainly as you head up that spectrum you do end up opening up possibilities of materials—my reference to the cross pollination was mostly in the analytical side of it, the tools that are available to us for analysis of composite materials that have been developed by the much better funded aerospace industry have really changed the way we can design our product in this industry. But for sure we're not using the same products as the aerospace people are using. And as I said, it's actually sometimes working the other way around, that we're starting to provide solutions which are not so very far away in terms of performance from what the aerospace industry are using, and then realising we're doing it at very much lower cost, to the point where they're coming to us asking us how we do it, because they want to use marine solutions in aerospace to save themselves money. But I absolutely agree with what you're saying there, about the difference.

**Celine**

And just to finish, the problem is that usually in the aerospace there's not exactly what is the cost of everything, and how much they agree to invest to save one kilo. What we notice is that usually in the marine field the price comparison is kilo per kilo, I have one kilo of steel and one kilo of aluminium and aluminium is more expensive so I take steel. And they don't include all the things around, and that's also one problem.

**Martin**

Thank you for that. Germanischer Lloyd please.

**Frans**

I would just like to come back to Jan Rozie's introduction; Jan, you mentioned something—compare the chemical hardened glass with the thermal toughened glass and talking about a hole in the ship and the safety of thermally toughened compared to chemically toughened glass, but I think you compared at that moment laminated chemically toughened glass was monolithic, heated glass, because if you have also a laminated system of thermal toughened safety glass you would also have no hole in the ship so safety would just be achieved—

**Jan**

No no we work with chemically toughened laminated security glass.

**Frans**

Yes yes of course. But you just told in your introduction that it is more safe because if it breaks you would not have a hole in the ship. There you compared monolithic thermal toughened safety glass with a laminated system so if you have from both a laminated system you would not have this problem at all, from both sides, so just to clarify here within this forum.

**Jan**

We have 2 systems. We have laminated chemically a system and a laminated thermally toughened system. The problem is always with the thermally toughened system that after the breakage it flies out, when both windows are broken. So, but a chemically toughened glass is a security glass, you can see it especially in the last tests we made with the 6 8 and 8 8, you see that the breakage of a thermally toughened glass has very little parts, so it blows out. It stays, OK, I think that there are forces of course where we are testing with but you've got to take a worst case test, sunshine is not very nice to test glass in, but in the worst case you see that all the thermally toughened glass flies out, in all the tests. The chemically toughened glass has a breakage— there is also a misunderstanding by many people that you can use chemically toughened glass, monolithic is never allowed, because the breakage pattern is the same as normal glass, it's absolutely sharp, it is even not allowed in the normal building regulations and many suppliers build in monolithic chemically toughened glass in their construction so chemically toughened glass is only allowed to build in when it is laminated, and the structure that you can understand when it breaks as normal glass, the chemical parts, then you have a pattern which is very stiff and at all our tests you can see that when it is chemically

toughened and there is a lot of pressure on it after the breakage, that the glue is still functioning, it's closed, they are watertight absolutely, and that is a security window. If I was on a ship in heavy weather and the window was broken and no water came inside and the glue was OK then I would say that is a security window.

**Frans**

Yes of course, I know you are thinking that because you already hold many certificates! Just that the first thing was for me a little confusing, so this is—

**Jan**

The problem is always we see it in our tests also, you know when you take pictures from them, the forces are very high when you take it, so all the people think, chemically toughened glass, that is something that you put in a bath, hey it's super, but the problem is when it breaks, it is really so sharp like a knife. So when you have a beautiful windscreen and then it breaks, and flies through the air, yes, someone can be hurt.

**Frans**

Yes, this is the reason why officially the safety glass cannot be considered as chemically hardened glass because you know that the breakage and the pieces are defined within the international standards, but we both know about it. And just coming back to the composite systems I fully agree that it is just a matter of how to design the composite then we can also use big glass windows like you proposed but we should really take care of these problems of deflection and so on.

**Martin**

Before we wrap up, can I just do a quick straw poll on the subject. Can you raise your hand if you feel that the idea of building faster more efficiently with modular construction is where we're heading? And if you think we should stick to the full custom forty month build programme that we all have lots of fun doing and we seem to still do for the last 10 years? No? So we're heading into the new wave of yacht construction, building boats faster, more efficiently. Ian sorry, robots are in.

Allright thank you very much everyone, thank you panel. Whisky is now served, courtesy of Royal Bank of Scotland.

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