

PROJECT USA 2007

Conference Day 2 — Thursday 10TH May 2007

New Technology Sessions

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| Bill Burns | M Ship Co LLC |
| Lee Erdman | Voith Marine Systems North America |
| Dr Mathias Voight | Hamann AG |

Martin Redmayne

Let's settle down for the afternoon. I have a little thing I've just been told I have to tell you. Tonight we are almost at capacity for the yacht club dinner so if anyone is planning to bring a partner and hasn't told us yet, please see Karine. Because we have only got a limited number of seats available and I believe we've got 2 left, I think she said. And if you're not actually coming to the dinner tonight let her know, that may release a seat for someone to bring their wife, girlfriend, boyfriend or husband. In that order.

This afternoon's session is the New Technology session where we have three individual companies or organisations to talk about three totally different technologies. It's just really to give snapshot interesting dialogue on things that apply to the yacht market that have got great potential. The first one I've seen in action on a video which I think is quite incredible, the M Ship Technology, I've already talked to someone about whether they can build a 150foot project for someone, so I think there's some interesting developments. Voith is obviously a proven commercial ship technology which I think has applications for the yacht market now, and obviously the Hamann organisation most of you know about but I'm sure they've got something enlightening to share with us. I hope it's not anything you've heard before. We'll start with Bill Burns from M Ship Technology.

Bill Burns M Ship Co LLC

I'm Bill Burns, I'm co-founder of M Ship Co and I want to talk a little bit about what a Navy ship looks like. There's a lot of different types of craft, this is an aircraft carrier, there's planing craft like this Mark V, there's multi hull craft, not quite as many but they're becoming a little bit more in vogue in the Navy and then air cushioned or supported ships. But you probably haven't seen something like this before. This is an M hull ship, and it's actually a double M hull, and it is something that the Navy really hasn't explored before. In fact we built this boat through a special department in Washington called the Office of Force Transformation. And their whole mission was to create something new. Get something new on the water. You can see both above the water and below the water it looks different. And what we've been able to do with this stiletto is to create a very aggressive prismatic geometry craft that goes fast through the water, but still has payload carrying capabilities and stability. How many people have seen a stiletto? OK, for those of you who have, and some of you have actually driven it, or for those of you who haven't seen it I've got a short video here and if the power point gods are with me we should be able to watch it.

You can tell this is pretty unusual. It's actually for a 2 to 1 length to beam ratio so it's 80ft long x 40ft wide, and one of the things that's pretty remarkable about this design is its ability to go fast in the water. When you look at it here it kind of looks like a

barge. You know, it's hard to believe this thing can do 50knots. It also turns with incredible stability. You can see it here, this is a 45knot turn, there's very little wake in the water, it's very flat, which is something that the government's very interested in. You'll also notice there that there's very little wake coming off the boat. You can see that there's actually an air cushion being created under the boat and some of that air is actually spilling out. This is a full speed turn at about 45 knots and it's remarkable how little weight there is and that translates into speed. We go into this turn at let's say 45 knots and we only shave off a couple of knots of speed when we come out of it. There's also an electronic keel system that's incorporated into this design. So the Navy claims it's the fastest and smartest ship within the force. So that was the stiletto. This was actually built right here in San Diego by Knight & Carver, they were able to build it in less than a year and it is one of the fastest ships in the Navy, it's also the only one and the biggest one built out of carbon fibre. The question is, is this the future of the Navy? Is this something that the Navy is going to embrace in the future? And the answer is yes. The Navy's focussed on a whole new battlespace, it's the litoral and the riverine environment. This is the shallow water area that exists around the world. And the military's focussed on it. They have a new mission and a new warfare and they need new types of craft to operate in this area. In fact 25% of all the high conflict areas that they forecast in the future will occur within 25 miles of the coast. And the best way to get there is by sea. The stiletto has an M hull technology and this M hull technology really is a new way, a new relationship, of looking at how a hull interacts with the air in the water. By capturing the bow wave, and harnessing that energy, we create a cushion under the craft and that cushion, in combination with the air and water that's being mixed underneath the boat, can reduce the discus drag and allow us to improve the ride quality. This gives you an idea of what the basic geometry looks like. There's three unique elements; there's a central displacement section which is in the middle—this really acts like the backbone of the craft. Then on either side there's two tunnels, here and here, and this is where we capture the bow wave and harness that air energy. And finally the skirts are on the outside and that contains all of this pressure. What's really unique about this design is that we've decoupled the high speed planing surfaces from the displacement part of the boat and that allows us to actually get up on a plane without having to trim up. That's a unique feature to this design and it allows us to reduce the vertical accelerations on the boat, it allows us to accelerate more quickly. And this gives you an idea of the difference between a conventional planing craft and our M hull. This is an actual test that we did, side by side with the US Customs and we were in identical sea conditions, in fact in this test we were doing about 45 knots in sea state 2, which is a fairly mild sea state, and the Customs boat experienced an acceleration on the order of 5 Gs, which you can see right here. That's the equivalent of a jet pilot experiencing accelerations in a curve. The largest M hull acceleration was 1.5 Gs. Right here. And you'll notice the M hull is the pink line here, that the accelerations on average are quite a bit less than the conventional Customs planing craft. Another advantage of the M hull is roll stability. Because of the shape of the craft we have a lot of low speed or form stability, but at high speeds we are actually very stable because of the bow wave that is captured in the tunnels here. And in a turn, the outside bow wave is actually larger than the inside one, and that creates a dynamic stability for the craft. A conventional planing craft, and in this case it's an 11metre craft, it rolls through 44°, almost 45° in an S turn. The M hull only rolls through 5°. This is extremely important for the gunnery, because they're very concerned about keeping their weapons on target and keeping communication links, which is becoming more and more important. Another great advantage of the M hull technology is the way that we carry the lift underneath the boat. Conventional planing craft has basically one, or a very localised, lifting point under the craft. It's very critical to make sure you get the LCG and the load in the right spot. The M hull actually has several different spots to carry this lift and it allows the boat to be much more tolerant

of shifts in LCG or payload and also if the sea state changes the boat is more stable. This contributes directly to the reduction in vertical accelerations that we've seen already. On the stiletto we actually have 8 separate lifting points, and that's why the boat is so stable at speed. Another advantage of the M hull is acceleration. We're able to get out quicker than a conventional planing craft because we don't have to trim up as much. Because these tunnels have a positive angle of attack the boat just lifts up out of the water. A conventional 11 metre rib will go through an 8.5° trim change. The M hull will only go through a 3.5° so there's a reduction of 5°. This translates directly into faster speed, faster acceleration and less motion of the boat. This is a great shot to show you the difference in a wake that's coming off the boat. This on the right hand side, we have our prototype; and on the left hand side we have a conventional sport fishing boat with deep V hull. You'll notice that the wake is quite a bit bigger over here, compared to the M hull which is capturing it. If you look closely you can actually see a bit of an air bubble that's being created, and helping to smooth out their ride. More importantly, you'll notice that in the wake there's lots of little outcrops of white wash. And this represents the slamming as the boat's going through the water. So each one of those represents an impact or vertical acceleration of the boat. And we've been able to capture that, harness that energy and smooth out the ride. As far as the Navy goes, the conventional wisdom and sort of the history of larger ships is to become longer and narrower for speed and stability. What we've done is to turn that whole concept on its ear, and we've created something that's wider, shallower and faster. Some of the benefits of the M hull technology include its speed, its stability, its agility and the fact that it's very shallow in the water. And that's really important, especially in this lateral and riverine environment that the Navy is working on in the future. The current state of development is a lot of research and development. We developed the whole M hull concept really empirically. We started off with an objective, reducing the wave pollution in Venice, Italy. From that we started discovering a lot of other nice advantages to this hull form. So now we're going back and working with the office of Navy research to put the science behind this technology. And then develop tools which will allow us to design future boats. Bigger boats, smaller boats, find the crossover points between single M and double M hulls. We're also developing in house our own system for evaluating on new ideas and new technology. We call this REI. Or rapid empirical innovation. And this is a way that we blend the science and the theory with experimentation and observation. And in a quick and inexpensive way we can try out new ideas, discard them if they're really far out, or look for that one gem we might discover and then try to explore that to see if it has applications in future designs. We're also still working with the stiletto. It's on the East Coast now, in Norfolk, Virginia. The Navy is developing some new concepts of using the boat in the future. In fact this design is so different and so unusual that they're finding and discovering new ways of using a boat to support their mission. Some of these missions are going to be port security, special operations, and also unmanned vehicle support, which is becoming more and more important within the government. There's also a lot of opportunity in the riverine and patrol craft market, ranging from the coastguard to the marines, to unmanned surface vehicles. And this technology applies just as well to other market places, like the commercial and recreational market. This is a 65footer that we're developing, it is a double M hull, 40ft wide, it has a lot of new opportunities for layouts inside the boat. And this whole ship is so unique that it allows us to do some fun things with smaller craft as well. This is a limousine that we're developing for a European client and it has a very unique look. We're trying to match the aggressive nature of the hull with an overall layout on the topside. And we've even taken this concept all the way down to a very small level. This is a 22foot electric powered boat, which is an environmentally friendly boat, it's electric powered, doesn't have any wave pollution or air pollution. It's also a double M hull, which is a little unusual. We're discovering new ways of using this hull form for different applications, across the whole range of sizes. So just

to wrap it up, we've developed an innovative technology that seems to have a lot of applications in several markets—the commercial market, the recreational market, and the military market and it allows us to redefine what kind of geometries and shapes we can use in the future. So if you have any questions I'll be pleased to take them

Martin

Yes. What we'll do is to have questions at the end of each session now, rather than everyone speaking first. So we'll come straight in with 10 minutes of questions for Bill. So any questions from the floor please? Over there on the right hand side please, Esther.

Actually I have one question to ask you straightaway, please Bill. How does the hull behave at anchor?

Bill

It's actually very stable at low speeds and that's something that the military likes quite a bit. Most of the operators, the war fighters, are operating at zero speed or very slow speed, you know they only sprint for a small percentage of the time. And the low speed and loiter conditions fatigues the sailors quite a bit, because of the constant motion on most deep V hulls. But because of the geometry of the M hull it's very stable in the water and has good form stability but it also entrains a lot of water so it actually picks up additional damping from the water itself, because of the corrugated shape underneath it.

Dean West Merrill Stevens

Does the length to beam ratio need to stay at that 2:1 formula?

Bill

We're actually exploring that right now. We're discovering that it doesn't need to and there are trade offs associated with that. Part of the work we're doing with the Navy is to evaluate exactly how far we can push it, and where those crossover points are. We're actually exploring some new concepts of taking conventional design elements and combining them with the M hull. So we have some shapes that look very unusual, using maybe long slender shapes with M hulls on the side in order to optimise the lift to drag characteristics of the boat.

Martin

Roger, over there please.

Roger Marshall The Yacht Report

Looking at the prototype, it looks very much like a Boston whaler; what is the difference between the Boston whaler hull and this type of hull?

Bill

Sure. The Boston whaler is a cathedral hull. And the tunnels actually come down fairly rapidly to the water. The M hull tunnels come all the way to the back of the boat. And they're actually designed for planing lift close to the centre of the boat. In fact we

optimised the shape so that as the hull transitions in the water, bow down or stern down, the lifting vectors shift up and down in those tunnels so the tunnels really function as an automatic adjustment of lift to stabilise the craft, and that's not the case for the typical cathedral hull.

Jeff Bowles Donald Blount & Associates

It looks similar to a catamaran and the research that we've done in house shows that catamarans are very sensitive to weight, both wave piercers, planing cats, however you want to look at it. Whereas a monohull can generally take a little bit more weight growth and the performance of the vessel as significantly. Can you comment on what type of research or experiments you've done with overloading an M ship to see if all of the performance attributes go away or if they still remain present?

Bill

That's actually one of the advantages of this hull form. In fact we like to look at the M hull as being a combination of all these other different hull forms. Taking some of the best features of each, and combining them together into one hull form that performs better. And we've actually put that theory to practice with the stiletto and we have overloaded it and we're finding that it has a very very good tolerance to being overloaded, extra payload. We actually went 20% over the designed weight of the stiletto and we only lost 2 knots of boat speed. And I think the reason why that happens is because we have such a broad beam, we have so much volume in the water, that when you overload the boat it doesn't sink down far so you're not actually operating the boat very far outside of its design conditions. And we've actually documented that in our tank testing with O&R as well, so it was a little bit of an unexpected surprise for us but we were certainly happy to see it.

Martin

How can people use the M ship technology? Is it licensed?

Bill

It is patented technology, we have international patents on it and we are looking at finding partners and collaborators to help us take this technology to the next level. We're doing that with the military, and we're just beginning to break out and find some strategic partners with the recreational market and the commercial marketplace. We're finding that any place you need to operate a boat that needs to go fast, needs to have shallow draught, needs to be sensitive to the lateral environment, in other words low weight, the M hull has some unique advantages. So we are in the process of doing that.

Martin

Billy, you've been shaking your head and smirking. Can I give you the microphone? You've got 5 minutes.

[From the floor]

What's the displacement of the stiletto versus the speed? And what is the cost per pound?

Bill

Well, the displacement is 67 tons, and the speed is 52 knots. So the cost is \$6million so what ratio did you want?

[From the floor]

In the comparison that you did between the Customs boat and the M craft, what was the size of the Customs boat, and what was the size of the M craft?

Bill

The Customs boat was 39feet, our boat is 38feet. We were within 500lbs of displacement and we had an accelerometer on both boats, a black box, that we swapped back and forth to make sure there was no problem with the accelerometers on one boat versus the other. So it was actually very good test conditions.

[From the floor]

And what was the bottom configuration of the Customs boat?

Bill

The Customs boat is a high speed deep V craft similar to a scarab type design.

[From the floor]

My problem with the concept is that in the past every time someone came out with a unique or radical looking boat it's not accepted by the yachting public. Ocean Fast did one years ago, it was a very interesting boat, unique layout and everything but it was just not accepted.

Bill

Well, we've taken on an even more difficult market and that's the military. And there was a lot of resistance initially to the introduction. Quite frankly the only reason this boat was able to get in the water was because of the Office of Force Transformation. They took a risk with this concept because the Navy wasn't going to touch it. Now that it's in the water, the Navy is beginning to evaluate it and they're very happy with the results to date. So I think, in answer to your question, and your challenge, we need to get some boats on the water to demonstrate how it operates, and then at that point we'll slowly begin to break down that natural resistance in the marketplace.

[From the floor]

And how is the performance of the boat with water jet versus the surface piercing, because our experience with the military in the past is the surface piercing throws up too much of a telltale rooster tail that can be detected both with thermo and with radar.

Bill

That's exactly right. The objective of the stiletto was to evaluate the hull, and we were able to get the boat in the water quickly, and push it to the speeds that we needed to push it. But the military does want us to go back to a water jet solution. The water jets

aren't as efficient so we'll shave off probably 2 to 3 knots in boat speed, but it's more important for them to have low signature, and also to protect the people, and the animals and the mammals that are in the water. This boat, one of the nice features of this boat compared to a catamaran is that the transom is right at the water level so if you're supporting unmanned assets like UUVs or unmanned undersea vehicles, or USVs, it's much easier to handle them, right at the water level, than to try and take them up to the main deck in a catamaran. Or even in a conventional mono hull, which rolls a lot. There's a lot of challenges to doing that. So that's one nice thing about the design.

Martin

OK. One final pointer from me—Howard, what do you think about a Novurania with an M ship?

Howard Rogers Novurania of America Inc

I tend to agree with Billy that the fact that although this may be a fantastic idea, that we still go back to the problem that the client would look at a boat like that and they become nervous of something that looks like something out of Star Wars. There's a number of big yachts being built today which look strange, to say the least, and apart from the shock that we've had in our business when we go to Monaco and look at a Wally, a 44foot boat that costs \$1.2million, so obviously there are people that are looking at that particular market. But it will be interesting to see just how small you could go with a hull design like that. So that would be my question. Is there any limit to how small you can go?

Bill

Yes. Obviously we're looking for early adopters initially. To get the product out on the water. We've actually been doing some testing with smaller models for the unmanned surface vehicle marketplace, and you wouldn't think that this was the case but actually the smaller craft is more sensitive to a lot of the trim issues that I discussed today, than a larger craft. Because they have a larger payload and typically that payload can move around easily especially in an unmanned surface vehicle, if you have guns or equipment and as the sea state changes that changes the balance of the boat as well and we're finding that for a smaller craft this hull technology works extremely well. We're pursuing a couple of unmanned surface vehicle contracts with the government to put this hull technology on unmanned surface vehicles for the military.

Martin

OK thank you very much indeed, Bill. Lee, please?

Lee Erdman Voith Marine Systems North America

I'm going to hopefully within 20 minutes give you a quick overview of the Voith Schneider Propulsion System and some of the other things that Voith is doing, looking at the things we're targeting within the yacht community, not only propulsion but also looking at stabilisation.

Very quickly, Voith. Voith is a global company, and you can see by the numbers up there, relatively large, performing in paper turbo, which is what Voith Schneider is a part of, power generation and industrial services. We're going to talk about a bunch

of different things here; Voith Schneider propeller, we're going to talk about roll stabilisation, going to talk about the cycloidal rudder, Voith motion control, we'll also touch on the air contra propeller and inline thrusters. Very quickly to give you a real quick overview of what the Voith Schneider propeller is, it's a cycloidal propulsion system, think of a helicopter, take those blades from the helicopter, put them vertically, put them in the water, you have a Voith Schneider propeller that's flying through the water. So what you have here is a unit that has multiple capabilities in one unit; you're able to have propulsion, a rudder system and now you have active roll stabilisation. Power ranges—260kw, up to over 3,800kw. So you've got that well within the range of a yacht. Maximum speed, right now, up to 17, we're pushing 18. In a typical yacht application we're putting propulsion systems aft, with a Voith Schneider propeller, you'll notice the blades don't go below the baseline, a lot of people think about Voith Schneider propeller and right away they think about the water tractor and they think about how deep that draught is. Well right now we've got ferries out there running that are less than 5 feet so it can be done. Advantage of the Voith Schneider propeller? You've got excellent manoeuvrability. Think of the ability instantly change direction from full ahead to going sideways as fast you can move your joy stick. No rudder, no propeller, no long dry shaft required. Very very high efficiency, with recent tests we were running in the .7 to .75 or even higher propulsion efficiency range; no stern thrusters required, you've got a Voith Schneider propeller back there that doesn't care what direction it's going. 360° propulsion any direction within seconds. Redundancy—very very good, typically a yacht with two propellers on it you're able to lose one of those propellers and still have full control over your vessel. Low noise and vibration levels, specifically in the yacht and coming out of our experience in the mine hunter community we're looking at what we call a PP design which is essentially a dual pinion system, you have a primary pinion that runs off your primary propulsor, a big diesel engine. Potentially. Then you have a secondary pinion, which is some other material, not metal, maybe fibre, plastic, or bronze, that you run for ultra quiet operations. You shut down your main propulsion system, you'll run your hotel power generator, you'll power an electric motor that plugs into your Voith Schneider propeller, you'll take your Voith Schneider propeller and run it at a reduced rpm, potentially doing 1, 2, 5 knots, whatever, but what you add to that is the ability of active roll stabilisation. So now you're running at zero speed up to 5 knots and by the way you can use it with your main engine online too. You're able to do roll stabilisation at zero speed. So if you're out to dinner, you have guests, doing 2 knots, nice and slow, no roll. Also, hotel power only, no loud noise, no vibration. Really nice. So if we look at that, take a look at the picture down on the lower right hand corner, I put an arrow there, take a look at the horizon. This is the roll control system working for you, started out with that system off, now we're going to turn it on. And you'll see by the end of this video that you've got almost rock solid here. This is taken on a tender up in the North Sea, and we did this for prototype testing. The interesting thing with this, we had this vessel for about half a day, we took our roll control system, put up the acceleration and roll system monitors and within that period of time we had it up and running and we had a stable ship. How about that. And the proof of concept there was, the guys told me who took the video that they were really feeling sick beforehand, once they got done, they were nice and stable and feeling fine. So what we've done is a lot of tests; we do have capability within Voith in Heidenheim; we have our own tank where we can do limited tests but we also go out, you'll notice the SVA on the back of that one model, we go to multiple locations to do proofs and trials so we make sure we've got that third party input into our designs. You'll notice the design of the hull aft, we give it a slight deconfiguration aft so that we also reduce slamming and improve that longitudinal stability. We found that as the VSPs are running they actually create a slight suction effect and provide a water cushion aft. A lot of our research here has been targeted at the offshore vessel market and so a lot of the development here is absolutely applicable to the yacht market. Here you'll see

some tests with roll system off, you'll see some of the extent of the roll there with the roll on we tried to show the extent there. But more important is looking at some of the graphs, looking at the roll stabilisation that we're coming up with in these tests, the blue line is what the waves are giving us and the red line is what the vessel is actually seeing in true roll. So we're doing that with the Voith Schneider propeller essentially providing the propulsion, providing the roll control, providing all your manoeuvrability in that package. We've taken the Voith Schneider propeller now, taken all but two blades off. We have something that we now call the Voith cycloidal rudder. Essentially it offers propulsion, it offers a manoeuvring capability, and it also offers the roll stabilisation. So what that does for you is that essentially it acts as a rudder, and you're using a secondary drive, essentially an electric motor, a positioning motor, to operate in two different ways. You've got on the left hand side the active mode, just like a Voith Schneider propeller, that's propelling your vessel forward, where on the right hand side you're operating a passive motor with a standard propeller so you're acting as a rudder. Think of this way, when you build a vessel, design that rudder, you're designing that rudder to perform at the lowest possible speed that that boat will move, OK, without needing assistance. What you're able to do here is you can minimise your rudder area by putting a cycloidal rudder in so you really minimise that drag that's in the water. When you fall below that manoeuvre speed, 5 knots, pick a speed, you go active with your cycloidal rudder and now you can propel your boat, and steer your boat, OK, without having that extra drag. So what you've got here is essentially some really neat manoeuvring capabilities. On the left hand side you'll see a docking scenario here, watch the blades pitch as they're moving up here. You can see the blades pitching right now to move the vessel forward, you'll see the blades move to zero pitch, on the right hand side you're seeing that vessel's standard rudder manoeuvring around a rock or obstruction just like any other rudder would do. So now I'm pitching those blades on the left hand side, I'm moving my vessel sideways into the berth. So what I've got here with a Voith cycloidal rudder is that improvement of mobility, I've got low resistance in the water, I've got very very high efficiency, no stern thruster required on my vessel, redundancy. Think of it, you've got a standard propeller with a cycloidal rudder behind it, your main propulsion system fails, you still get home capability with this thing. So you may be going a little slower, but you're still going home. So you've got a controllable pitch propeller, offering those efficiencies and again the cycloidal rudder offers the ability to provide that active roll stabilisation even at zero speed. So now we've got something that's a little different. We take that cycloidal rudder, we start to move it amidships, in this kind of a position, and from the side it looks like that. So we've moved now into the position of fin stabilisers. We put the cycloidal rudder in place of those fin stabilisers and we're still doing all the same things. Under way, we're using those and pitching them just like a fin stabiliser would, as we slow down, go to zero speed, now we take these things active. So now they're moving, rotating and active mode and controlling my pitch and movement of the vessel, so now you're on your slow cruise, 1, 2, 5 knots, using cycloidal rudder or Voith motion control in the position of a stabiliser plane. So what you get out of that is something that's very interesting. The side by side comparison really tells a story, if you watch we'll have some motion here. The waves are exactly the same in these tank tests; if you watch the difference in roll of these two models. And this is a relatively good sea state, Andreas is here from Heidenheim, what was the sea state, Andreas? 1½ metres, in this test. So this is what we get out of that. 78.3% roll reduction. And you're seeing a 5 second period up there, here this is one is a .75 metre wave, we've got another one and 1.35 quartering waves. This is pretty impressive. It's a pretty basic chart but it shows you some neat things. You look at the hull there on the left, no roll stabilisation whatsoever. You add passive fins, you get a little bit of improvement. You go to active zero speed fins, you get a little more improvement but still not as good as going way over there to the right, you see the

Voith roll stabilisation is on and all of a sudden you're down to a significant roll angle of just a little over 2° and a sort of validation of that, if you look at passive fins and the Voith roll stabilisation system off, pretty much the same thing in test results. Jump right over to looking at the air control propeller. We're looking at propellers made from carbon fibre reinforced plastic, they're essentially an engineered composite propeller. Right now we're taking diameters up to 3 metres, we're doing R+D now to go up over 5 and towards 7, power ranges up to 3500kw. Pictures you're looking at there, on the left is a mine hunter application, and on the right is a yacht. And what's interesting here, you've got a couple of things here—you see the propeller is essentially a—let me call it a kit. Where you can take the individual fibre composite blades into dovetailed slots in the hub, they slide into that hub and lock into place with a locking ring. If you strike something in the water, run aground, do that sort of thing, you can send a diver under your boat, pop those blades out, put new ones in. You've got your spares sitting in essentially a shoe box in the engine room so you don't have to worry about being, as I heard it earlier today, somewhere out in the far ends of the distribution chain waiting for a propeller to show up. And I know some people have experienced that, with trying to find a charter or something like that, because those propellers are on site way out in the boondocks. So those are clear advantages to the propeller. But the really neat thing here is, you've got a compliant propeller that flexes and moves as you change load and speed on the propeller, so what you're seeing in general in a design, is about a 10% improvement in fuel efficiency as this thing is operating. If you watch, what happens with this propeller, is it will flex, and move, as the load increases. You watch the load on the propeller here slowly increase, you'll see I've marked it here at the top, watch the blades move as they flex, to adjust within the performance requirements of the vessel. Now captains have said, I've installed them on their yachts so far, you gave me a sports car, because of the way that these blades flex and essentially bite into the water, to take that vessel and push it off the starting line. And you'll see here as the blade, as that load comes up and that blade starts to flex more and more, remember where it started out there, where I put the cursor. So we have here the contra propeller, we have a propeller that has exchangeable composite blades, we have a weight that's about 1/4 to 1/3 of what a typical metal propeller would be, we have very low noise and vibration and think how much lighter that is and how much big rotational weight you don't have out at the end of that propeller shaft. You're also thinking about reductions potentially on your bearing requirements, some of those other things on board your vessel. You're looking at essentially a system that's engineered to your hull, your engine, your speeds, to make it work exactly in your environment. You have much reduced chance of cavitation, currently the US Navy is working through some development programmes again with O&R funding, we're looking at processes and abilities to put that into ultra quiet operations. Very very good emergency characteristics. That's an interesting one. What happens when this propeller hits something. The answer is, it breaks. But if it breaks, you don't bend it, you don't go out of balance, you maybe have a half a propeller left but you can still go home. So until you get to some place where you can exchange that propeller, send someone down to push the old blade out and put a new one in, you still have the ability to go home. It doesn't corrode, because it's plastic and I talked about the fuel consumption—really neat. If you think about a branch propeller, you design that propeller for a certain speed, a certain sweet spot when it's running. When you take this thing, you actually broaden that sweet spot by a certain amount and again, depending on your vessel and your performance requirements, you see that expanded performance area. I'd also like to look at inline thrusters. This is another product, that AIR provides. They have again, blades that are made of this composite plastic, very very light and efficient, very low noise, if you look at its design you're looking at a propulsor that essentially is a rim drive. You're looking at a motor that's

built into the rim of the propulsor and what you have then is you have no tip cavitation. You've probably all heard the yachts with their bow thrusters, you can hear them when they run and shut down, virtually no noise out of this propulsor. You're also seeing a tremendous improvement in the efficiency, because you don't have those tip losses. Very lightweight, installation is as simple as sliding a package in, either from above or below, and plugging it in. There are no external drive mechanisms or anything like that. You've got everything contained within this unit. Seawater lubricated bearings keep it very reliable, and essentially very simple. That sort of wraps it up, there are two of us here at the symposium, myself and Andreas, we'll be eager to answer any questions, or talk about anything a little bit more. Those people that have been trapped at lunch with us know that for a fact. So anyway, open for questions.

Martin

Thank you very much, Lee. Yes, thank you, immediately in the front there please.

Don Gale Gibbs & Cox, Naval Architects

This is definitely a very interesting propulsion system, I just wanted to clarify something. I'd gathered at the outset that you were proposing it as a main propulsion system but it sounded like, as you progressed, you were recommending it as an auxiliary, as well as of course the stabilisation characteristics. Could this be used, I know you mentioned top speeds of 17, possibly going toward 18, knots nowadays, could it be used for the main propulsors on a boat that didn't have a mission speed any higher ?

Lee

Oh absolutely. That's our primary goal, to put it on as a primary propulsion system. To use it in that mode. Right now the Navies of the world in their mine hunters are using the Voith Schneider propeller as their primary propulsion because they are so quiet and so manoeuvrable, so they're using essentially two propellers aft, in a yacht configuration.

Don

OK. And you mentioned the roll control and it's also got pitch control characteristics? I understand many large yachts nowadays are incorporating bow bulbs into the design for that purpose. Would you say that the Voith system would be able to take the place of a bow bulb or pitch control?

Lee

A good question. It's a case by case thing. Voith prides itself on having a very good engineering department, tied with its Voith Schneider Group. We will work with the naval architect very specifically with your design, we have very capable CFD in our facility. I think we're up to about 54 CPUs right now, running CFD Comet and the like, doing that, so we can run full simulations, we do analysis of lines, we look at all those things to make sure, working again with the architect, to make sure that the designs are optimised for the Voith Schneider propeller, we will make recommendations relative to things like that to say this will help, this won't help, we'll run a test or trial that includes that or takes it away, so you can clearly see the difference between two different configurations. So at the end of the day you'll come out with something that is extremely efficient. We found that working with naval

architects, they are very familiar with standard propellers, but when it comes to working with a Voith Schneider propeller we work with them to some degree, a little bit of on the job training to help them understand the dynamics, performances and flow, of the Voith Schneider propeller. So with that, you're able to get a hull that truly works as designed and will meet those performance requirements.

Don

I imagine that one of the key drivers of having a bow bulb being the bow wave reduction as well as pitch control, I imagine having both in place might probably even be an advantage. Thank you very much.

Holger Hamann Holger Hamann Consulting

So if I understand it, it could be an alternative to the Azipods, is that right?

Lee

Absolutely.

Holger

And just a question, do you have any experience pricewise comparable to Azipods?

Lee

They are reasonably comparable in the size range we're talking about. It depends on the installation and application, looking at how we do the gearing, those sorts of things, because we tend to provide an entire package versus just providing the propeller. So we'll work with you all the way through your engine drive line, and everything.

Holger

Could it also be possible as an alternative for sailing boats, let's say bigger sailing boats where we have the propellers of course stopping the speed, that you can turn the blades in the way you have a free flow for the sailing boat when it's under sail?

Lee

For a sailing boat application I'd have to recommend the two bladed cycloidal rudder. Because that gives you that rudder capability that you need in the sailing boat but also provides you with your basic propulsion in that package. And then again, it has to be a larger vessel. You're looking at—a Voith Schneider propeller is a very robust system, it's a way of saying it's a little bit heavier that what you might be used to. So in a sailing boat, because of the way that the Voith Schneider is constructed, everything is physically tied together, so the ability to feather those four, five or six blades into the flow of the water is too complex, it would reduce the reliability of the vessel for the propulsion system so we generally don't do that.

Holger

OK, thank you.

Jeffrey Benneville Camper & Nicholsons

Pertaining to it as a primary propulsion unit, the ability to operate with a blade down, if you damage a blade, is there significant vibration?

Lee

Let's say some of the stories—the US Navy and their mine hunters, were absolutely surprised when they found out half a blade was gone. They send a diver down to do inspections routinely and they found half a blade was gone. So vibrations are not a big deal. You can have blades that are bent, for example, and the system will still run. And you will not have extraordinary vibrations because your rotational speed in the propeller is so low. Generally in the size range we're talking about here, that would go on a yacht, you're looking at speeds roughly 80-90rpm in the water. So pretty well.

Jeffrey

And if you needed to repair that blade, like your composite, can they switched out under water individual or does it normally result in a hole.

Lee

It depends on the design of your vessel. If you see that as being a primary concern that you want to be able to change blades in the water, we will help you design a vessel so that your water line is above essentially the installation rim of the propeller itself. But in general yes, it will result in—the ferry operators have put a gravel truck to wind into their ferry for example to take that end out of the water, so that they can change blades in the water. And that's how they do it.

Martin

Roger, over there, please.

[From the floor]

Are the blades custom built for the boats? It seems to me that if you're going to need to change the blade or change the pitch on the propeller, then you've got to have a large stock of blades ready for these boats.

Lee

You're talking about the Voith Schneider propeller? They are pretty much a standard configuration now. Based on the size of propeller that's installed the blades are specific length. Generally if we work with someone we may go to a custom length; generally those custom lengths are shorter than the stock blades.

[From the floor]

I meant on your flexible propeller that you can change the blades on. It seems to me if you're going to have—a designer doesn't always hit the right pitch right off, and it seems to me if you want to change the pitch on the blade you ought to have a supply of different pitch blades available.

Lee

The moulds that are built to lay out the blades are custom done, if the design of the pitch change needs to be made, we cut a new mould to change that pitch.

[From the floor]

So is the cost that much more expensive?

Lee

It is not as cheap as a bronze blade, let me put it that way. But it's a custom blade.

Martin

Any more questions?

Michael Eaglen High Modulus (New Zealand) Ltd

You made the comment about your carbon fibre propellers that if you hit something and broke a blade that it wouldn't fall out of balance. Can you explain that some more for us?

Lee

It's because the blades are so light. A lot of your primary weight for the propeller as a whole is actually the hub. The blades themselves are very light so you don't have that large mass swinging out as you would with a metal blade.

Michael

But surely the imbalance in the water would be more hydrodynamic than mass inertia based.

Lee

Yes, we have operators that are running sport fishers, for example, we've got blades in the range of 35-40", they have broken blades off, or in half, one or two blades, and they're still able to run home. They know that they've got some kind of vibration, they don't know what it is, but they know they've got a vibration. But it's not shutting them down. It's not keeping them from running.

Martin

Lee, a question from me. Has the at anchor stabilisation proposal been used yet, in a yacht application.

Lee

Not in a yacht, specifically. We have two projects in Europe at the moment and one here in the US so our validation, if you will, is in the model tank and in OSVs. Not in the yacht market at the moment.

Peter Southgate Cayman Islands Shipping Registry

I had some experience with Voith on my hunters myself, in the past and they were primarily designed for slow speed but high manoeuvrability. You mentioned that you have capability of achieving 17 knots. What is the main limitation to exceed that.

Lee

Physics.

Peter

Just physics. Easy question.

Martin

Alright, Lee, thank you very much indeed.

Dr Mathias Voight Hamann AG

Thank you and good afternoon, ladies and gentlemen. This is the last presentation of this session and now we're getting dirty. It's back to the nitty gritty bit, and we hope to share with you and discuss with you some new ideas about biological treatment of waste water on board ships. But before I get into the presentation let me tell you a few words about the company of Hamann AG. Hamann is located in Hollenstedt, this is the new company premises and the company has been in the market for more than thirty years and many of you may know the name of Hamann Wassertechnik. In January 2004 the Hamann AG was established and at present the company has some 65 people working there and the tendency is rising, and it's rising fast. This building that you see here today is just one of three buildings, we have just doubled the workshop area and added another 2½ thousand sq metres of production space and 700sq metres of office space to the company to keep up with the current development. This is where the company is based and you see all these little tiny dots, that's the world wide network of service stations and agents round the globe. Today we are talking just about waste water treatment but Hamann is not limited to that, there's also fresh water production, ballast water treatment, but today it's just waste water.

So I'll try to tag on to what Eric briefly laid out yesterday about the quality of the waste that we are trying to treat with the new system, give a short explanation on the waste streams on board the ship, go into the regulations and then give you some technical explanations on the new system and then show you test results. So typically on board the ship we have black water which consists of everything that's going down the toilets and on bigger boats, on the cruise ships, from the hospital, and we have the grey water, which is consisting of galley water, laundry water, and the accommodation showers and sinks. But as you are well aware there's an ongoing discussion about what is actually the contamination of that water and, depending on who you ask, you get a lot of different information. So what do we have? And this is basically the same that Eric showed you yesterday, those are data from 2003 and they give a pretty accurate picture of the situation on a typical cruise ship. There's the percentage of the different waste lines vary greatly as do the contamination sources like COD, BOD and TSS. But on a yacht things are different yet again. Because normally we do not have this dewatering of food waste on a yacht so that waste source is out of the picture but we have a different percentage of the individual waste lines on board a yacht. We have much more laundry water, we have a little bit less galley water. The contamination remains the same as the individual waste water

sources but in the end we have a different combination and a different timing of the waste. I'll get back to that later.

So what are the current regulations for waste water? Very generally speaking, there's a very good— [*phone ringing? Say hullo to Mom?*] . There's a growing gap between the improvements in ship's technologies, we have vacuum systems, we have higher concentrated waste loads all the time, and on the other end of the stick we have stricter environmental regulations. Just think about Alaska and Miami. That gap is really putting the pressure on to the industry coming up with solutions that grab both ends of the stick and come to a feasible solution to the problem. We think this is more a challenge than a problem, really. So the answer would be to have a system that can be looked at as an integrated liquid waste management concept. So this is something fairly new. It's not only treating the waste, it's an integration of the system into the ship. And this is what it may look like. This would be a typical design for a yacht say with 40 passengers; we have a pre filtration in the first step, where we get most of the solids out and what's even more important, everything that should not belong to black water like people put down towels in the toilets, eventually a glass, or if something's coming out of the galley like kitchen knives, whatever. So that is separated out here and then the treatment process is started and I'll briefly try and explain to you the entire idea of the system. We are combining the waste lines into a single mixing or collecting tank. And from here we go through this pre filtration bit, separate out the solids, and they are actually very very dry. They are packed in endless bags here and easy to dispose of. And after that the liquid phase, and only that, is going to a pre aeration tank where again we have mixing of the entire waste line and all of this is at constant flow. And then in constant flow we go into the bio reactor and here's where it all happens, where the bugs are working for us, breaking down the biology. And then from the bio reactor we go into this funny designed settling tank. Which is designed like that for a reason, because only if we have a design like that can we fill it up 100% and the ship's movements do not interfere with the settling of the biology here. Because if you have free surfaces in a settling tank and the ship's moving, you wouldn't experience any settling at all. So most of the solids settle here and they can actually be put back into the system, back into the process, and only the super natant, only this is going to the membranes. And the membranes, and this is another new thing to the system that we have developed, they are by no means connected and do not interfere with the biology. Most of the other systems they have either submerged membranes, directly in the biology, or they have the membranes outside, attached but still drawing the water directly from the biology through the membranes and let the membranes do the job. We have a different philosophy. We let the biology do the job, have a settling and then just the final bit of solids that is going over here with the super natant, that's confronted with the membrane so we have very very little sludge production in the system, but I'll get to this later on. You see this is again the pre filtration. It is a basically green process, and the waste water is going through a very small sieve, about 1mm in size, and then the solids are pushed towards one end and there's a cone, and then it's dewatered again and this is the outcome. And the typical amount of solids that you separate out of the system for say 30 to 40 people would be 1 bucketful of solids. And that's all. Then the second step is that a two step bio reactor, where we have a continuous aeration in a specially designed tank. Why specially designed? I'll explain that a bit later. And then we are changing from constant flow to batch mode and transfer batches of waste water to the settlement and the settling is not only removing solids but also acting as a stage where we have different bacteria working there for us. And this is what, you may not be able to see it that well, this is what a typical design of an aeration tank would be. You see it's straight up here, and then it's bending at an angle. We do that because to have an efficient aeration of waste water you always need a minimum height of water column above your aeration membranes to be able

to actually transfer the air into the water and have a biological process going. We achieve that by keeping the water levels in the tank always up to here, so at any time, any status of the system we have at least one metre of water column above the membranes for sufficient oxygen transfer and this is the volume that we're actually operating in batch mode. And after the biology and after the settling this is what we achieve. We actually create biology, we transfer the waste into living biological bio mass, this is what's settling here, and this is the super natant that is going towards the membranes. The membranes are plate membranes in this tank here and they are only confronted with what's left from the biological process. That sounds very theoretical. Let me give you some practical land based test results. The tests were carried out at full scale at 35 cubic metres waste flow per day and at a land based sewage treatment plant and the challenge conditions of the water were well above normal ship's conditions. So we thought that we should test at significant loads and to remind us what is the significant load, talking about waste water, it's a COD of round about 2000mg per litre, BOD round about 869 and a TSS of 770. Well, if you would test just to IMO regulations you could get away with testing at just 500mg TSS, that's what's required even according to the latest test guidelines, but we figured well that's not significant and that's not good enough. So these three columns here, those are the values that we have used during the ten days IMO, US Coastguard type approval testing. So you see all of these parameters were well above standard and normal ship conditions and way above the requirements to which you have to test if you test according to IMO regulations. And we've done that throughout the entire test period of 10 days and these are the results from the US Coastguard certified lab in Hamburg and you see, after the membranes, even with a load condition like that over the entire period of the testing, we were well into Alaska regulations, which are 30 and 30 regarding TSS and BOD and this parameter, the COD, that was not even required while we did the testing there but it's going to be required from 2010 in the new IMO regulations and the value that you have to achieve there is 125mgs COD and you see under these conditions we achieved 80. So this is already future built in for the new regulations. But if that wasn't difficult enough we said what's happening at real peak load conditions? And peak load with our definition is not only an increase in the hydraulic load but also an increase in the contamination of the waste water. Picture a situation where you have a nice party on board your ship and some of the people have a lot of food, a lot of drink and then one sludge pump gets stuck and all of a sudden the system gets confronted with what is after the sludge pump is working again. And you do not want to wreck your party saying sorry guys, toilets are closed so this will be the situation. And this would be what's confronting the system. But with the configuration that we have come up with in our system, after the bio reactor this is what is left from this contamination, so we managed to change the biological process. We didn't reinvent the wheel, it's just spinning it a little bit different. So what we achieved is, we have a full biological process and after the bio reactor this is prior to the membranes, this is the reduction we achieved. It is more than 95% of all the biology is already gone there. And we can truly say it's a full biological process and as a good indication, in untreated sewage you will find a ratio from the biological oxygen demand compared to the chemical oxygen demand of two in one, roughly, as a rule of thumb. 1.8 to 1, to 2 to 1. And if a true biological process has happened, that ratio is changing and is going towards 5 to 1, 4.5 to 1 and this is what you see here. This is the result at the end point of a biological process, and when this is then put through the membranes, even under conditions like this, and this is at full hydraulic load of the system, but with contamination like that we are still in compliance with Alaska regulations and even in compliance with the new requirements of the IMO. So to come back to this, how can we achieve that? Well, it is because we are able to reuse the biology that we are creating in the process. We are not wasting the bugs, we are pampering them. So what we do is, when the organics come into the bio reactor, the bacteria start growing very very rapidly. And what we do is we operate

the system so that the growth of the bacteria is always in the lock phase. We are not allowing them to come to the steady stage when they are not growing any more. And so after this bit is done, and after settling, we reuse this activated sludge in this pre aeration tank, and this is for two reasons. One, we have a pre conditioning of the waste and two, we are protecting the system from toxic shocks that are occurring regularly on every vessel. Picture your crew being very bored after that long party you had and they still have to clean up, they still have to clean all the toilets and instead of well, using a brush, they just pour down a couple of litres of chlorine down the toilet so that is coming instantly to your system. If you do not have these two protecting stages of the system it'll stuff up the entire biology and your system will not be able to work anymore. But because we have this mixing here and we have this pre conditioning and pre inoculation with living bacteria in this tank here, we reduce the impact of any toxic shocks that may come to the system and protect the biology that way. So one other beauty of the system is that you can actually use a very large number of existing tanks, because there are only two tanks with special design requirements, that's the settling tank and the aeration tank. The remaining capacities that we have to have you can use existing tanks, or tanks already specified in the layout of the vessel. The second big advantage is the low sludge production. And this is a long term average, is 2%. Under regular situations where we operate the system with constant loads that are relevant to ships operation we find periods where we have no extra sludge at all. Because we are reusing all the sludge to keep the bugs happy and keep the biology going. So this process design not only protects the system but it's also increasing the waste streams that we are always creating with a biological system. It's full POC steering, well that's normal and the operator has the ability to look at each individual step of the system and is able to take precautionary measures if necessary, if anything goes wrong. So the major inventions in this is that we have the membranes separate from the biology and in a separate tank that they could not interfere with the bugs, we do not have any heating or we do not create any heat input into the biology so you do not have to cool the bio reactor. We have pre conditioning of the waste, we have a better protection of the biology like that and we have through those engineering things that we apply to the system we can say that we can settle the sludge in any seagoing conditions. The modular concept of this system is so advanced that we have a type certificate for capacities from 5-950 cubic metres per day. So with any capacity in that range, we can offer systems that follow the same concept but allow a great variation in the load. I think that's all for now. Thank you.

Martin

Mathias, thank you very much. Any sludge questions? OK a question from me then. What is the engine room footprint?

Mathias

It really depends on the capacity.

Martin

Thank you. So give me a typical 50metre, 12 guests, plenty of activity?

Mathias

Well, 12 guests will be the smallest size, 5 cubic metres per day roughly. So that will have a total tank volume of say 3½ or 4 cubic metres, and then it depends on the

ship's layout which tanks can be used. But those tanks that should be designed into the ship may be 2 sq metres roughly.

Martin

And from an engineer's point of view what is the maintenance programme on board?

Mathias

So far we have regular cleaning of the membranes but they are operating at a pulse pause principle, so that's only in a say 3 month interval. And we do not use any chemical in the general operation of the system and the biology is self maintaining. And so is the pre filtration; the only thing you have to do is to empty those, cut off those endless bags, that are collecting the solids, and dispose of them. That's it.

Martin

OK. Mathias, thank you very much indeed.
