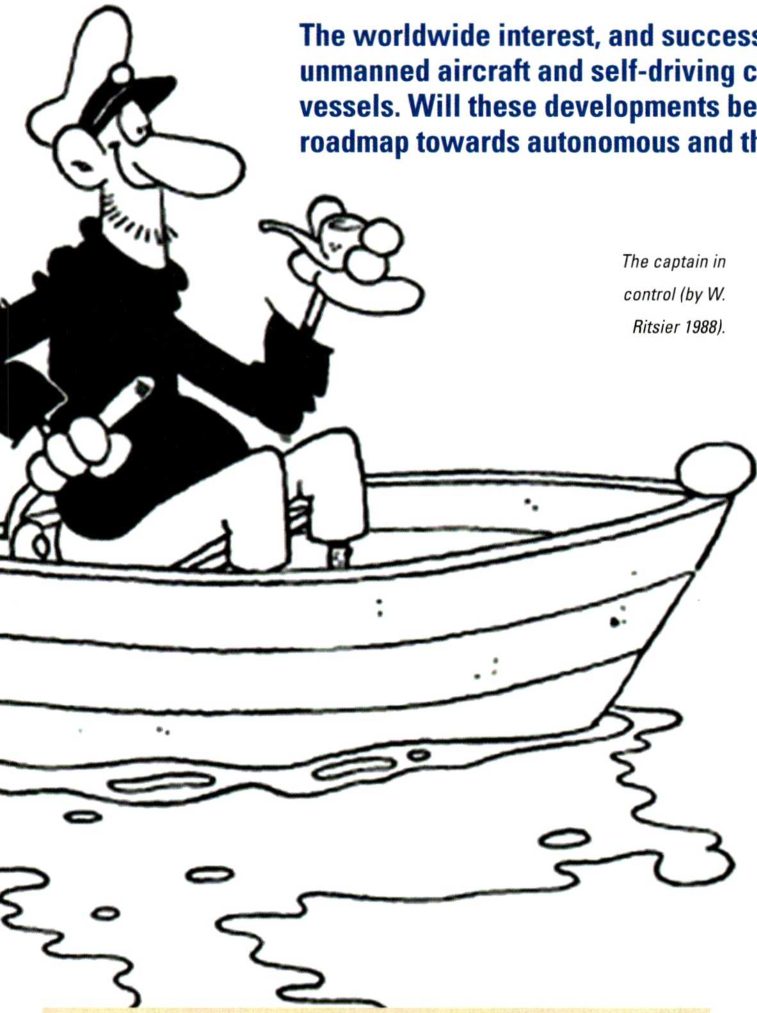
Door P.G.M. van der Klugt

Peter van der Klugt is oprichter en eigenaar van PK Marine en focust zich op het verbeteren van scheepsautomatisering door middel van kunstmatige intelligentie.

Autonomous Ships: Dawn of the Artificial Crew (1)

The Many Interpretations of 'Autonomous'

The worldwide interest, and successes, on applying robotic technologies to realise unmanned aircraft and self-driving cars encourage many to apply similar technologies for vessels. Will these developments be the end of the mariner? An exploration of the roadmap towards autonomous and the impact of these developments on the mariner.



The captain in control (by W. Ritsier 1988).

Stories in the press and nice videos on the Internet suggest that serious progress has been made with military robotic craft and robotic measurement craft; big companies such as Rolls-Royce and Kongsberg bask in the attention they receive for their "visionary" research activities. Unfortunately, the maritime market is not a volume market, has (technology-wise) always lagged behind those other markets due to the lower innovation budgets and smaller market size, and is characterised by its hostile (and usually inaccessible) environment. Technology driven companies tend to make light of the many odd tasks the crew executes on their ships, tasks that more often than not determine whether or not ship and cargo arrive safely at their destination.

This article introduces the artificial crew as the core of a fully autonomous robotic vessel. It will show why mariners do not have to worry for their jobs for a long time to come. Quite the contrary: they may anticipate serious benefits as technology progresses.

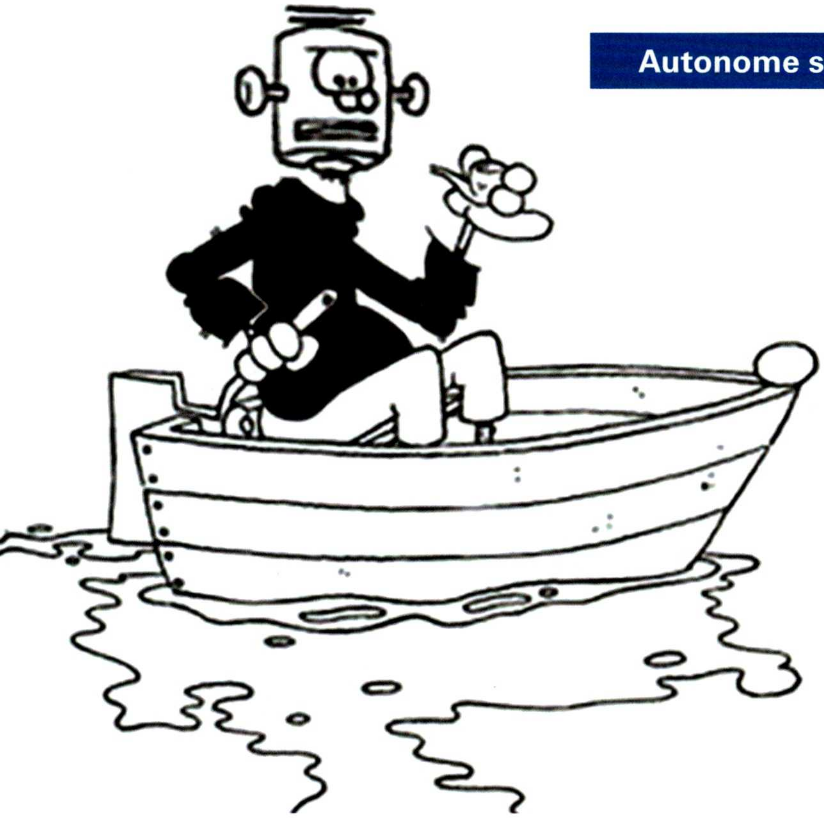
Part 1

This article has been divided into three parts. This first part goes into the different interpretations of autonomous, unmanned and remote. The second part, titled "Back to the Drawing Board", discusses the human aspects to be taken into consideration when moving towards autonomous as well as the responsibility question and will be published in SWZ|Maritime's February issue. The third and final part, to be published in our March issue, will introduce and discuss the "artificial crew".

The Many Interpretations of "Autonomous"

"Autonomy" is a matter of perspective. From the point of view of a ship operator, a captain and people who watch as ships sail by, a "manned" ship is fully autonomous. A captain may take into account suggestions by the ship operator, other crew members, a pilot or harbour authorities and he/she may decide to delegate some of his/her tasks. Yet, in the end, HE/SHE has the final responsibility and determines what the ship will actually do. Self-determination is a property of the combination of a ship and its captain. This property matches the following definition of autonomy: 'Has the liberty and/or authority to make decisions and to act on those decisions.'

Why then have the "unmanned ship" and the "autonomous ship" become, in the eye of the general public, synonyms of the "robot ship"? Furthermore, why do companies and potential end-users associate designs of shore-based facilities from which to supervise robotic ships with autonomous while "remote supervision" implies that the ship is not really autonomous?



The computer in control of the ship (free after W. Ritsier 1988).

The answer to these questions lies partially in the current interest in autonomous vehicles, driven by the developments in automotive and aircraft industry and partially in the need for companies to acquire funding for their developments. The subject autonomous ships attracts attention of the press, is sufficiently vague that everybody seems to know what it is about and is regarded by many as a game-changing technology. Nice, futuristic pictures and videos on the Internet seem so close to reality that it is all too easy to miss the many constraints of the presented solutions. Constraints that upon closer inspection require a serious research effort to overcome and that mark the difference between development of merely a remote-operated ship and of a really autonomous ship.
So are autonomous ships a hoax or is there really something in it? Will it come to naught or will we see the first robotic ships sailing across the inland waters or oceans within a decade?
The answer to those questions is not a simple one and starts with a better, objective classification of unmanned and/or autonomous ships. Only with this classification at hand, will it be possible to discuss development time-scales and the impact of development steps on today's maritime operations.

Remote and Local (Operation)

In principle, remote/local operation merely describes the distance between the ship systems and the human operator with his Human Machine Interface (HMI). Within a vessel, it cannot be more local than moving a helm by human force. Follow-up control with a steering wheel at the bridge and a hydraulic system to move the rudder is already a form of remote operation (made possible by wired connections between steering gear and bridge).
Likewise, the engine control room is, from the engineer's perspective, the place from which he remotely monitors and controls engines, power supply and distribution, et cetera. In most cases, these systems have local back-up controls in close proximity. Wired or wireless is just a technical solution to realise a remote HMI. Wireless allows for a much larger distance between the system and the human operator with his HMI. Wired implies that human operator and his HMI are confined to the ship (although there are examples where the ship is moored and plugged into shore based facilities from which the ship is guarded).

Manned and Unmanned (Operation)

There is some debate about whether or not a plane remotely controlled by a remote human operator should be regarded as a manned or unmanned plane. Likewise, if a ship carries passengers or a temporary maintenance crew, should it be regarded as manned or unmanned?
In this article, the following definition is used:

- Manned: there is crew on board and that crew is critical for completing the operation of the vessel.
- Unmanned: not staffed.

So, an unmanned ship with a serious problem that receives a maintenance team on board to resolve that problem remains an unmanned ship. However, when a team member assumes control of a critical system to guide the ship to safety, the ship should be regarded as manned.

Attended and Unattended (Operation)

The separation in attended and unattended is about the role of the human operator. Attended implies that the human operator fulfills a crucial role in the operation of the ship. That role can be from some place at the ship or from some shore based facility. Most of today's research activities, and most of the so-called autonomous vessels currently on the market, have a human supervisor who has the final decision what the vessel should and should not do. Additionally, most unmanned vehicles have a form of remote control in which the human operator either gives steering and propulsion commands or provides autopilot setpoints. As a human is responsible, attended implies there is someone to blame in case of serious problems (see rulings at www.themaritimedisciplinarycourtofthenetherlands.com). On a manned ship, the maritime disciplinary court may blame the officers, on an unmanned ship it may blame the remote officer/supervisor.
Unattended is what a "real" robotic ship is about; there is not even a human supervisor to make any tough decisions. The ship itself has to make all necessary decisions to start, execute and conclude the required operation and everything that entails. For that, it has to gather information, not only from its sensors and system diagnostics, but also from other ships, traffic control and other stakeholders that may help, or interfere, with the intended operation.
The only remaining human task is to give commands on when/where to go and what to do while underway until it has finally arrived at its destination.

Manual, Automatic and Supervisory (Ship Control)

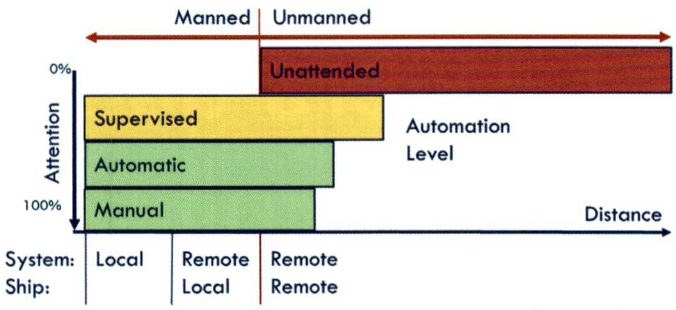
Many studies have discussed levels of automation or levels of control. Whereas they may vary in the number of levels they distinguish, with respect to ship control the basics are the same.

Manual ship control, includes sub levels where a human operator addresses actuation devices directly by human force, aided by machinery power or by generating a setpoint that is subsequently realised by a control system. Characteristic is the span of control: limited to an actuation device such as a rudder or an engine. The ship's motion is almost an accidental side effect and the operator decides whether or not that side effect has any merits or that he has to make adjustments. "Joystick control", where an algorithm cleverly distributes the joystick commands to the various actuation devices, is also a sublevel of manual control.

In automatic control, the operator gives setpoints in the ship's reference system (heading, speed, position, roll, et cetera). An automatic ship control system is responsible for realising those setpoints and for providing performance information. It is about the many versions of autopilot, DP system, roll stabilisation system, and other systems to control one or more of the degrees of freedom of the ship.

Whereas there is a clear distinction between manual and automatic ship control, the boundary between automatic and supervisory is less easy to define. Supervisory control is often used to describe the control of complex automation systems, including the monitoring and control of the ship's machinery systems from the engine control room. Yet, if that is the definition, what about a navigator who "supervises" the performance of his auto- or trackpilot?

The answer chosen in this article is to base the definition on the control context. At the lowest (manual) level, the context is the actuation device and that has no knowledge of its impact on the next level (automatic). Likewise, at the second (automatic) level, the context is the system being controlled (for example the ship with its six degrees of freedom) and that has no knowledge of its impact on the next level (supervisory). With this definition, executing a planned route, gathering sensor data to monitor and assess the situation, warning about imminent danger or about an initiated evasive manoeuvring and condition monitoring are all examples of supervisory control: the ship has to report to some supervisor and serious decisions can only be made by that supervisor. With respect to the control of the ship's automation systems, the same definitions can be applied: supervisory control crosses the boundaries of the individual systems. The diagram below summarises the above.



Autonomy classes.

Supervisory control: the ship has to report to a supervisor and serious decisions can only be made by that supervisor (by W. Ritsier, 1988).

Placing Examples into Categories

From these definitions, one may conclude that today, there are very few examples of vessels that are fully autonomous (unattended). Most developments on unmanned underwater and surface vessels concentrate on remote/unmanned/attended, and of those developments, manual and automatic control are considered to be state-of-the-art technologies while supervisory control is posed as revolutionary, worthy of serious public attention.

ROVs are operated remote/unmanned/attended/manual (by an operator working from a mothership). A flying drone that moves automatically from waypoint to waypoint along a 3D path, is remote/unmanned/attended/supervisory.

The systems controlled from a manned engine control room at a ship or at the shore are remote/unmanned/attended/automatic. From the bridge, or from shore based facilities that address multiple ships, these systems are remote/unmanned/attended/supervised.

To be continued in part 2.

About the Author

Peter van der Klugt (1956) got his Ph.D. in 1987 on the subject Rudder Roll Reduction. Until 2016, he was employed by Imtech Marine (now RH Marine), working on innovation of ship control systems, integrated bridges, machinery automation, and so on. His designs are used to control naval vessels, luxury yachts, offshore vessels and even remote-commanded, free-sailing craft. In 1989, he posed his ideas with respect to artificial intelligence for the first time, ideas that gradually affected the bridge systems manufactured by Imtech Marine and, recently, IEC legislation with respect to Bridge Alert Management.

In 2016, he started PK Marine and acquired the freedom to focus on machine intelligence as a means to significantly improve ship automation systems. Today, he is working together with an expanding group of small companies, such as sens2sea, MH Marine and Condast, institutes and students to realise what he refers to as the "Artificial Navigator".

Door P.G.M. van der Klugt

Autonomous Ships: Dawn of the Artificial Crew (2)

Back to the Drawing Board

Is it really the bridge of the future? (picture by Rolls-Royce).

The worldwide interest, and successes, on applying robotic technologies to realise unmanned aircraft and self-driving cars encourage many to apply similar technologies for vessels. Will these developments be the end of the mariner? An exploration of the roadmap towards autonomous and the impact of these developments on the mariner.

More often than not, those involved in the development of unmanned vessels tend to ignore the limitations of the human operator as well as the many, seemingly insignificant, jobs a ship's crew does to keep a ship fully operational. Whereas this may be a pragmatic approach that enables developers to get quick results attracting wide interest, it is bound to lead to disappointments once it becomes clear that these human aspects are too easily ignored.

'Remote' Implies a Significant Data Reduction

The problems already start with the word "remote". Remote as in

Part 2

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"from a mothership" implies that data transfer of video streams from a camera and radar images is state-of-the-art technology. However, as distance increases, so are the problems to transfer enough data to allow a shore crew to operate a vessel as if they were on board. The transfer rate in the middle of the ocean (let alone in the polar regions) is nowhere near what is possible on shore and costs much more. Streaming video to provide a view from the environment and from critical compartments within the ship will not be possible for some time to come. In addition, the distance does not bode well for the time lag of the interaction between human operator and ship either. As a consequence, a significant data reduction is required that goes well beyond what is possible with today's data compression techniques. Even driving remote mimics with data transmitted by the ship's systems is already a too-high burden. Pre-processing is necessary to transform such data to the really essential information a remote operator needs for executing his tasks. Applying human machine interfaces (HMIs) similar to those found on today's ships is not really a solution unless the unmanned ship remains close to land so the data link offers a high data rate.

Humans Are Poor Supervisors

Let us assume that there is a human operator supervising an unmanned ship far out at sea from a control centre on shore. For days on end, little happens except for regular remarks about some system that informs him about minor problems that do not really require serious attention. What will happen if he is suddenly confronted with a rare problem with serious consequences, such that his screens are flooded with data while he is expected to quickly come up with an appropriate response? At least on board, the human operator can temporarily suspend his supervisory activities, take a stroll along the various systems to smell and sense what is going on and look whether or not maintenance activities are in order. This way, he gets a real feel for his systems and this familiarity helps him when decisive action is in order. From a distance, and certainly from some shore-based premises, it is hard to recognise what is happening in severe seas, or to have that same sense of awareness that helps him to quickly recognise what to do. Furthermore, there is this thing about training that is oh so common in the aircraft industry: it requires experience and serious training on handling rare situations before an operator is able to address a rare problem quickly. Years of focusing on safety have led to insights and a level of harmonisation that the shipping industry can only dream of. On the contrary, the interest in unmanned comes with even more, often spectacular, designs.

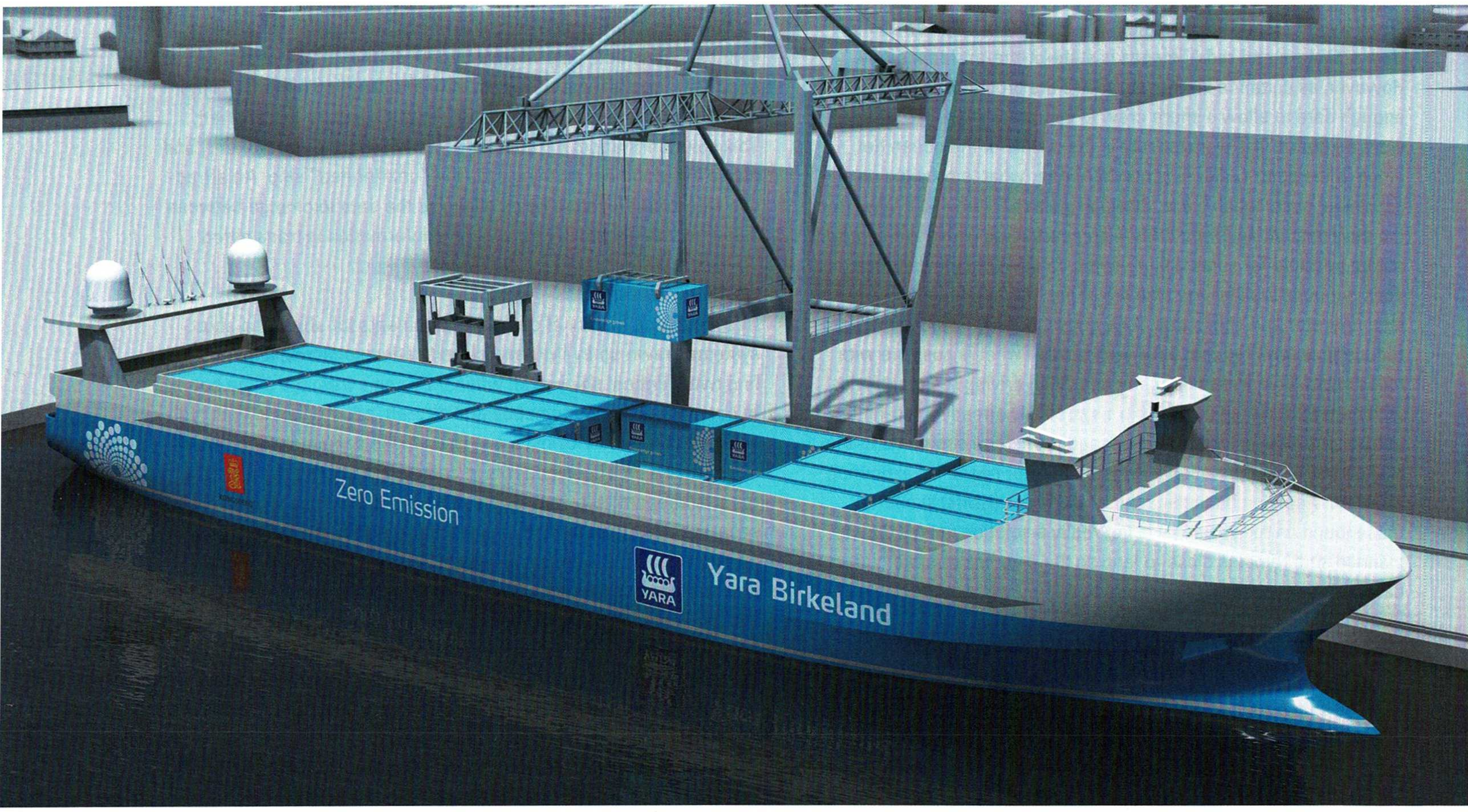
The path to supervision from shore requires a significant improvement of the HMI that supports the interaction between the remote supervisor and the unmanned ship and its systems. Even more so than with remote manual monitoring and control (where the operator is almost continuously working with his systems), measures are necessary to cope with the limited attention span of supervising humans. One solution, and likely the only one, is to give the automation on board the unmanned ship the artificial intelligence to make its own decisions and, only when it cannot do that (or is not authorised to do that) give a clear assessment of the situation (virtual reality) together with precise questions on what it wants to be resolved. This solution is about introducing a restricted form of autonomy and also a development step towards the "unattended" ship. An attractive side effect is that it helps minimise the data exchange between ship and shore station; only essential information is transmitted.

Standardisation

Despite a long history of design requirements for ships and ship systems drawn up by IMO and classification societies, it is hard to find two identical ships even when they come from the same batch. In comparison, the automobile and aircraft industry come with high volumes of very few designs and even those seemingly different designs have a lot of components in common. A shore based control room is economically only viable if it can be designed to supervise several ships. How to do that when there are so many differences among ships? The problem is not caused by differences in engine size, efficiency of propellers or the output of the power plant. Rather it is the lack of standardisation in monitoring and control options, the data details provided by the automation components and the sheer variety of components. Where to plug-in in a ship to acquire information on how well the ship's systems do as is so common in cars?

Yet, is this only a problem of unmanned ships or is it already a problem of today's manned (SOLAS) ships? With respect to bridge automation, legislation has led to standardisation of at least the basic navigation functions. With respect to engine room automation, even that is not true. Some ships have a high level of automation, some ships do not even have engine room automation. Over the life span of a ship, its systems change and that is particularly true for its ICT components. It is only because the crew learns and evolves together with the ship and its systems that they manage to adjust so seemingly easily that their employers think it is only natural that they can sail away safely with little or no training. However, times are changing. Modern automation has many advantages in terms of safety and fuel and operational efficiency. Yet, to achieve those advantages, modern automation also comes with serious training requirements. How much longer will it be before we see accidents where the root cause is unfamiliarity with a ship's automation? One cannot but conclude that, on manned ships, standardisation such that the crew can easily shift from one ship to the other is as important as for unmanned ships where the crew on shore has to supervise several ships simultaneously. Standardisation is an essential step towards further improving manned ships and to keep the rising costs of ship automation in check. It is also an essential step towards unmanned ships, and even further, to unattended ships.

Even more so, without significant steps towards harmonisation of all those systems on board a ship, it will be virtually impossible to develop the economically viable artificial intelligence that is the core of each robotic ship.



Kongsberg's vessel Yara Birkeland will be a fully electric and autonomous container ship with zero emissions (picture by Kongsberg).

The Responsibility Question

Required changes are not just limited to technology. Various legislation issues have to be re-addressed too. With respect to unattended ships, the most pressing one obviously is "who is responsible if an unattended ship is involved in an accident?" Who can be questioned by the maritime disciplinary court about the assessment of the situation prior to the accident and about the chosen action if no human has the role of officer? Who has to pay when the maritime disciplinary court finds the robotic ship is the guilty party? In case of unmanned ships, various stakeholders have influence on what the ship will decide to do. Besides technology providers, it may act on information provided by other ships, traffic control, electronic charts, ship operators, and so on. There are no officers with the ability to resolve conflicting requirements in rare, unforeseen, situations. Will it see designers of robotic technology before the maritime disciplinary court or will it be the end of that court? This is certainly no easy problem to solve and it is severe enough to make it unlikely that full-size unattended ships will sail in the midst of manned vessels any time soon.

What about Unmanned/Attended/Supervised Ships?

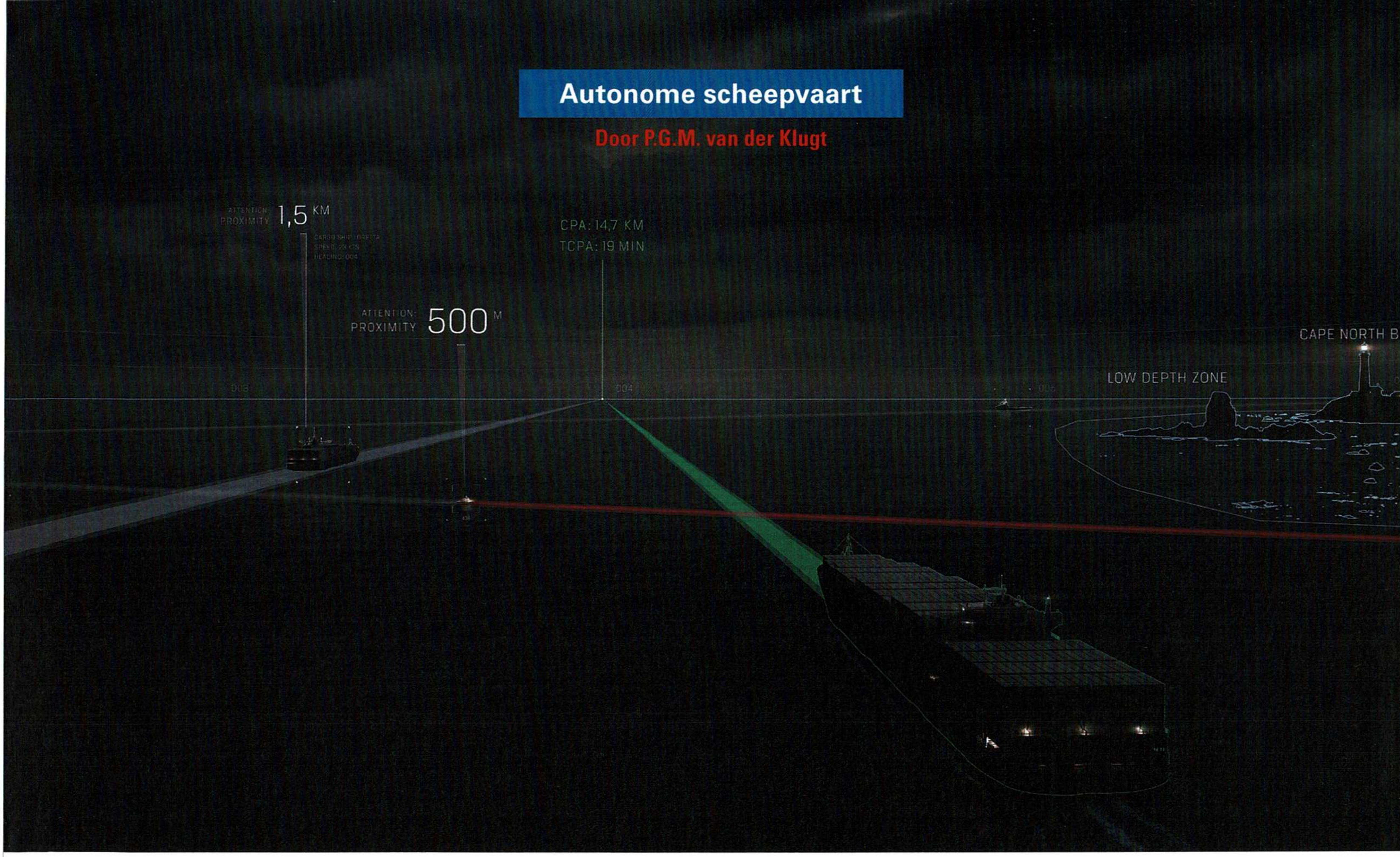
As long as there is supervision from shore, by a human operator with equivalent information and control options as a human operator at the ship would have, that human operator may be held responsible (although even that will require legislation to be adjusted). What if the root problem is some malfunction that could have been dealt with by a human crew? Or what if during the build-up of the circumstances that led to the incident, the data connection experienced problems such that the human operator was not fully aware of the situation?

Most research activities that address the operation of unmanned vessels one way or the other restrict the operational freedom of the vessel. In some projects, the ship is manned prior to sailing in traffic conditions. In others, the unmanned ships are only allowed to sail in stretches of waters dedicated to those ships. Only in case of naval research projects, enough funding is available to go beyond those limitations. Yet, even there, the presence of someone in authority supervising the ship is still regarded as the way to go.

All in all, the responsibility question while sailing seems to be one that is yet too difficult to answer. However, whereas that implies that there is little chance of unmanned sailing SOLAS ships in the near future, there are still ample of opportunities for small niche vessels that sail in restricted conditions, and for SOLAS ships that are unmanned/supervised when they are anchored or moored.

To be continued in part 3.

Door P.G.M. van der Klugt



Intelligent awareness may make vessels safer, easier and more efficient, but will they be able to respond correctly to an unexpected occurance? (picture by Rolls-Royce).

Autonomous Ships: Dawn of the Artificial Crew (3)

Unattended Requires an Artificial Crew

The worldwide interest, and successes, on applying robotic technologies to realise unmanned aircraft and self-driving cars encourage many to apply similar technologies for vessels. Will these developments be the end of the mariner? An exploration of the roadmap towards autonomous and the impact of these developments on the mariner.

While one may argue about WHEN unmanned/unattended vessels will really sail among their manned equivalents, there should be no doubt that in the coming years they will enter the market. As with cars and planes, there is a variety of reasons why unattended vessels are attractive. So the market is there, it seems to be "only" a matter of further development of the required technology and "some" changes in legislation. At least, that is what the many articles in the press seem to suggest. Unfortunately, if history gives one lesson about technological development, it is that it starts as if the sky is the limit until the first serious disappointments. Real develop-

Part 3

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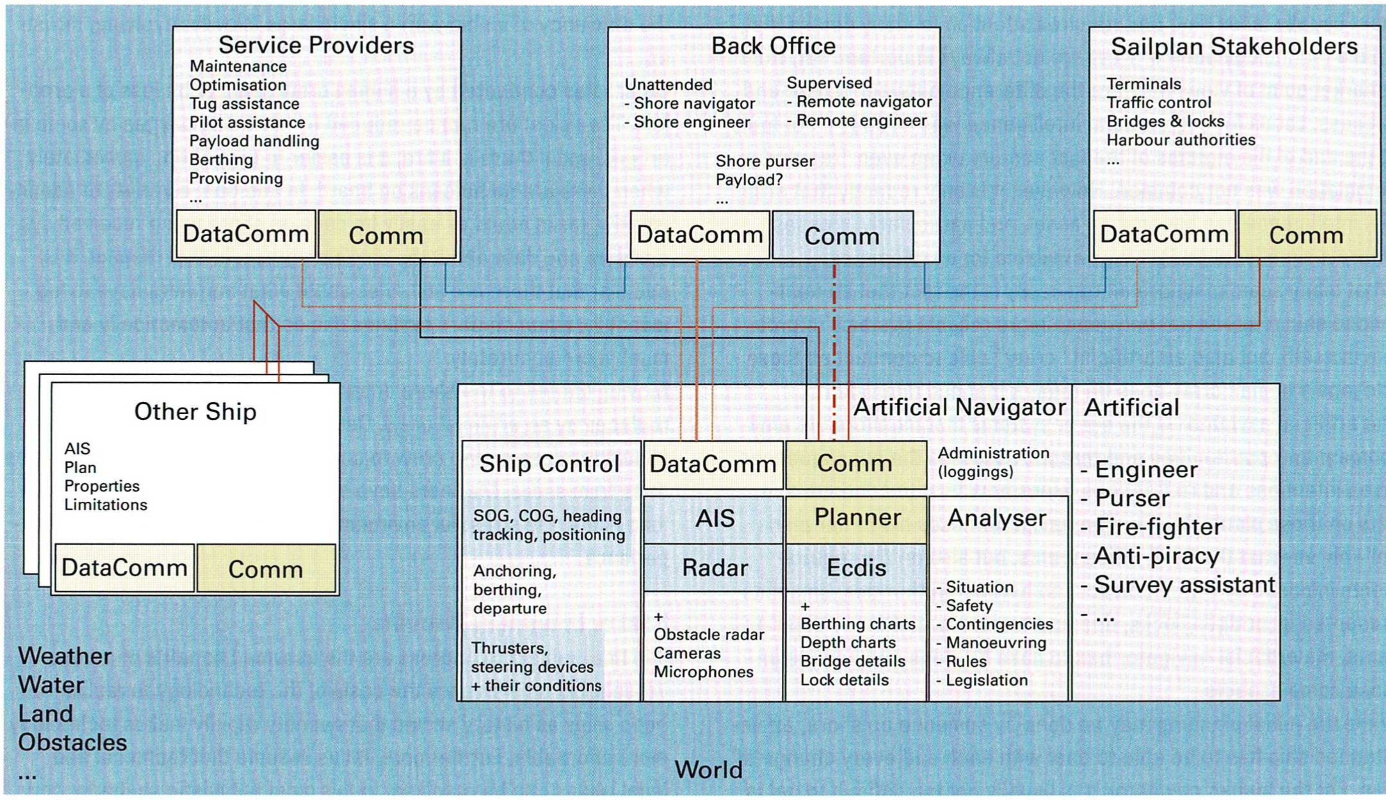
ment usually takes time and requires attention to many details that, from a technology point of view are not always important. Yet, from a market point of view, they are the difference between failure and success. Let us face it, artificial intelligence was already a hot topic at the end of the eighties of the last century when even "regular" automation was not common. However, it is only recently that artificial intelligence has become an asset, and particularly in cases where a significant budget was available for development.
What many seem to ignore all too easily is the fact that an unattended ship requires not only much more reliable systems (a problem in itself), but also an artificial "crew" able to conduct all those odd jobs a human crew does on today's manned equivalent.
The artificial navigator is the set of systems that monitors the environment for opportunities and threats, assesses the consequences given intentions and restrictions, plans how best to continue and acts on those plans. As a human navigator bases his or her plans not only on what the back office wants, but also on the requirements imposed by traffic control and harbour authorities, timeslots presented by bridges, locks, tide and terminals, and many other aspects, the artificial navigator has to base its plans and actions on those same aspects.
While the initial planning may be done by someone on shore, an unattended ship has to be able to deal with each and every change of plan. For the human navigator, it is usually not too difficult to get in touch with other humans by VHF, mail or phone and acquire the necessary information. For an artificial navigator, this is a field yet to explore as the technology to understand what people are saying is far from mature. If all ships would get an artificial navigator at the same time, exchanging information would not be a problem. However, just as for the related autonomous car, the problem is all those humans out there that make mistakes all too easily and more or less expect others to compensate for those.
Additionally, there is of course that oh so important ability of the experienced navigator: the handling of his ship. Trackpilots and DP systems may be superior when it comes to controlling a ship for long periods in time. Yet, in rare conditions where systems will not behave as expected or where the environment interferes in ways not anticipated by the manufacturers of such systems, the human navigator still manages. A robotic ship should be much better manoeuvrable to compensate for this difference, but will it be so without substantial design differences?
Likewise, the artificial engineer has to be able to do the many chores his human counterpart does. At first glance, developing an artificial engineer seems less of a problem than an artificial navigator as he is less troubled by changes in his environment. However, a closer look reveals problems that are not easily resolved either. Because of his presence (and that of his assistants), propulsion systems, power systems and other essential systems can remain up and running for weeks on end. He resolves minor issues before they become big issues and prepares for maintenance activities upon arrival in the next harbour. Of course, redundancy will reduce this type of problem, but redundancy comes at a price as nothing beats the efficiency of a ship with a single large, slowly revolving, thruster.
Other roles conducted by a human crew seem to be less of a problem. The risk of fire can be reduced by replacing oxygen by some inert gas, and if there is a fire, it is easier to take action immediately when there are no humans on board. In addition, a variety of administrative tasks could as easily be done on shore using received system data and data about the ship's progress. In that respect, it is peculiar that there are still rules about what mariners have to log manually, when modern systems can do that automatically and much more accurately.
Moving chores to the shore does not imply the human crew is fully replaced by an artificial crew. One may argue that ship operators should rely less on the crew to conduct chores that can as easily be done from shore. Mariners have more than enough tasks given the long hours, the stressful environment and the lack of sleep they experience.

Real or Imaginary Benefits

The final subject to address are the assumed benefits of robotic vessels. Let us disregard the costs of the technology to realise robotic ships as history shows that quantity rapidly makes technology more affordable. Furthermore, let us assume that technical and legal issues can be resolved. In this most optimistic scenario, how realistic are the arguments in favour of robotic ships?

- *Do robotic ships increase safety? Answer: No.*
  The assumption is that humans make mistakes and that most incidents with ships are caused by human error. Yet, this assumption is wrong. A professional crew is less prone to make errors:
  - if they have properly (that is significantly better than today) designed equipment at their disposal, equipment that does more than just provide (a lot of) data to be interpreted by the mariner (as is, unfortunately, common for today's systems);
  - if they are regularly trained, also to experience problems that may only rarily occur (as is the case in the aircraft industry); and
  - if they do not structurally suffer from fatigue.

  In that sense, ship operators/owners and equipment manufacturers should at least share the blame. Even more so, this question overlooks the fact that mariners so often act to prevent minor problems from becoming serious problems. At best, one may state that moving a ship's crew increases the safety of that crew. This is one of the main reasons that navies are interested in unmanned technology.
- *Do unmanned ships reduce manning costs? Answer: That depends.*
  For the current type of commercial vessels, the answer should be "no". The tasks on board an unmanned ship do not differ that much from those on board a manned ship: they merely shift to people who are shore based. Yes, they may bring their own sandwiches and make a cook superfluous, but the higher level



An artificial crew.

of automation more than offsets that adversely by imposing higher requirements on the other "crew" members. Nevertheless, there is a high potential for small vessels that do all kinds of measurements at sea, in harbours and on inland waterways. The value of the acquired data is generally too low to warrant the use of manned vessels. This niche is already showing application of small unmanned vessels with various abilities and is expected to grow quickly. The military market shows a similar niche; small unmanned vessels are a relatively cheap and unobtrusive means to gather intelligence and can even be used as precise instruments of destruction. People are considered to be valuable assets, so removing them from immediate danger is a form of cost reduction.

- *When will we see unmanned SOLAS ships? Answer: Not in the near future.*
  Of course, the underlying assumption is that an unmanned ship can be regarded as a SOLAS ship and that is, given current legislation, not true. Still, even if it were true, there are just too many hurdles to overcome. The technology requires some serious development. This is not only true with respect to artificial intelligence, nor is it limited to ship automation and shore-based facilities. All ship systems should go back to the drawing board, as should the design of the ship itself. Ships and ship systems are designed to have humans on board who can prevent problems and who can execute fall-back scenarios. In addition, measures against fire, flooding and pirates, for example, do take into account the (potential) presence of people. Without that presence, there are more efficient alternatives available. Legislation requires some fundamental changes too, not only with respect to responsibility in case of incidents, but also on more mundane aspects such as equipment requirements and about what to do if another (manned) ship in the vicinity experiences a serious problem.
- *When will we see robotic vessels? Answer: That depends.*
  If one refers to robotic vessels that sail, unattended, in the midst of manned vessels, the answer has to be: 'Not in the near future'. However, today, there already are examples in niche markets where vessels are small enough to accept a loss or where vessels operate in severely restricted conditions (mostly still in their development phase). As with flying and land-based vehicles, developments in those niche markets will accelerate as soon as customers recognise how they can profit from such vessels.

Learn What It Entails to Be a Mariner

The first part of this article started with today's confusion about the different interpretations of autonomous, unmanned and remote. It introduced the classes attended and unattended to make clear what a "real" robotic ship is and it gave a clear definition of "remote". Within the class attended, it used commonly used levels of

automation. From the proposed subdivision in classes, it has become easier to look into the future and to discuss the impact of unmanned developments for the mariner.
Development of unmanned ships, whether remote supervised or unattended, requires significant improvement of most of the technology that is at the disposal of mariners today. In that sense, mariners should applaud these developments as they will profit either by having systems that better match their needs, or in the form of remote assistance, the ability to interact with experts on shore who have been temporarily granted access to their systems.
One should not too quickly opt for real robotic ships as legislation and financial hurdles are huge. Commercially, other forms of unmanned options, in particular remote controlled, or remote commanded, can be more attractive as they are just an evolution of today's technology. Remote-supervision of unmanned vessels should first see operation in severely restricted conditions, thus gaining the time needed for adjustment of legislation.
Subsequently, real robotic vessels will seem to be a natural next step as solutions are introduced to gradually remove the need for human supervision in specific conditions (for instance, in case of a temporary loss of the data link).

The mariner will be happy to know that the roadmap towards unmanned ships requires serious adjustment of the automation technology applied on modern ships. Rather than providing him with a lot of data that may hide the relevant data needed to quickly make the appropriate decisions, systems will tell him what is going on and what his options are. Furthermore, he may await the rise of remote expertise that will assist him in trouble shooting, optimising systems and the many other tasks he is expected to do.
Finally, researchers and developers, as well as the press that takes over their ideas with little criticism, should not think so lightly of a ship's crew. In general, crew members are professionals who manage to keep their ship up and running and bring it safely to its destination in adverse conditions. When they do seem to make a mistake, the real culprits are usually poor equipment and fatigue, so the real blame for the consequences should be laid at the feet of those responsible for the equipment choice and the workload.
A real robotic ship able to sail unattended in the midst of manned vessels requires an artificial crew that emulates many of the tasks of a human crew. Therefore, manufacturers and researchers should learn much more about what it entails to be a mariner if they want to make serious progress towards robotic vessels.