The advent of autonomy

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Stories of ghost ships sailing the oceans without a living soul on board have been around for as long as mankind has crossed the seas. But what used to be a cock-and-bull story for centuries will now become reality. At a time where unmanned drones fly around the globe, public railway transportation systems run driverless in numerous cities and self-steering cars are on in-situ trial runs, unmanned and autonomous ships can no longer be perceived as unrealistic.

Intelligent ships

MUNIN, a collaborative research project funded under the European Commission's 7th Framework Programme, is developing a concept for a merchant ship able to conduct intercontinental voyages without any crew on board. The overall vision comprises a fleet of ships which are guided to and from port by an on-board control team and released to self-controlled operation for the open-sea passage. This temporary crew will disembark and return to their home port which is somewhat comparable to deep sea pilotage services already existing today. The fleet of autonomous and unmanned ships will be constantly monitored by a shore-based control station manned with skilled operators and engineers. Even though there will be the possibility of human intervention, the ships are designed and equipped in a way that allows them to solve unexpected problems by themselves. This comprises issues of weather routing and operation in rough seas, as well as small object detection and collision avoidance.

The introduction of autonomy in merchant shipping is surely not at hand and without a doubt will require a certain effort from all parties involved in maritime transport. Yet, the idea offers tremendous opportunities for the industry.

While automation at sea is still at a conceptual phase, automation in ports is already several steps ahead. Beyond the ever-improving distribution of data, automated cargo-handling has already found its way into many terminals. Gantry cranes load and unload ships while transport vehicles and portal cranes take care of the optimal distribution and storage of cargo – automation of these processes has limited human involvement to a necessary minimum. Such applied technologies are widely accepted, having already proven their suitability on an every-day basis.

Mobile internet availability, as well as the establishment of DGPS and AIS, is greatly improving the safety of ship navigation and communication in coastal and harbour waters. Application of further technologies such as real-time tidal prediction systems, berthing assistance systems, as well as load monitoring systems for ship mooring lines, represent already existing opportunities for further automation.

Designing the autonomous ship

The first and most obvious step will be to develop the design for an unmanned and autonomous ship. Accommodation facilities for much smaller crews staying only for relatively short periods will be necessary. During these times of conventional operation, a navigational bridge and an engine control-room for ship handling purposes need to be set up. Thus, up to this point, there are no significant modifications to be expected. Nevertheless, the technical equipment on board will have to be much more sophisticated compared to devices and machineries deployed today. Expectations toward the standard of performance, reliability and efficiency are much higher as there will be nobody to repair malfunctioning equipment. Furthermore, a system of highly accurate navigational sensors embedded in a holistic autonomous ship controller is necessary to compensate for the lack of human perception, Such an advanced sensor system will be able to produce much more precise and reliable data than that available today. Much of the technology needed to enable unmanned shipping can also be used to support crews on conventional ships. This will of course be to the greater benefit of maritime traffic's overall safety.

The right operatives

To implement the concept developed by the MUNIN project and to enable human interaction with the autonomous system, additional services are required. A shore control centre has to be set up, operating as a supervisory entity conducting the tasks of monitoring and controlling a fleet of autonomous ships. As autonomous merchant ships become more and more accepted, their deployment will increase, as will the number of such ships. Trained staff needs to be available to maintain safe ship operation in restricted and confined coastal waters. On-board control teams will consist of navigators and engineers handling the ship in coastal waters as well as during port approaches and departures.

These services demand staff qualified beyond STCW standards, preferably with personal knowledge of the respective sea areas. While shore control centres are likely to be located in places relevant to the industry, such as at Houston, London and Singapore, the on-board control teams will be based directly in respective ports as well as close to major shipping lanes.

Maintenance and servicing

During port stays, an unmanned and autonomous ship will have different service requirements for port facilities compared to conventional ships. As machinery reliability has been identified to be one of the major issues to be solved,

Diagram showing MUNIN's vision of the unmanned and autonomous ship system and its individual components

a main focus within the MUNIN project is on system redundancy and preventive maintenance. As there will be no engineer on board to repair a malfunctioning rudder pump or to exchange a damaged piston ring, solutions will have to be found to ensure that the ship will be able to safely continue its voyage regardless. As a technical breakdown is not acceptable, a preventive maintenance concept will be installed. Some of the related tasks will be carried out by members of the on-board control team, but others will be too complex to be conducted during the relatively short periods of manned operation. Inevitably, this will lead to a demand for new maintenance services and, thereby, create new business opportunities. Thus, the introduction of autonomy in shipping will push the industry towards the development of what might be called a cyber-physical shipyard. Single devices, individual ships, entire fleets, shipping companies, manufacturers and maintenance providers will be connected via a data infrastructure to monitor components so as to ensure utmost reliability throughout the product cycle.

Information exchange

Entity interconnectivity is perceived to be a key enabler toward autonomy in shipping. Such a system can only be run successfully if all relevant data is reliably available where it is needed, when it is needed. Currently, many ports are setting up holistic information exchange systems to streamline processes, connecting terminals, shipping companies and agencies, port authorities, pilots and other stakeholders involved in maritime transportation. This can only be the first step as individual solutions for individual ports will not be sufficient to meet future demands. Information exchange systems on a regional and even on a global level, connecting entire port ranges, allowing for real-time tracking of ships and shipments will have to be installed to further improve port competitiveness and capacity utilisation.

Furthermore, communication links between ship and shore have greatly improved in recent years and this development is still ongoing. Thus, it is expected that the global bandwidth requirements to allow for autonomous maritime traffic will be met in ample time.

The MUNIN project will conduct a feasibility study focusing on whether or not an unmanned and autonomous ship will be able to safely conduct a deep-sea voyage. Operation in coastal and restricted waters is out of the current scope of investigation.

From this overall perspective, autonomous ship operation in narrow and congested waters seems to be the missing link within the maritime transport chain. At the same time, IMO's e-Navigation initiative is pushing forward to produce solutions for a worldwide increase of safety in commercial shipping. Several projects from numerous organisations are addressing issues such as resilient PNT, traffic data exchange, maritime spatial planning and sea-traffic management. The implementation of such concepts will without a doubt help to bridge this gap.

The launch of autonomous and unmanned ships will certainly not happen overnight. But the overall and long-term impact can be expected to be comparable to the introduction of container trades in the 1950s which has irreversibly transformed the face of maritime transportation in the years ever since.

Rather, it is expected to be a continuous, long-term implementation process of ship- and land-based support systems dedicated to assist crews as well as to increase the safety and efficiency of shipping. This development will run in parallel with a shift of tasks and responsibilities from sea to shore – something that is already being witnessed today.

About the author

Wilko C. Bruhn is employed as research associate at Fraunhofer Center for Maritime Logistics and Services CML situated at Hamburg University of Technology, Germany. The main focus of his current work is within the fields of maritime simulation, navigational safety and sea-traffic management. A graduate of nautical and maritime studies at Bremen University of Applied Sciences, Bruhn holds a ship officer's certificate of competency and has seagoing experience on multi-purpose vessels. Specialising in ship management and maritime economics, he has further industry insight from professional experience gained in a shipping company and a classification society.

About the organisation

Research of practical utility lies at the heart of all activities pursued by the Fraunhofer-Gesellschaft. At present, the society maintains 67 institutes and research units. The majority of the more than 23,000 staff are qualified scientists and engineers. Fraunhofer CML develops and optimises processes and systems alongside the maritime supply chain. With practically-oriented research projects, CML supports public and private port-operating clients as well as in the logistics services and shipping sectors to initiate and realise innovations.

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