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How the 'Automation Virus' Took Hold

The Introduction of Control Engineering on Board of Merchant Ships

The Andorra was the first ship to go to sea with arrangements to allow the ship to sail with an unattended engine room. Marine automation took flight between 1960 to 1980. In 1960, ships still sailed with manually operated machinery and large engine room crews. Some twenty years later, the operation of ships with unattended machinery spaces and reduced crews was well established and generally accepted in the industry.

The first ship without a watch below, the Andorra.

Whilst the world seems certain to expect the introduction of autonomous vehicles on our roads sooner rather than later, and the marine industry has projects in hand that may lead to remotely controlled or autonomous ships, it is interesting to look back and consider how ships were first "automated". How did it start, develop, what problems did it present and how did it affect manning requirements?

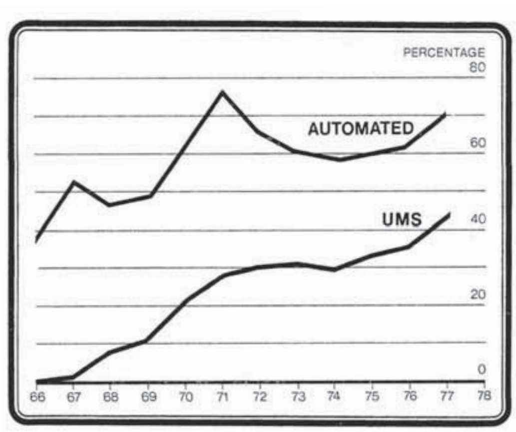
In the late fifties and early sixties, the challenge of reducing ship operating personnel was much in the minds of ship owners. The golden years for shipping that followed the Second World War were over, fleets had been renewed and enlarged, competition started to bite and some fleets feared a manning problem. Stimulated by developments in control engineering and automation taking place in the oil, chemical and other process industries, marine engineering systems started to change from fully manual to partly automatic and remotely controlled systems.

Setting the Example

Japanese owners and builders were first. Following a study of automation and rationalisation carried out by the Mitsui group of companies, the MV Kinkasan Maru went to sea in 1960 with an enclosed air-conditioned watchkeeping room in the engine room, provided with essential controls and instruments for the main engine and other essential systems. By 1963, some thirty Japanese ships were already equipped with control engineering systems, allowing engine room manning levels to drop from some 25 to about fifteen officers and ratings.

By that time, owners in other countries had also started to install control engineering equipment on their ships. The first British ship with the machinery designed for automation and operated from a control room was the MV Clan Macgillivray, which went to sea in 1962, and was soon followed by two similar vessels, the Clan Macgregor and Clan Macgowan. The arrangements in these ships

had the limited aim of reducing the number of personnel in the machinery space to just two, one engineer officer for watchkeeping and one rating for routine cleaning. An air-conditioned and partially sound-insulated control room was provided in the engine room and from this position, the officer could observe essential data, manoeuvre the Sulzer main engine, start and stop pumps and control and parallel the diesel generators. Automatic controls and alarms were provided for temperature, pressure and other systems.
In 1964, the next important milestone was reached when the MV Andorra, owned by the East Asiatic Company, went to sea without a watch below. The owner's prime intention was not so much to reduce the number of crew, but to dispense with the unrewarding watchkeeping task and to redeploy staff during daylight hours on maintenance tasks that could be carried out at sea. The ship was propelled by a 12,000 bhp diesel engine driving a controllable pitch propeller that could be controlled from the wheelhouse. A control room had been fitted in the engine room, containing switchboards, propulsion controls and the alarm and instruments panels.
By that time, the "automation virus" had seriously affected the marine industry. Engineers from yards, contractors, shipping companies, statutory bodies and classification societies were sent on courses to learn about pneumatic, electric and hydraulic control systems and components. Conferences and seminars were organised, just as they are now, on the possible advent of unmanned ships. Ship owners and equipment manufacturers in particular showed great interest and were attracted by the potential for smaller crews and increased demand for control equipment respectively.
Many ship owners started to convert the machinery installations of existing ships in order to operate the installations with fewer personnel down below. In general, these modifications were not intended to run the ships with unattended engine rooms, but usually for operation with one watchkeeper at sea and unattended in port.
On diesel-propelled ships, these installations included bridge control for propulsion, automatic auxiliary boiler operation, automatic control of temperatures and pressures, an alarm and monitoring installation and a fire detection system.



The percentage of automated and UMS ships built to LR class in the period 1966 to 1977 (from LR Annual Report 1978).

Unattended Machinery Spaces Notation

Classification societies and statutory bodies became involved in these developments and in 1963, Lloyd's Register (LR) issued a guide to owners and builders titled "Automation in Ships". In 1966, Donald Gray, principal surveyor of LR, published "Centralised and Automatic Controls in Ships", the first book on marine control engineering.
Whilst installations in ships enabling them to operate without engine room watchkeepers had already been approved, in 1968 this was followed up by LR with the introduction of the official "Unattended Machinery Spaces" (UMS) notation. This notation could be obtained if the installations complied with the basic safety requirements that had been inserted in the classification regulations. Within one year, some 205 diesel and 23 steam turbine ships qualified for the UMS notation. Other classification societies took similar action, introducing their own notations for such ships.
The essential safety features required for UMS operation at that time included:

- bridge control for propulsion;
- alarm system for propulsion and other essential machinery;
- control station for machinery;
- fire detection alarm system;
- fire prevention arrangements;
- bilge level alarm system; and
- facilities for local control in case remote or automatic controls being out of action.

The Early Years

It is understandable that in those early years of marine automation, problems were experienced with control and monitoring equipment. The difficulties encountered were usually associated with environmental conditions, lack of adequate testing and failure to appreciate the requirements.
Many of the hardware items used in those years had been in industrial use for a sufficiently long time to have established their reliability in such applications, but they were not good enough for shipboard use. Attempts by manufacturers and contractors to "marinise" the equipment often failed and complete re-design was necessary.
Learned papers from the likes of Gray, Munton and McNaught list in great detail the multitude of failures which were experienced in those early years of marine automation. McNaught's paper includes the table below referring to the experience on the three Clan vessels referred to earlier.

Ships	Macgillivray	Macgregor	Macgowan
Total watches	290	192	101
Number of watches with one or more faults	40	34	25

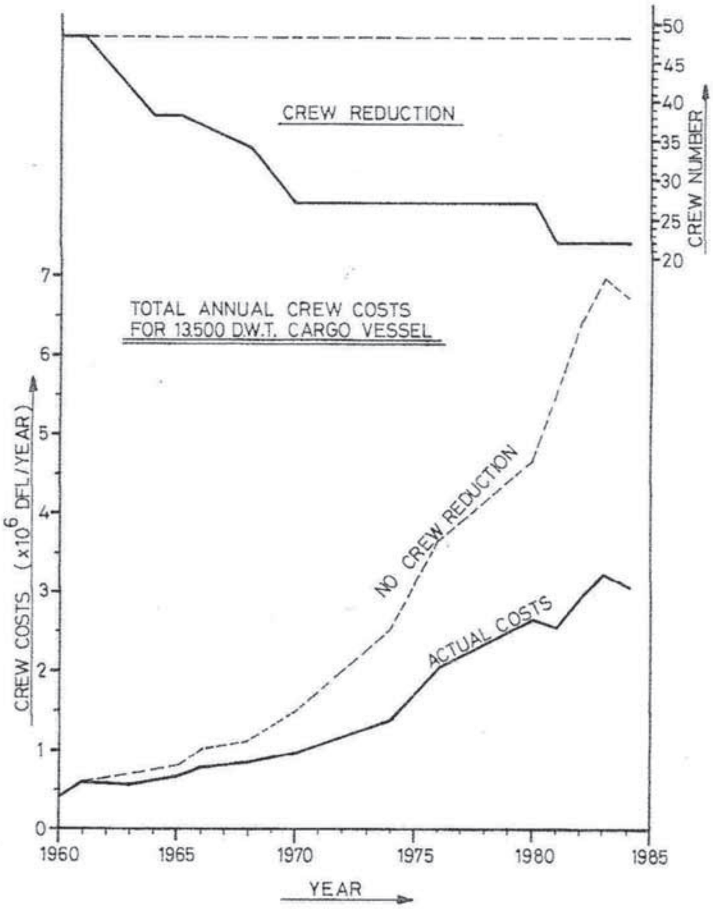
Statistics on the Clan vessels' early "unmanned" watches.

These ships were not operated with the machinery space unattended, but with an engineer officer in the control room and a rating down below for cleaning and routine maintenance. Not all of these faults concerned control equipment, some were due to failures of the conventional equipment. This questioned whether the machinery itself was sufficiently reliable to be automated. One leading marine engineer declared in 1964 that the 'machinery in its present state of development cannot be left for long periods of time without human observation or action.' Similarly, another senior marine engineer said that 'limitations on automation are imposed more by doubts on reliability of conventional equipment than by availability of components for an automation scheme.' No doubt such questions stimulated the efforts to make conventional equipment and systems more reliable.

Particularly on existing ships being converted to reach a certain stage of automation, the early systems were rather primitive – simple pneumatic bridge control systems, alarm systems with rows of lamps controlled by electromechanical relays and sensing and measuring devices not very suitable for marine use. Sensors were often unreliable, difficult to adjust and with tiny terminal boxes unsuitable for marine cables.

In order to improve the situation, in 1968, LR issued an "Environmental Test Specification", to which equipment could be tested under standard conditions that simulate the marine environment, with particular attention paid to the effects of heat, humidity and vibration. On the basis of such tests to this or equivalent specifications, lists of type-approved instruments and control equipment were published.

Items that initially worried designers, owners and authorities, more than anything else, concerned the layout, the choice of sensors and testing of fire detection installations – essential for safe UMS operation. In machinery spaces, detectors have to function under the most complex conditions of atmosphere at sea and in port with widely varying climatic conditions. The direction of air currents in such a space will vary greatly under these conditions, which makes it difficult to achieve the optimum siting of the detector heads. These detector heads could be tested by a test unit provided by the manufacturer or by a realistic test fire. With a test unit, one could not test whether the siting was correct and an open test fire in a machinery space is not an attractive idea. Just the use of smoke, delivered by a stage smoke generator, did not work either as the cold smoke from such a device does not have any updraught and is blown away by the engine room ventilation before reaching the sensors. Over time and with growing experience, practical solutions were found, both to select and locate the sensors and how to test them.



The crew reduction on a 13,500 dwt general cargo vessel used in a liner service over the period 1960-1984. It also shows the financial effect of this change.

Effect on Manning

The general cargo and multi-purpose ships, used by liner companies in the late 1950s and early 1960s, had crews of some forty to fifty officers and ratings. Usually on such ships, the engine room crew consisted of about eight to ten officers and a corresponding number of ratings. These ships were completely manually operated – on most ships, the automatic pilot system for navigation was the only automated function. At sea, two officers would be down in the engine room, plus a rating. Due to the advent of automation and control engineering, engine room crews were gradually reduced. By the end of the seventies, engine room crews amounted to some five officers and a few ratings. Through rationalisation and technical changes on board, not only in the engine room, but also on deck and elsewhere, the total crews of ships were drastically reduced. For the liner companies, the introduction of the relatively simple container ship, replacing the liner general cargo vessels, plus not requiring crew to deal with cargo handling equipment, also played an important role.

As a result of the technical changes on board and the drive for rationalisation, some owners and maritime countries experimented with so-called "integrated crews" and the use of maritime officers. These maritime officers were trained for both deck and engine room work. It is surprising perhaps that this development, which seems so logical taking into account the way ships can now be operated, did not become more popular.

Further Developments in the Run up to 1980

In the following years, new systems were introduced and marine control engineering became a more professional business. Sometimes, however, the ambition was too great. In the late sixties, a bulk carrier was equipped with a hard-wired data logger, collecting data from the machinery and other systems, which was subsequently sent to the owner's office by Telex Over Radio (TOR). After some time, the office staff did not know what to do with the sheer amount of collected data. The story goes that the crew got fed up and were instructed to disconnect the three large cubicles of the data logger and throw them over the side!

In 1969, the Sea Sovereign, a 210,000 dwt steam turbine tanker, was the first ship with an online computer. This was an 18-bit computer with 16-bit used for the programme, one bit for testing and one bit for programme protection. The brain of the system was the central unit with a core memory of 24k words. The main functions of the ship to which the computer was applied were: propulsion (bridge control, boiler control, and such), navigation (auto pilot, course prediction, et cetera) and cargo handling (loading and unloading).

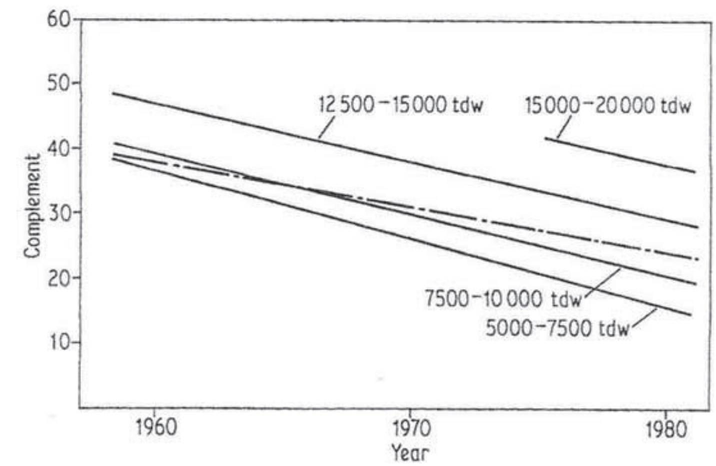
The cargo program used the whole of the core memory, as did the sea programme. Consequently, the sea programme had to be removed from the memory and stored on tape when cargo pumping was in progress. Standard control systems were available in case the computer system was out of order.

In the 1970s, integrated circuits, microprocessors and larger computers became available, enabling more advanced equipment. Such systems allowed the input of digital as well as analogue sensors, which was a great leap forward. The subsequent systems were not only more advanced, but were also much better suited for the marine environment.

Generally, it could be said that by the year 1980 shipping had become used to these systems and that UMS operation was by then, for most types of ships, fully accepted.

Building Trust

As part of the research for this article, a number of senior marine engineers, deck officers and captains were consulted to establish how they experienced the introduction of initially simple, followed by more advanced, automation equipment and the advent of UMS operation. Some of those officers had commenced their career on fully-manned ships, without any form of automation, and were subsequently subjected to these systems and the new way of working. Others came on board once the first steps had already been taken. The overall consensus was that it was sometimes difficult with unreliable equipment – not just the automation equipment, but also the conventional equipment – but that they could manage and that they gradually put more trust in the systems. Once the systems really got working, they found that the engine rooms became safer and better places. Continuous supervision of machinery with good monitoring and alarm systems was found to be better than the old system of regular, but manual watchkeeping, which required good housekeeping and completion of a decent checklist before leaving the engine



— International trend, based on publications of approximately 50 multi-purpose vessels in 1960, 1970 and 1980.
–.– Manning onboard ships in the Netherlands (according to Capt. Wepster, Ergosea Conference, 1981).

The crew reduction for a few ship types over 1960-1984.

room unattended. Without this, watchkeepers were punished by alarms during their night of rest. Plus, it was reassuring to know that in the case of automation systems failing, they would be able to operate manually. Still, engineers had to get used to the idea that somebody on the bridge was in control of "their" engine and many captains were initially nervous when operating direct bridge control systems, instead of an engine telegraph and leaving the actual engine control to the engineer down below.

Looking back, one may conclude that the engine room crews deserve praise for the way they adjusted to the new way of working. Few serious casualties were ever reported due to unattended machinery operation.

Are There Lessons to Be Learned?

Looking to the future and expecting ships with smaller and smaller crews, finally perhaps leading to unmanned ships, the question arises whether in that process one may learn from the experiences described above. Preparing for a crewless ship, the following points may be worth remembering:

- go carefully – build up experience step by step;
- use properly tested sensors and sensor systems – do not make the same mistake we made some forty or fifty years ago;
- do away with equipment relying on regular onboard maintenance, such as fuel oil treatment systems, auxiliary boilers and oily water separators.

Will equipment such as ballast water management systems (BWMSs) and exhaust gas scrubbers ever be suitable for unmanned operation for days or weeks? After all, there will be no maintenance staff on board working in the engine room during the day to keep the equipment going. It may be doubtful even whether main and auxiliary diesel engines will be reliable enough to operate

long periods of time without human intervention. Redundancy arrangements will not solve all these issues.
The reports we have seen until now concerning the introduction of unmanned and autonomous ships mainly concentrate on the “Big Data” systems required for remote and autonomous operation. It may well turn out that these systems will become available without too many problems. It is more likely that the real problems will lie in the area of machinery and sensor systems, both for propulsion and navigation. These problems may be easy to solve with battery-operated ferries on short routes, but the situation may well prove to be very different for worldwide trading cargo ships.

One of the first “television screen” alarm monitors.

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