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FUTURE MINE COUNTERMEASURES

No Easy Solutions

Commander Martin Schwarz, German Navy

We have lost control of the seas to a nation without a navy, using pre-World War I weapons, laid by vessels that were utilized at the time of the birth of Christ.

REAR ADMIRAL ALLEN E. SMITH, U.S. NAVY, 1950

Admiral Smith's point might be as valid today as it was sixty-four years ago. It refers to mines that he faced off the coast of Korea. Naval (or sea) mines are, by themselves or in combination with other weapons, a promising choice to parties pursuing antiaccess/area-denial objectives. The number of mines in the stocks of countries around the world and the ease of laying them mean that sea control is very likely to be lost again in future tension and conflict. This article is an attempt to describe the means, and to some extent the methods, under consideration to win it back if the need arises again. Mines pose a threat not only to military use of the sea but also to civilian shipping. The global economy depends on secure access to the global commons. With roughly 95 percent of world trade

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being shipped by sea, it is clear how much the economy depends on open trade routes and sea areas.¹ Therefore, the capability to counter mine threats is needed to provide freedom of movement not only to one's own and friendly naval forces but to merchant shipping as well.

The following research questions are at the heart of this analysis; the answers to them will help characterize the situation and prospects.

- What are the shortfalls of mine-warfare vessels today?
- What are the requirements for a future vessel?
- What concepts are currently under development?

To ensure a comprehensive picture, however, the analysis will go beyond these questions, to look at current developments and their potential future capabilities. The main issues will be discussed in more detail. It may be impossible to provide a definitive answer, as nations have varying purposes and ambitions for their forces. Emphasis will be put on capabilities rather than the vessels that carry them, as the focus seems to be shifting from a platform-centric approach toward a capability-based one. Argues one naval observer, “It is the mission system that is the key—once you understand that, you can understand what the replacement platform is going to look like.”² The U.S. Navy’s Chief of Naval Operations has declared, “We will need to shift from a focus on platforms to instead focus on what the platform carries.”³ His statement indicates that there may be a shift in the thinking of strategic planners. A platform focus may no longer be feasible. It is all about the capability a platform can carry and employ.

THE THREAT

This article cannot describe the various types of mines, their sensors, and their payloads. It will suffice here to mention, generally, that there are bottom mines (lying on or buried in the seabed) and moored mines (floating in the water column, held in place by an anchor or drifting on or just below the surface). Mines can be actuated by contact, by influence, or on command. Sea mines can sense ships’ “influences”—magnetic, acoustic, pressure, seismic, and others, in various combinations. Sea mines employ techniques to defeat mine countermeasures (MCM). These include coatings, deceptive shaping, and self-burial to prevent detection by sonar. To counter minesweeping, mines use enhanced sensors and signal processors to recognize a sweep attempt and avoid premature firing. Modern sea mines can be programmed to target certain types of ships.

Even this brief summary should be sufficient to show that mines must today be seen as a real threat to alliance or coalition naval operations and civilian shipping. A recent example is offered by the 1991 Gulf war, in which coalition forces had to abandon a planned amphibious assault because of the presence of more than 1,300 mines.⁴

Sea mines are force multipliers. Even if they do not prevent a navy from acting, they can surely delay it for a prolonged period of time or force it to choose other options. The sea mine’s goal is to deny access. Uncertainty alone about whether mines have been laid can achieve this effect. In fact, dummy mines—shapes that do not hold explosives or sensors—can delay MCM operations. Attention must be also paid to ordnance and ammunition already scattered on the seabed.

Sea mines can be laid by almost any vehicle, from dedicated minelayers to aircraft, submarines, pleasure boats, or fishing vessels. Even a sport-utility vehicle can drop one from a bridge into an important harbor. Mines can be used in a wide

range of water spaces, from the surf zone to depths greater than three hundred meters. They can be used defensively, off a state's own coast, or offensively, off an opponent's shores or harbors. Sea mines are one of the world's most widely proliferated weapons. Excluding the U.S. inventory, their number is estimated at around a million, of more than three hundred types, in the inventories of more than sixty navies—plus underwater improvised explosive devices (UWIEDs).⁵ Although some effort has been put into limiting proliferation and tracking sales, there is no clear picture of where mines are, or have been, or to whom they are sold.

Sea mines are called “poor man's artillery” as truly today as they were decades ago.⁶ An actor does not need to acquire the most sophisticated expensive modern mine. Older weapons, using technology of World War II or even older, can be as effective today as when they were state of the art. Traditional navies and maritime terrorists can use, and have used, not only mines but UWIEDs to obstruct military and commercial uses of the seas.⁷ Both mines and UWIEDs are easy and cheap; they offer high effect for low cost. The older versions are quite simple, not requiring special training; they offer “affordable security via asymmetric means.”⁸

Sea mines change the usability of the maritime environment. Especially near shore—since they are most effective in water depths between two hundred and ten meters—they force opponents to adjust their plans or clear sufficient areas for their forces to operate in.

SCENARIOS

“Scenarios,” a distinguished scholar of military and security affairs has observed, “have much to recommend them as functional surrogates for the inaccessible, and indeed undesired, real thing.”⁹ Scenarios recommend themselves as guide rails for the development of requirements, and they should cover a wide spectrum of possible tasks in peace, crisis, and war. What are the likely scenarios for the employment of a future mine countermeasures capability? The focus has clearly shifted from European coastal waters to the littorals in distant areas of the globe. However, the possibility of operations to protect one's own harbors and approaches cannot be excluded. They might be conducted in peacetime conditions, in expeditionary circumstances, or in wartime. The following scenarios suggest themselves for further investigation:

- MCM prior to or during expeditionary operations off foreign coasts
- MCM in response to a mine threat in own and friendly waters
- Postconflict clearance operations.

Mine countermeasures prior to and during operations off foreign coasts must be seen as the most demanding for the platforms engaged in them. They are likely to be conducted at significant distances from home waters, by forward-deployed

units or after prolonged transits. Such a transit is ideally conducted ahead of a task force, in order not to delay its operations on arrival. The opponent, for his part, will have an interest in the protection of his minefields. He will pose threats by fast attack craft, land-based missiles, or artillery. Privately owned helicopters or unmanned aircraft are likely weapons to be used against MCM forces. Although the approaching task force should, and probably would, establish air superiority prior to the beginning of maritime operations, defense of a minefield by minor aircraft and watercraft is highly likely. Further, MCM operations off an unfriendly coast give away the intentions of one's forces. The recent operations off Libya can be seen as an example; MCM took place off the Libyan city of Misrata, in the face of threats from the coast.¹⁰

Information about the environment in the operation area—the key to efficient MCM—must be collected. The amount of knowledge available might be slight, especially compared with home waters. A rapid environmental assessment will be needed, preferably covert. If mines are detected, the boundaries of the minefield must be found. If there is an area free of mines, traffic should be diverted to it whenever possible.

The platform that performs these tasks may have to be able to do so covertly and must be able to protect itself effectively. Covering naval forces should not be counted on, especially if the MCM element arrives ahead of the force. Its range and sustainability must be similar to those of the other ships in the task force. Dependence on specialized supporting units, as is current practice, should be avoided, as the specialized ships required drive cost.

A response to mine threats in home waters or those of a friendly nation may not involve long distances, but, in view of the length of, say, the European coastline, it might very well. Such an operation would probably not face threats other than mines, but transit speed could be important, as a prolonged mine threat in home or allied waters is likely to cause significant economic damage.

An additional task that falls into this scenario is route survey. Some countries survey routes in their territorial waters periodically; the detailed knowledge of the environment offers the basis for speedy MCM if the need arises. Required assets are derived from the routes to be covered and the nationally defined repetition of coverage. France and the United Kingdom put special emphasis on the approaches to their nuclear submarine bases. This requirement would seem unique to those two countries, but is it really? Arguably all nations have interests in keeping open the approaches to their naval bases and commercial harbors.

Postconflict clearance would be conducted in the same waters as expeditionary operations—again, possibly far from home waters but this time without other threats but with an enduring nature. Clearance after the 1991 Gulf war took the mine-countermeasures forces of a large number of NATO member states almost

two years to complete. Operation “ALLIED HARVEST” in 1999 can be seen as a variant of this type of employment; its task was to clear the Adriatic seabed of ammunition dropped by aircraft returning from strikes in Yugoslavia during Operation “ALLIED FORCE” prior to landing on their carriers. Clearing historical ordnance in local waters also falls into this category. Considering the number of mines laid during both world wars and the ammunition dumped into the sea after them and during the Cold War, it has to be assumed that the task of removing them will remain with European navies for years, maybe even decades.

CAN LEGACY SYSTEMS COPE WITH THE SCENARIOS?

The current MCM capability in Europe is provided mainly by purpose-built, dedicated vessels.¹¹ They are highly specialized and costly in relation to the overall capability they provide to a fleet. It is common knowledge not only in the MCM community that these vessels, being small, have significant restrictions. The systems now in use with European NATO navies were planned and built around the end of the Cold War. They were designed for individual or combined mine countermeasures (e.g., hunting/sweeping) in homeland-defense scenarios. Seaworthiness, endurance, and interactions with other types of naval vessels did not play significant roles in their designs. But numbers did—the navies of Belgium, France, Germany, Britain, and the Netherlands alone had 152 MCM vessels in their combined order of battle in 1990.¹² That number has since been substantially reduced. By 2012 it had dropped to just fifty-two, and further reductions are not unlikely.

The existing platforms have top speeds ranging from twelve to eighteen knots, transit speeds between ten and sixteen knots, and crews of around forty. Their range, seaworthiness, self-defense, sustainability, and ability to share information with task forces all must be labeled minimal at best. They are able to operate only from three to seven days before resting their crews and resupplying. They have in the past deployed to distant locations—the Arabian Gulf, the U.S. East Coast (distant with respect to European nations), and the Black Sea—but they took weeks to get there. Weather slows their transit even more and could prevent their employment once on station from progressing past an early stage. Operations off hostile coasts must be seen as problematic. These ships would not be able to deploy, communicate, or exchange information with a task force or to defend themselves. They would need, therefore, dedicated support and command ships, as well as protection by more capable warships. This protection has been attempted using a “babysitter” tactic, assigning frigates and destroyers to protect an MCM force, but the approach never accomplished much, and with the number of frigates and destroyers dropping as well, it must be questioned whether commanders will be willing to assign any to look after MCM vessels.

The current capability is sufficient for what it was designed for—homeland defense and, to some extent, postconflict clearance. But even for those tasks, numbers are now of concern. The reductions to date have brought force levels so low as to multiply the time needed to clear given areas. Any losses would have a much higher impact than in the past. As the Royal Navy has declared, “In the future, until sea control has been assured to an acceptable level of risk, the contested littoral will remain no place for mission-essential units.”¹³ But it is unclear today what a “mission essential” unit is—given such small numbers, all units may have to be seen as mission essential.

How can the shortfalls in this crucial capability be mitigated? Upgrading legacy systems is not the ultimate solution, because of their small size; there is simply no space left. They must, then, be replaced—but with what? British doctrine lays down that “the ability to conduct war-fighting under-writes the ability to deliver maritime security and international engagement and this role has primacy.”¹⁴ This clear statement points to the three scenarios that must be weighted in importance. Having three different types of platform for the three scenarios is out of the question (as will be seen below). Requirements should be derived for the most demanding scenario and then checked against the others. The replacement should be able to cope with these scenarios and correct the deficiencies of legacy platforms. A design is needed that can act in what is called the “contested littoral.” As it will never be expendable, it will need a degree of survivability and self-defense capability. It must have “longer legs” than today’s vessels and be more seaworthy—and accordingly, perhaps, bigger. The main reasons to keep the vessel as small as possible, however, are cost, manning, and the (controversial, as we will see) need for signature reduction. It should also be faster and able to carry, launch, and recover unmanned vehicles in significantly higher sea states than is possible today.

COST AS A FACTOR

“Defense wears a dollar sign.”¹⁵ Owing to this fact and ongoing economic difficulties, austerity measures can be seen in most Western armed forces. Their militaries are no longer in the public focus; people concentrate on social, education, and health issues. These influences are forcing states to reduce numbers in personnel and equipment. It is doubtful whether a single-role platform is affordable; any larger and more capable MCM platform would have to be usable for other tasks as well. Some navies are doing this already. Consideration must be given to making vessels primarily intended for other purposes able to carry MCM modules, as some navies are planning to do. Intensive dialogue will be needed with the surface community to define what this “designated,” as opposed to dedicated, vessel will be able to do and when a dedicated MCM force will be needed. A platform

that carries a mine-countermeasures capability might find itself tactically tied to MCM tasks at the expense of other tasks. A balance is needed.

Procurement and life-cycle cost (LCC) must be kept in mind. Roughly 70 percent of a ship's overall costs are incurred after construction; its drivers are operation, modernization, and people.¹⁶ Modularity and reduced manning offer savings. The speed of a platform depends very much on the money that can be spent. Size, level of protection, endurance, and range impact cost. The same is true for the degree of integration of systems. While a dedicated platform should have a high level of integration, a designated platform could instead need modular control stations for added modules. One of the main cost drivers is the size of the complement. Crews need to be recruited, trained, fed, paid, and also accommodated at an acceptable standard, to keep service on board naval ships attractive. It will be absolutely essential during development to distinguish clearly between "need to have" and "nice to have." As the British observe, "With procurement timescales stretching into decades, and life spans of platforms being thirty years or more, adaptability must be found primarily within the people and systems which operate in, and from, the platform."¹⁷

There is a clear need to plan for spare room for additional capability in the future, as this might not be possible to achieve by just replacing old equipment with new. Easing modernization is an argument for building modularly (about which more below). A module can be taken off and replaced by a new one much more easily and cheaply than a fixed system can be replaced or a new one fitted.

Operating and maintenance costs must be considered too. To drive down operating costs, alternative propulsion should be considered. Diesel engines may not be the most efficient way of driving a ship today. Fuel cells are a possibility; they are being used in submarines with substantial success. Using material other than steel could drive down maintenance costs. Systems should be designed aiming at minimum maintenance; this will reduce the workload of the crew and thus its size. Again, a balance has to be found, or reduction in maintenance and operating costs will drive up those of procurement.

Another consideration is a country's need for its navy to operate in the Arctic. Norway may have a very different view on this than, for instance, Italy. The need to operate in the demanding environment of the very cold Arctic waters will impose special requirements on both modules and platform. By the same token, very warm waters, such as in the Arabian Gulf, are also challenging, for systems and ships alike. Ability to operate in both areas would be desirable, as it offers options to decision makers, but it also drives cost up. Trade-offs will become a necessity, just as in all other areas—the "nice to have" is likely to be unaffordable.

Factors driving the size of the platform—such as the number and size of modules—need to be examined at this stage. Those choices, in turn, are influenced by

how a navy defines missions and the systems required for them. The European Defence Agency (EDA) has also started to address the question. There is talk of “MCM mission packages” as comprising mine-countermeasures, command-and-control, and launch-and-recovery (L&R) systems, a team of operators, and divers. An MCM vessel itself—what the planners of the U.S. Littoral Combat Ship called a “seaframe”—plus the mission package would, then, form a specialized MCM capability.

As far as numbers are concerned, the EDA envisions a future dedicated MCM vessel to be able to carry and operate something around five modules. A designated platform would support a given mission by embarking one or two modules. Further contribution could be provided by land-based systems. Interoperability with legacy MCM vessels is considered a definite requirement.¹⁸

Finally, the *Common Staff Requirements* of the EDA states the new MCM vessel’s possible standoff distance (i.e., from the mined area) as being from twenty-five to thirty nautical miles.¹⁹ These values might have to be revisited. They could be significant cost drivers and put pressure on technological solutions. They might contradict the stated need to use mature technologies.

MODULARITY: THE WAY OUT OF TROUBLE?

It becomes clearer what a follow-on platform may have to be capable of. But the need to keep cost low makes trade-offs necessary. Without austerity it would no doubt be possible to develop a system that fulfills all requirements and could be built, manned, and worked up in sufficient numbers. As conditions are, modularity may offer cost-saving options and offer a wider range of employment. As an Australian analyst has observed, “A significant amount of research has been undertaken in the field of modularization of naval vessel capabilities, which potentially offers significant procurement and operational cost benefits to owners and operators as well as increased fleet flexibilities.”²⁰ But it may have disadvantages. Training and crew integration are just two issues. It is also well understood today that a system meant to be able to do everything can, in the end, do nothing satisfactorily. So it seems that there are limitations to modularity.

Modularity can be approached in various ways and to various extents, as categorized by the Australian analysis just cited. “Type I” concerns modular containers or other modular installations (modular “plug and play” space) involving minimal installation time. “Type II” differs in that it requires significant installation time. Finally, “Type III” provides modular space for capability-specific equipment.²¹

Another distinction is between construction and mission modularity. There are a number of existing modular designs and concepts. For example, the Royal

Danish Navy uses the Stanflex concept, the German shipyard Blohm & Voss has developed the “Mehrzweck Kombination” (MEKO) design, and Abeking & Rasmussen (A&R), another German shipyard, offers the Modular Platform Concept (MOPCO).²² Stanflex, dating back to the 1980s, replaced twenty-two aging, small warships with a purpose-built modularized capability, with modules interchangeable between vessels. This concept, which used common platforms across multiple capabilities and thus cuts LCC, has been developed further and applied fleet-wide. The MEKO concept, the most widely employed in ship design and construction, utilizes a standard platform and offers variable, customized levels of outfitting, to be chosen by the customer. It allows for significant savings in production costs. MOPCO puts together the above approaches, combining common systems into larger task modules. These modules contain all equipment required for a given capability.

A conceptual design for a forty-five-meter “small-waterplane-area twin hull” (SWATH) platform has been published. Its primary task is MCM; it comprises MCM, accommodation, and ship-control modules. Reconfiguration to other missions is achieved by complete replacement of the MCM module.²³ Thyssen Krupp Marine Systems (TKMS) has taken development further, with the MEKO-Fusion project. This envisages interchangeable use of mission modules housed in twenty-foot ISO Type 1c containers, underscoring an emphasis on speedy role change. In the basic version it would carry out constabulary tasks, but it could, by adding other sensors and effectors such as radars, sonars, and weapons, change roles and assume war-fighting tasks, MCM among them. The mission modules incorporate existing naval systems, such as BAE System’s 57 mm gun and Saab’s RBS 15 missile. The initial eighty-four-meter, 1,500-ton, all-composite ship has some resemblance to the Kockums *Visby*-class corvette. Its “extreme delta” hull will have some advantages over a conventional fast monohull. The speed of the suggested design would be above forty knots but could be reduced (to save cost) by reducing installed power. The hull shape offers a wide stern with space for mission modules and L&R systems.²⁴

As suggested above, modular design has significant benefits but also disadvantages and risks.²⁵ A risk is that it may be impossible to provide sufficient numbers of trained crew to allow full utilization of modular capability. There is also a chance of in-service failure due to increased system complexity and the use of unproven technologies. The main inherent disadvantages are area size generally larger than would be required for a role-specific platform, meaning less efficiency with respect to each role; the need for trade-offs in order to serve all planned roles; and complications in combining systems that could lead to increases in weight, complexity, and cost.

The benefits are possible LCC savings (at the price, as noted, of efficiency), resulting from a high degree of commonality for stores and maintenance, increased flexibility, reduced off-task times and redundancy, and fleet-wide applications of modular technology. A common platform that utilizes modular capability offers the possibility of concentrating on one use in times of need; for example, all ships could be configured for MCM if an imminent threat requires maximum attention. Modularity, as suggested above, makes modernizing a ship much easier; if the platform is simply a “truck” carrying mission systems, modernization can be achieved by changing the load of the “truck.” Further savings can be found in managing the number of modules procured; ships in workup or other nonoperational phases of their employment cycle would not need a full outfit. Shore-based versions of modules, or modules not needed at a given time by deployed ships, could be used for training.

CURRENT DEVELOPMENTS

An overview of concepts currently under consideration or being developed will give an idea of the general movement toward the use of modular systems. First, let us look at how the U.S. Navy, the unquestioned leader in modern naval technology, is tackling the problem. The United States has stated an aim of overcoming antiaccess strategies.²⁶ Doing so is seen as a preparation to defeat adversaries and to operate in all domains. To that end, and to carry mine countermeasures into the future, a replacement is planned for the legacy *Avenger* class, the Littoral Combat Ship (LCS).

LCS is a totally mission-modular concept. The platform will be reconfigurable any place in the world and can assume various roles, one of them MCM. There are currently two versions; both can reach speeds well over forty knots. USS *Freedom* (LCS 1), designed and built by Lockheed Martin, has a high-speed, semiplaning monohull 115.5 meters long and a full-load displacement of three thousand tons. USS *Independence* (LCS 2), designed and built by General Dynamics, has a trimaran stabilized aluminum hull 127.8 meters long and a full-load displacement of 2,637 tons.²⁷ Both have core complements of around forty. Mission crews will come on board with any of the planned twenty-four MCM mission packages. LCS will carry and employ a variety of off-board sensors and effectors. The U.S. Navy has clearly defined “mission systems” as vehicles, sensors, and weapons; “mission modules” as mission systems plus support equipment; and a “mission package” as mission modules plus mission crew detachments, plus aircraft.²⁸ In the MCM role, LCS is supposed to remain outside the minefield; it is therefore not protected against mines like the legacy ships it replaces. LCSs are planned to operate in groups, assisting each other.

LCS is seen to have revolutionized current approaches to acquisition, operation, and modernization. It is referred to as the first platform to be designed with modernization in mind. Industry was allowed to produce ideas under research-and-development funding.²⁹ But LCS is also under constant criticism, for a variety of reasons. One is that LCS will not cover all scenarios. Like the once-planned “craft of opportunity” MCM program, it aims solely at the expeditionary role: “The sea is a maneuver area. From the U.S. Navy’s perspective, the goal of MCM is to enable maneuver of naval forces, not to counter every mine.”³⁰ So there may be a requirement to cover a gap, the clearing of broad areas after the initial “punch through.” Having ships operate in groups in the contested littoral environment has the clear advantage of maintaining a large degree of capability in the event of losing a platform. But the variety of possible roles comes at a considerable price, and the group concept requires numbers. Smaller navies might not be able to embark on a similar project. Here cooperation could provide a practicable option, as the members of groups do not need to come from one country (see NATO’s Standing Naval MCM Groups).

In Europe, France and the United Kingdom have agreed on extended military cooperation, in their 2010 Lancaster House treaties. One observer has noted, “The Royal Navy has already begun collaborating with France on an MCM equipment module for whatever the new vessels turn out to be.”³¹ Both nations did some work on the problem; they have slightly different approaches but share a common baseline. Research has been extremely complicated, as information cannot easily be found in open sources and agencies in the United Kingdom have been unwilling or, for classification reasons, unable to assist the author. So the depth of the analysis in this section is limited.

In the United Kingdom, the 2010 Strategic Defense and Security Review confirmed the need to replace the current fleet of MCM vessels; it points in a direction similar to LCS but not to the same degree of modularity. Both France and the United Kingdom have started demonstrator trials. Britain is following a “twin-track approach.”³² The Royal Navy has recognized the need to ensure the maturity of the new systems before making the leap to a new class, in order not to be left with capability gaps. What is needed is a proven “system of systems,” able to provide end-to-end surveillance, minesweeping, and mine disposal.³³ The result is a phased approach, proving first the off-board capability, then the ability to perform the mission from outside the minefield. This means that the systems and the platform can be developed independently.

There seems to be considerable doubt that the “man out of the minefield” principle can be applied in toto. The skills provided by clearance divers may still be required. The future end state has been described as a “trinity of capability”

also known as “portable, organic and dedicated.”³⁴ However, over the past years some experience has been gained with the operation of autonomous underwater vehicles (AUVs). A further step will be taken with “flexible agile sweeping technology” (FAST), involving an unmanned surface vehicle (USV) capable of remotely controlled minesweeping and possibly mine-hunting tasks. It can be employed from the current Hunt class. In addition, unmanned aerial vehicles (UAVs) may have roles in surveillance, detection of near-surface mines, and communication relay over the horizon.

The aim is to develop and mature a capability that covers areas ranging from harbors or confined waters to the very-shallow-water region, and to the deep sea. The United Kingdom’s plan is to design a common hull that can carry out MCM, hydrographic, and patrol tasks—a Mine Countermeasure, Hydrography, and Patrol Capability (MHPC). Mine countermeasures and hydrography have common requirements to map the seabed and analyze the environment. The patrol capability will be inherent in the platform.

A possible answer is the BMT Venator project.³⁵ With a length of just over ninety-three meters and displacement just above three thousand tons, this proposed vessel would be significantly larger than legacy ships, providing it more seaworthiness, speed, range, and endurance. It is planned to be able to travel with a task force at eighteen knots in sea state 6 and to have a sprint speed of twenty-five knots.³⁶ (High speed is not a requirement in the Royal Navy.) It would be operated by a core crew of forty but would have accommodations for up to eighty. The design offers a payload capability of seven hundred tons.³⁷ It would carry mainly autonomous underwater and surface vehicles to hunt and sweep mines. The ship itself would remain outside the minefield, a fact that reduces its cost.

The need for a highly specialized platform may be decreasing, but whether it has disappeared completely remains doubtful. Detailed research has shown that a ninety-meter monohull design with a flight deck and “garage space” below it (in which to store vehicles and from which to deliver them over a stern ramp) would be optimal. It could be manned by a crew of eighty, including embarked personnel. It would host UAVs and provide shelter in a retractable hangar for a Lynx-sized helicopter. Such an approach, at least in some ways, would be the *Black Swan*-class sloop of war.³⁸ This platform would have a displacement of 3,150 tons, a length of ninety-five meters, a top speed of eighteen knots, and a complement of forty. Both *Black Swan* and BMT Venator rely on keeping “the man out of the minefield.”

The Royal Australian Navy is developing a similar concept, called the Off-shore Combatant Vessel (OCV), or Project Sea 1180.³⁹ It envisions a single class of modular, multirole offshore combatants conducting the tasks of four existing role-specific types: patrol boats, MCM vessels, hydrographic survey ships, and

oceanographic/environmental assessment vessels.⁴⁰ It is based on an aluminum-alloy trimaran developed by Austal, the MRV 80. The design is eighty meters long and displaces roughly two thousand tons. Top speed is to be twenty-six knots, and a complement of up to eighty-seven personnel is planned. It includes a flight deck and a storage space below it for mission modules. It will not be able to operate inside a minefield.

The French Navy plans to develop in parallel a full capability and also a portable capability. The full capability will be based on a host platform that stands off the mine-danger area.⁴¹ USVs will transport mine-hunting systems able to perform the detect-to-countermining sequence into the minefield. The USVs can be operated either by the new dedicated platform being planned or by (in the “portable capability” variant) a *Mistral*-class amphibious assault ship. The dedicated platform will be designed and constructed by DCNS. It is likely to be a hundred-meter-long SWATH hull of between two and three thousand tons;⁴² however, there are catamaran and monohull designs (Gowind-OPV) under consideration as well. All variants would feature a flight deck and a stern ramp for launch and recovery of boats, USVs, and AUVs. None would be built to low-signature standards; all therefore would have to remain outside the minefield. There will be an interface with the seventeen-meter ESPADON USV, which is undergoing tests.⁴³ The ESPADON displaces twenty-five tons and is intended mainly to transport large AUVs and one-shot mine destructors.

The Royal Swedish Navy is considering a concept based on Kockums’ FLEXpatrol MCM.⁴⁴ The concept comprises a corvette-sized vessel capable of transporting modular manned and unmanned off-board equipment for patrol, hydrographic, and MCM tasks. These modules would be added to permanently installed equipment that would form the baseline of operation, protection, and communications. The idea is to have a flight deck and beneath it a “garage” with stern ramp to deploy and recover boats, AUVs, and USVs. The concept goes beyond tying the modules to the platform—it speaks of MCM as a “toolbox.” The modules, which consist of the vehicle and a control station, can be employed on other vessels, such as the *Visby*-class corvette, or ashore. The FLEX platform itself will be roughly eighty meters long, with a displacement of a thousand tons plus. Its endurance is to be between twenty and thirty days, its range between three and four thousand miles, and its speed twenty to twenty-five knots. A carbon-fiber hull design reduces underwater signature, weight, and maintenance (80 percent less than for a steel hull), and it enhances shock resistance and stealth. The concept is seen as a complement to both organic and designated MCM: the organic capability of the *Visby*-class corvette would “punch through” a minefield, and FLEX, able to operate inside a minefield, would clear the area.

Abeking & Rasmussen has developed a concept based on a number of small units. The vessel is derived from a demonstrator the German Navy has used for a “Mine Hunting 2000” project. It is a SWATH design just over twenty-eight meters long, with a displacement of 140 tons and a speed of approximately twenty-one knots. SWATH is known for seaworthiness. Because crew size is one of the main cost drivers, A&R has kept the crew to the very minimum, eight. Latvia has procured some of these vessels with mission modules for patrol and MCM. All modules are based on twenty-foot containers. A&R argues that having a number of small vessels operating modular equipment has the advantage of resilience compared with one large, integrated platform, in case of losses.⁴⁵ A large “mother” dock-type ship could transport the small vessels and so mitigate their lack of endurance and range.

The European Defence Agency runs a project—Maritime Mine Counter Measures Next Generation, or MMCM NG. Its cornerstones are rapid MCM; security, flexibility, and modularity; decreased logistical dependence, maintenance, and LCC; and higher MCM capability (with fewer units and people) and deployment speed.⁴⁶ The project is led by Germany; other participating countries are Belgium, France, Netherlands, Sweden, and Estonia. Norway, although not a member of the European Union (EU), is also involved. The initial workshop took place in Brussels in February 2013. Directly connected is a research and technology program known as European Unmanned Maritime Systems for Mine-Counter-Measures and Other Naval Applications.⁴⁷

The MMCM NG project was one of twelve selected by the EDA steering board in 2008. The twelve constitute the EDA’s Initial Capability Development Plan and contribute to long-term capability development within the European Security and Defense Policy. The goal is to introduce a new generation of MCM able to counter threats from old mines to the most advanced ones in a more effective and safe way than at present. The agency appears to be on a promising track, as the initiative offers a path toward the EU’s “pooling and sharing” of capability. This would also be in line with NATO’s “smart defense” principle. Both EU and EDA see this program as a promising way ahead, inasmuch as nations are feeling more and more constrained in their abilities to acquire missing capabilities on their own. Small numbers and rising costs are driving total costs further. That is even more true of unique equipment, although life-cycle costs are getting higher than those of acquisition.

A corvette-sized vessel seems to be the answer. It is small enough to reduce its signatures to allow it to enter a minefield. It is large enough to provide space for a number of AUVs and USVs and to be comparatively seaworthy. It would also

provide the baseline requirements for range and sustainability. Manning could be kept at a minimum through a high degree of ship-systems automation and alternative operational approaches. The sizes of the AUV and (mainly) USVs would be limited, but the FAST system could well be transported on and employed from such a platform.

The degree of mission automation is another factor to be considered. Should a drone have the capability to decide to fire a weapon? Is a human needed to make this decision? A future large AUV could carry mine-disposal weapons and fire them on the basis of a computerized assessment; a networked group of USVs or a single vehicle could be so advanced as to identify a mine, assign a disposal weapon, and fire it, all automatically. The advantages of the vehicle acting autonomously to such an extent can be seen in covert operations and over-the-horizon employment. However, national views on this issue vary. Some nations seem to have no concern over automated firing; others see it as a “red line.”

Mission bays are included in most proposals, and there seems to be agreement that stern ramps are the best way to launch and recover off-board systems. The combination of mission bay and stern ramp has been investigated by the Babcock Marine and Technology Division, initially for the Royal Navy’s new Type 26 frigate project.⁴⁸ Innovative ways of moving equipment inside the bay, such as rail systems in the deck or overhead, would enable handling in sea states up to 6. More controversial is the use of standard twenty-foot containers as a baseline for modules. While some concepts rely heavily on it, others would prefer a smaller standard. All concepts include flight decks for UAVs and helicopters; some have a form hangar, for medium-sized helicopters. All proposals envision fixed, installed equipment for self-defense, communication suites, and surveillance. These may constitute a patrol and maritime-security operations (MSO) capability.

Displacements vary from around a thousand tons to over three thousand. In Europe there seems to be a common understanding that speed above twenty-five knots is not required. This again limits cost, as higher speed requires additional power, a significant cost driver. The U.S. Navy’s LCS and the TKMS project are clear exceptions here. Core crew sizes are mostly around forty; that is the current level, but the assumption is that future crews would be operating more systems. The projects have space for additional personnel. Range and endurance are greatly enhanced across the board, which could make specialized command and support platforms unnecessary.

Finally, the concepts generally concentrate on MCM, hydrography, and patrol tasks. Intelligence gathering is mentioned only in some of the EDA project briefs. There would clearly be a possibility of embarking such a capability in any such platform.

KEEP THE MAN OUT OF THE MINEFIELD?

Reliance on autonomous robotic systems deployed from standoff vessels, possibly over the horizon, would mean a total change in the conduct and culture of MCM and is not to be undertaken lightly. Can it be done? Can off-board sensors and effectors provide sufficient knowledge of the seabed? If the technology is mature enough to be trusted with the lives of seamen, there might be potential in the concept. The United States is, and the United Kingdom and France appear to be, convinced that it is mature enough; some members of the EDA project apparently differ. But there are more central questions: How certainly can the boundaries of a minefield be determined? How far must the seaframe stay from an area that is believed to be mined, not to risk entering it accidentally? What level of risk is acceptable? Standoff ranges and reliability must be considered as cost-driving factors, albeit with a potential for savings if signature reduction is achieved.

It may prove that keeping men out of minefields is not achievable and that platforms that can operate inside them are required. In that case drones may have to be developed—which might well be too large for platforms that need to be small to minimize their signatures. But even if it is achievable, fundamental issues arise, such as when the mother ship cannot avoid entering the minefield. Information about the field's boundaries, or about the mine threat itself, might be insufficient; the size of the minable area might exceed the range of the off-board systems; or the enemy might know about the concept and mine the mother ship's approach route.

Beyond these technological and operational factors, national ambitions may prove decisive. For instance, it might be possible to "punch through" a minefield, by the U.S. approach, without putting men into it, but other nations need the capability to clear larger areas. Does a country need deployable forces? For homeland defense only, the current platforms or modules operated from shore might be sufficient. For expeditionary roles, a platform that can survive in contested environments is needed, though the MCM modules might be the same.

In any case, as *Jane's* argues, "new MCM technologies need to be de-risked and new systems proven before the MCM community embraces standoff systems."⁴⁹ Meanwhile, the current systems—despite the limitations already noted—will remain in use for some years to come, and some navies have started to integrate new capabilities into them. This might prove the optimal way of "de-risking" standoff systems, determining how practicable "keeping the man out of the minefield" is and ensuring a smooth transition from legacy to new systems. But as we have seen, even mature technology does not guarantee success. The aim may stay an aim.

CREW CONCEPTS

Finally, manning must be considered in depth. There is a clear incentive—cost—to reduce crew size. A three-watch rotation for all stations prevents early crew fatigue but requires more personnel than the two-watch system that most legacy vehicles use. For ships that carry different modules for different missions, there are many options, each with pros and cons. One principle envisions a “core crew” for the ship and “mission crews” for the modules. This raises the problem of crew integration, especially with the minimal manning needed to reduce LCC. The two parts of the crew will have to work up to fight together, and in small ships, some tasks, such as damage control, are always “all hands.” It would be possible to equip, work up, and deploy the ship with certain modules and leave it that way for a considerable time; this integrates the crew but limits the modularity. Another option is to train one crew to use different modules. This again would ensure an integrated crew, but it would significantly lengthen training time (but maybe not training cost, as the training will have to be provided in any case). Refreshers prior to module and task changes might become necessary, limiting flexibility, or at least the speed with which roles can be changed.

A balance will have to be found between modularity and other cost-driving factors. Limiting modularity to some degree might be a satisfactory trade-off. In a dedicated platform, some capabilities could be integrated permanently—for instance, as noted above, self-defense and communication suites will be needed for almost all missions.

Promising approaches are available. But significant questions remain for further investigation. Of these, the issue of whether humans can realistically be kept out of the minefield appears to be a very important, if not the central, question. But there are others: Is technology mature enough to allow a leap in MCM philosophy to a possible next generation of capability? What are the implications for training, doctrine, and procedures?

The solution might be a tiered approach. If expeditionary-focused navies set themselves up for the “punch through” capability for which the United States has opted others may be needed for the challenging task of clearing larger areas, a task in which numbers will play an important role. There seems to be a drive toward a larger, more capable platform with space for future growth, but unit protection by signature reduction remains controversial. If it is needed, it will restrict the size of the vessel and the number and size of systems it can carry. The final result may have to be a compromise.

It seems to be the common view that a platform providing MCM capability alone is not feasible. However, the argument that a platform engaged in MCM

will be very restricted in performing other tasks is widely accepted; a ship launching and recovering unmanned systems will not be able to do much else. The requirement for a hydrographical capability varies, that not being a naval task in all countries. Patrol, in contrast, seems to be considered a given with any capable platform.

The need for a smooth transition from the current capability to the next generation is commonly acknowledged. It can be achieved by mitigating technological risk through maturing new systems on legacy platforms. Indeed, there seems to be agreement on the idea of MCM systems as the driving part of development and the platform as the enabling part. Also commonly accepted are stern ramps and flight decks.

But the question remains of how long the step to the next generation will be. The answer will be shaped—as the numerous approaches are investigated and, potentially, new ones are discovered—by national purposes, financial ability, political will, and readiness to cooperate.

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