The Belgian – Dutch replacement MCM programme

Innovative & (R)evolutionary

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Author Biographies

LtCdr Renauld Hock joined the Belgian Navy in 2011 graduating *suma cum laude*, as valedictorian from the Royal Military Academy with a Master of Science in Engineering.

After managing MCM projects, he served as Deputy Head of the Technical Department of the frigate F930 BNS Leopold 1 and participated in three operational missions. He then specialized in Cyber & Intelligence Operations and was deployed overseas in his capacity as Head of Technical Department.

After graduating *suma cum laude*, as valedictorian of the Candidate Senior Officer Course, he became the Project Leader of the binational rMCM programme and returned to those early works. Supported by a highly skilled binational team, he works towards the successful execution of this innovative and (r)evolutionary programme.

Synopsis

Recent events have shown the importance of Sea Lines of Communication (SLOCs). The blocking of the Suez Canal had a major impact on the world economy. Just imagine if a terrorist group lay a sea mine in the same Suez Canal or in one of those other Choke Points (CP) our world economy relies on. A simple mine threat would have catastrophic ramifications impact on our daily life!

In order to guarantee the success of military operations in protecting our world economy and overall way of life, the military has an obligation of success, not an obligation of means nor of efficiency. Our military capabilities have therefore to be as effective as possible.

The Belgian and Dutch Navies are world-renowned in Naval Mine Warfare (NMW) and notably host the NATO Center of Excellence (CoE) of Eguermin in Belgium.

However, current Mines Counter Measures (MCM) solutions worldwide have a number of recognized shortfalls hampering the effectiveness and efficiency of MCM operation, namely:

- Limited transit speed;
- High operation time;
- Very limited covert operation capabilities;
- Risk for personnel;
- Ships with limited self-defence, communications means, endurance and staff facilities;
- Limited solution to counter drifting and buried mines.

To guarantee the effectiveness and efficiency of future MCM operations, the Belgian and Dutch Navies developed innovative & (r)evolutionary new Concept of Operations (CONOPS) for the MCM warfare based on a modern standoff solution that will address observed shortcomings of current MCM solutions.

In May 2019, as a result of this new CONOPS, an industrial consortium, was awarded the contract to supply twelve MCM vessels to both the Belgian and Dutch Navies; equipped with around 100 drones, constituting approximately ten drone systems (toolboxes).

The rMCM programme, worth around 1,8 billion euros, will last ten years. The first delivery of a Belgian ship with its toolbox is scheduled for December 2024.

For this CONOPS and associated rMCM programme to succeed, the Belgian and Dutch Navies will have to find the appropriate balance between “operating risk” being linked to maintenance, training and maturity of the technology and “operational risk” linked to the command decision and therefore the trust we place in technology.

This innovative, robust and reliable system ensures the safety of operators and maneuvers to protect the ship, the Unmanned Surface Vehicles (USV) and its payloads, while offering a high level of mission availability.

This paper presents the methodology used in the rMCM programme through which the Belgian and Dutch Navies, together with the industry, intend to produce a paradigm shift in MCM Warfare, in some ways similar to the one we encounter during

World War (WWII) when the aircraft carrier replaced the cruiser as the highest value units of a fleet. Our solution, a decentralized system-of-systems will pave the way and become an example for all navies worldwide.

Keywords:

Innovation, MCM, System of Systems, Standoff, Belgian Navy, Royal Netherlands Navy.

1. Introduction

The Belgian and Dutch Navies will replace their current Mines Counter Measures (MCM) capability during the period 2023-2030 [Kalajzic E., Struye de Swielande T. Belgian Defence (2021) and Belgian Defence (2019)]. The rMCM (replacement MCM) capability needs to be tailored to today's unstable and tomorrow's unpredictable and fast evolving strategic and operational context, while being mindful of the modern mine threats and current capability shortcomings. In the future, Naval Mine Warfare (NMW) operations shall and will be conducted in a more effective, efficient and safe manner.

Sea mines constitute a clear tangible danger to our national military and economic interests; an impact which will be heavily felt because of the strategic importance of the main harbours of both nations. Apart from those national ambitions both the Belgian and Dutch Navies will continue to contribute to the NATO's, the EU's and UN's missions in a variety of potential scenarios ranging from homeland security over trade and Sea Lines of Communication (SLOCs) protection to expeditionary operations to protect the world economy and our overall way of life.

Sea mines have always been a simple and cheap weapon widely and easily available to all state and non-state actors. Current technology developments and studies show that this threat is rapidly evolving and becoming more and more sophisticated. As in all warfare, the on-going evolution in smart mine design will always pre-date the development of a countermeasure. On one hand, future MCM capabilities needs therefore – by design – to response to this evolving threat by efficient incremental improvements and innovative solutions. On the other hand, current MCM capability have already several recognized shortfalls hampering MCM operations. Modern Navies should as soon as possible overcome those shortfalls.

To guarantee the effectiveness and efficiency of future MCM operations on the long term, the Belgian and Dutch Navies have developed an new innovative & (r)evolutionary Concept Of Operations (CONOPS) for the MCM warfare based on a modern standoff solution that will overcome the recognized shortfalls of current MCM solutions.

This CONOPS is based on a System-of-Systems concept where the MCM Platform (MCMPF) deploys from a standoff distance a number of tools in the Mine Threat Area (MTA). The use of those unmanned and autonomous systems and tools, as well as the continued advance of unmanned technology have opened new ways for conducting MCM and will also contribute to other types of warfare than NMW.

This CONOPS requires regularly updating in a loop process, hand-in-hand with the firm to whom the contract was awarded to supply twelve MCM vessels to both the Belgian and Dutch Navies; equipped with around 100 drones, constituting approximately ten drone systems (toolboxes) and a dedicated simulation environment. Research and development (R&D) continuously feed the CONOPS that which in turn will feed the R&D.

This paper will detail the methodology used by Belgium and the Netherlands to replace their MCM capacity from this new CONOPS through the rMCM programme in other to produce a new paradigm shift in NMW. This paradigm shift will guarantee future operations to be conducted in a more effective, efficient and safe manner.

2. From a strategic ambition level to an innovative & (r)evolutionary CONOPS

a. About the importance of MCM operations

As defined in the military literature and national standards [Royal Netherlands Navy (2014) and Belgian Defence (2019], Maritime operations comprise three types of operation: maritime combat operations (MCO), maritime security operations (MSO) and maritime assistance (MA) as illustrated in figure 1.

Figure 1 - Types of maritime operations (Royal Netherlands Navy (2014))

MCO take place at the highest level of the spectrum of force, when combat takes place at sea and from the sea.

NMW operations are MCO that can be sub-divided into offensive and defensive NMW as known as MCM. As the former is not part of the strategic ambition of both the Belgian and the Dutch Navy, this paper will focus on the latter. However the rMCM programme was developed to be upgradable to address offensive NMW[1] if needed in the future.

MSO are activities undertaken at sea, which threaten security both at sea or on land (such as terrorism, arms smuggling or piracy, coastguard duties and enforcing maritime embargoes).

In MA, naval forces support the legitimate authority of a nation (e.g. humanitarian assistance, disaster relief, evacuations, reconstruction activities, maritime capability building, maritime diplomacy, intelligence).

In essence, MCM forces contribute to the free use of the sea for naval forces, and more importantly for transportation of goods through merchant vessels (e.g. energy and raw materials),at the core of our global blue economy[2]. They will also substantially contribute to the protection of the SLOCs, coastal approaches to and from the world's harbours or the vital infrastructural gateways in a global maritime transport network.

Today mines are easily accessible increasing possibility of a mine threat that could potentially impede the maritime traffic and disrupt any on-going maritime operations. Worldwide inventories could potentially include additional weapons such as :

- Underwater Improvised Explosive Devices (UW-IED) which can be utilised as sea mines;
- Unexploded Explosive Ordonnances (UXO), whether modern or historical;
- decoys and dummy mines often used in combination with real sea mines to mask their presence.

Sea mines are a key enabler to smaller navies and non-state actors to exercise effective anti-access/area-denial (A2/AD). The continuous evolution in mine technology causes technical challenges for MCM-systems. It will therefore always pre-date the development of a countermeasure.

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[1] Offensive MCM are designed to prevent the enemy from successfully laying sea mines. They include strategic bombing and missile attacks, attacks on minelayers and laying own minefields.

[2] Blue economy is a term in economics relating to the exploitation, preservation and regeneration of the marine environment.

Note also that Mine Counter-Counter Measures (MCCM) are designed to protect mines and minefields against MCM. Therefore A MCM capability needs, by design, to be able to accommodate continuous and responsive incremental improvements.

Environmental considerations play a significant part in the planning, execution and evaluation of MCM operations. Rapid Environmental Assessment (REA) is therefore key to the success of MCM operations which requires a large variety of sensors.

b. Belgium and the Netherlands' ambitions in NMW

In both Belgium and the Netherlands, the Ministry of Defence (MoD) defines the level of ambition for their Defence. Apart from their national ambitions, they will continue to contribute to NATO, EU and UN missions in a variety of potential scenarios. The Dutch Navy will also contribute to amphibious missions within the UK/NL Amphibious Force.

In the maritime domain, Belgium and the Netherlands have chosen to merge their naval capabilities into a common command structure, know as *Admiraal Benelux* (ABNL). In the NMW, the common level of ambition, to date, is limited to defensive NMW also known as MCM. Ambitions of the future ABNL rMCM capability is as follows [Belgian Defence 2016 and 2019]:

- Deploy worldwide (pre-deployed, forward deployed or integrated into a maritime task force);
- Operate in a joint and/or combined environment as an integrated part of a task force;
- Operate in both permissive and non-permissive environments. In a non-permissive environment the MCMPF requires adequate means for Self Defence (SD) and Force Protection (FP) against FIAC (Fast Inshore Attack Craft) and LSF (Low Slow Flyer) threats;
- Operate in an effective, efficient and safe manner, in the all spectrum of MCM operation as detailed in figure 2 (using mine hunting, influence minesweeping and EOD techniques). This requires to:
    - be ready to encounter a large spectrum of objects, from modern mines, UXOs to decoys:
    - to accept innovative incremental improvements in order to cope with changes in technology in MCM threats and solutions;
    - to deal with MCCM.

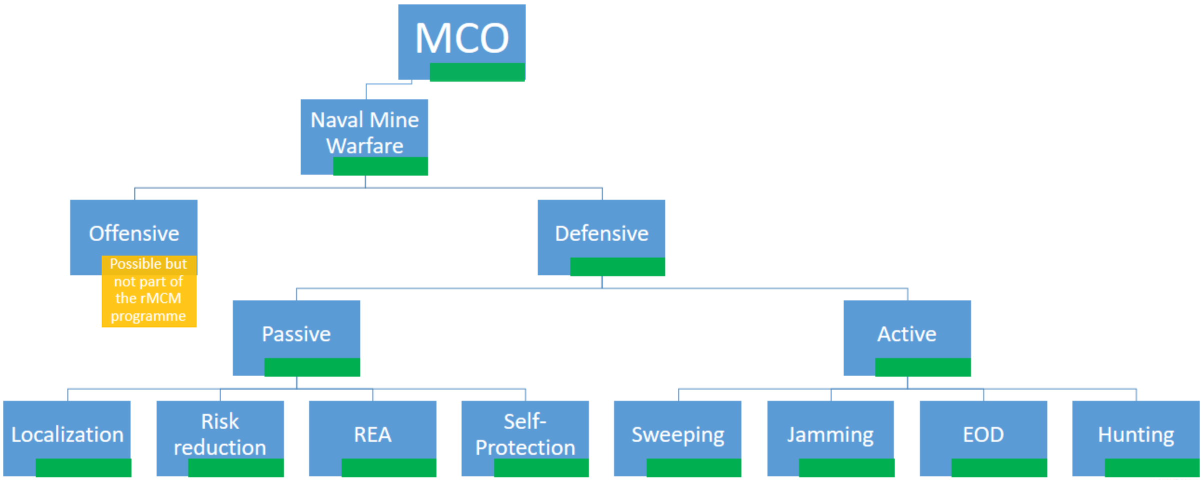

Figure 2 - Types of NWM operations

- Operate in a covert posture (e.g. in support of amphibious operations);
- Contribute to the different types of MCO, MSO and MA (detailed in figure 3). The contribution of all ABNL units ensures that Defence (within the maritime domain) cover all of its (legal) tasks. The units are generally specialized in one or more tasks.

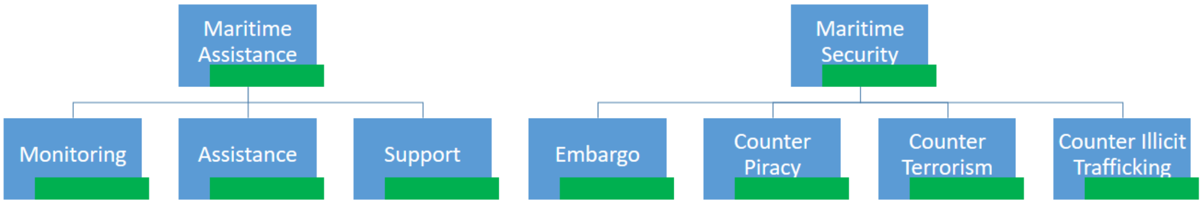

Figure 3 - Types of MA & MSO

- Operate in three types of scenarios:
    - Homeland Defence: clearance of mines and explosives in the Belgian and Netherlands' territorial waters (TTW), primarily the harbours and their approaches, and secondarily for NATO routes crossing the Belgian and Netherlands' part of the Continental Shelf. This covers also the Dutch territories overseas (Caribbean Sea);
    - Protection of the SLOCs and CP: the importance of the free use of trade routes is evident. Therefore, the protection of the SLOCs & CP leading to the strategic harbours remains a fundamental, current and future role for the MCM capability.
    - Expeditionary operations such as amphibious operations in support of (joint) operations on land, which is driven by the geostrategic evolution and in alignment with other navies' developments.

c. An innovative & (r)evolutionary CONOPS to produce a paradigm shift

In order to replace their current MCM capability, Belgium and the Netherlands have drafted an innovative & (r)evolutionary CONOPS from the rMCM based on the level of ambition defined here above. From this level of ambition, primary and secondary tasks are identified which lead to major design choices:

- The primary task of the rMCM capability is conducting the whole spectrum of defensive NMW (MCM) operations as part of MCO (see Figure 2). It consists of both active and passive measures. Defensive MCM consists of both active and passive measures:
    - Active MCM is the use of techniques (mine hunting and sweeping, jamming and EOD) to find and neutralise mines in an opponent's minefield. Mine hunting and mine sweeping are complementary and need, in principle, to both be applied in a dedicated sea area in order to be able to declare a sea area free of mines with limited remaining risk to shipping;
    - Passive MCM includes the exploitation of intelligence, routeing ships around minefields and Self-Protective Measures (SPMs), which seek to reduce vulnerability by signature control and/or shock hardening. The rMCM capability will utilize both active and passive measures.
- The secondary task of the rMCM capability is contributing to MSO and MA.

The priority for a Defence organisation is to guarantee their capacity to successfully execute on their assigned tasks. The capacity is designed based on the primary task but should allow for the execution of the secondary one. We have a duty of success and not of means. Therefore, our capabilities need primarily to be designed toward effectiveness in executing the primary, the need for efficiency as a second stage. For quite some time, a number of shortfalls of the current MCM capability have been identified that hamper the execution of MCM operations [e.g. Kimber A., Giles W. (2008) and Schwarz M. (2013)], namely:

- Limited transit speed & endurance;
- High operation time;
- Very limited covert operation capabilities;
- Risk for personnel;
- Limited self-defence, communications means and staff facilities;
- Not Suited for hybrid warfare environment (incl. cyber);
- Limited solution to counter drifting and buried mines;

To guarantee the safe, effective and efficient execution of future MCM operations, the rMCM CONOPS will, as illustrated, in figure 4:

- Use a modern decentralized system-of-systems solution based on manned and unmanned technology to maximize both effectiveness and efficiency of MCM operations;
- Use a standoff solution based on PF dedicated to MCM Operation (MCMPF), not a ship of opportunity (not designed for MCM task) to improve the safety of the crew and the platform. The MCMPF stays at a standoff distance, outside of the MTA while still accommodating specific MCM systems to reduce the risk on the crew;
- Use a modular concept of MCM TB deployable from the MCM PF or from other locations such as a ship of opportunity or directly from shore through the use of a containerized version of the TB (CONTTB). The MCMTB, at a standoff distance of the MCMPF, enter the MTA to execute both remotely and autonomously MCM Operations. The key element being the Unmanned Surface Vehicule (USV) that play the role of the current MCM ship (*vide infra*).
- Optimize the combination of MCM tools to execute all types of NWM operations (cfr. Figure 2) in order to maximize effectiveness of MCM operations. It is essential that MCM operations are conducted uninterrupted as long as possible to improve efficiency of MCM operations;
- Use modern dedicated MCM Simulator (MCMSIM) installed in NATO Center of Excellence (CoE) of Eguermin in Belgium in order to:
    - Maximize the safe, effective and efficient use of MCM capability;
    - Maximize the usability and acceptance of the new technology to the rMCM crew and staff;
    - Accommodate future change in MCM threats and develop new operational solutions.
- Optimize the balance between "operating risk" being linked to maintenance, training and maturity of the technology and "operational risk" linked to the command decision and therefore the trust we place in technology. In order to do so, ones needs to move step-by-step with the industry through the Technology Readiness Levels (TRL) of the all system-of-systems by combining operational use and simulation.
- The MCMPF was designed to accommodate new innovative evolutions for a duration of 30 years while the MCMTB and the MCMSIM should accommodate technological evolution on shortened periods of time such as the overall rMCM capability which will then be regularly updatable and upgradable in order to cope with change in MCM threats and solutions;
- Within the rMCM Programme and to support the corrective & evaluative maintenance, an extended rMCM In-Service Support (ISS) contract will be passed with industry in parallel with the rMCM acquisition contract.

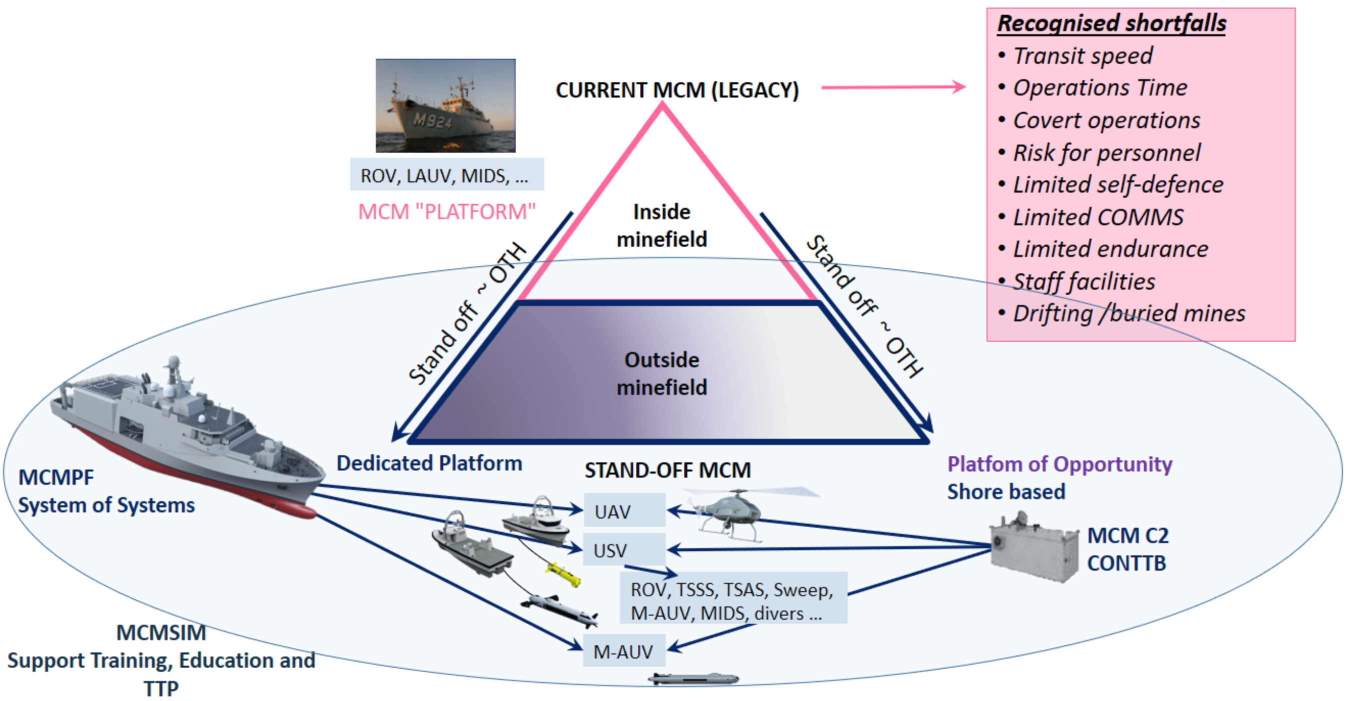

Figure 4 – rMCM CONOPS

3. From a CONOPS to the final operational product through the rMCM programme

a. The rMCM programme priorities

The objective of the rMCM programme is to provide ABNL with a new MCM capability able to execute on the CONOPS to perform the assigned task in meeting objectives defined in the ambition level. As ABNL has a duty of success and not of means, the priority of the rMCM programme is to provide ABNL the best possible MCM capability (Product) within a given time and budgetary (Cost) frame. Therefore, during the preparation and execution of the rMCM contrat, the priority will always be given to the Product before Costs and Time (given the balance triangle illustrated in figure 5).

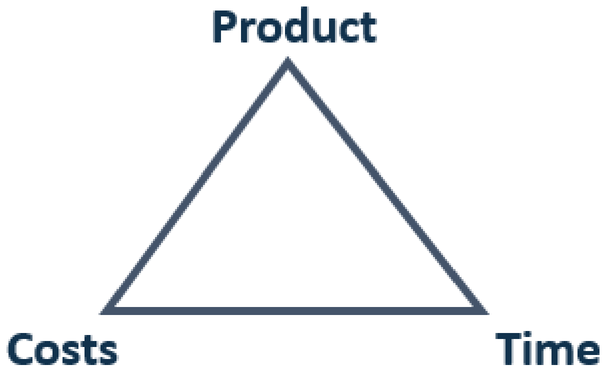

Figure 5 – rMCM Contract balance triangle

The final product, is the MCM capability as a whole, as defined in the NATO DOTMLPF (NATO 2015: Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities) which is standard in military programmes. The difference in the rMCM programme is the importance of the MCMTB that executes most of the tasks. It is therefore mandatory to find the correct balance between "operating risk" and "operational risk" as previously defined. To do so we not only need to work with the industry but we need to work with the crew that will control the MCMTB composed of autonomous tools. Each crew member needs to trust tools for the MCM capability to be usable and effective.

There are four dimensions in the human-agent trust establishment [Doroftei, D., De Vleeschauwer, T., Bue, S. L., Dewyn, M., Vanderstraeten, F., & De Cubber, G. 2021]:

- reliable performance;
- understanding of system processes;
- the match between the use of the system and its purpose;
- socio-ethical aspects.

The rMCM programme does not only need to guarantee the reliable performance of the systems-of-systems, that the crews understand the system processes but ultimately also need to help ABLN guarantee that each crew member understands the match between the rMCM systems and its purpose while dealing with socio-ethical in an iterative process. What we ultimately need is a paradigm shift not only on the technical level but in all aspects of the MCM capability: all aspect of DOTMLPF. A paradigm shift similar to the one we experienced during WWII: from the Cruiser to the Aircraft carrier as illustrated in figure 6: from a centralized system to a decentralized systems of systems that heavily relies on Command and Control (C2). This systems-of-unmanned-systems will be capable of automated operating actions on a large area of influence integrated with maned crews.

Cruiser	Aircraft Carrier	Future « Ships »
System	System of Systems	System of Systems – **Unmanned**
Centralized: • Fire power • C4I	Decentralized: • Fire power • C4I	Decentralized – **Unmanned & Automated**: • Fire power • C4I
	Command & Control	Command & Control - **Unmanned & Automated**
	Covered Area / Area of Influence	Covered Area / Area of Influence

Figure 6 – rMCM towards a paradigm shift

b. The rMCM programme's high-level requirements

The CONOPS defined three major entities forming the rMCM capability: the MCMPF, the MCMTB and the MCMSIM. Those have been further detailed in operational specifications for the industry to propose a technical solution. In 2019, after analysis of three offers from three different industrial consortium, a contract was signed to secure the most adapted solution.

In 2022, the rMCM programme is scheduled to pass the Critical Design Review (CDR) during which the final detailed design is to be accepted by Belgium and the Netherlands. The industry will then deliver from end 2024 until 2030:

- 12 MCMPFs (one new city-class ship every 6 months) :
    - Capable of sailing 3500 nautical miles without refuelling;
    - 200 days sustainment, without resupplies (not including fuel) for 30 days;
    - Integrated managements systems and specific cyber architecture with many automated functions:
        - Integrated Platform Management System (IPMS);
        - Integrated Bridge Management System (IBMS);
        - Combat Management System (CMS) embedded with NMW and Principal Warfare (PW) capabilities;
        - Secured Computerized Command, Control, Communications & Intelligence (C4I) systems and dedicated Cyber Management System to ensure the Confidentiality, Integrity and Availability (CIA).
    - A crane capable of carrying 20-foot containers, including a diver decompression container and MCM tools;
    - Two large Launch and Recovery System (LARS) for two large USVs;
    - Two small LARS for two RHIBs;
    - A Unmanned Aerial Vehicle (UAV) deck and storage facilities;
    - MAS;
    - Specific military characteristics: acoustic and electromagnetic discretion, shock resistance, automated FP & SD systems, large staff accommodation.
- 9 MCMTBs (illustrated in figure 7) in 8 batches :
    - Large autonomous underwater vehicles (AUV) with synthetic aperture sonar (SAS);
    - Towed SAS (TSAS);
    - UAV;
    - Mines Identification and Destruction System (MIDS) composed of two types of drones:
        - a Remotely Operated Vehicle (ROV) for Identification which is reusable;
        - a neutralization ROV consumable and disposable.
    - Influence Minesweeping System (IMS) composed 5 solenoids and 1 acoustic generator;

- Autonomous USV capable of
  - Unmanned mission by deploying the MIDS, the IMS, the towed sonar and transporting the AUV:
  - Manned mission for Divers, EOD and FP.

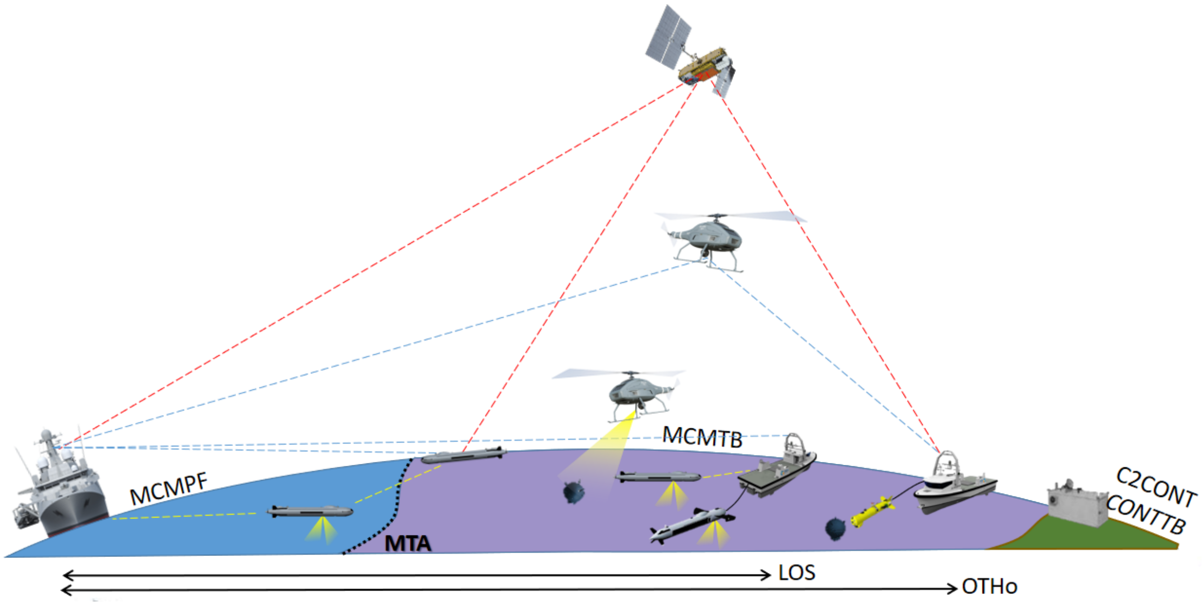

Figure 7 – MCMPF and MCMTB integrated

- An MCMSIM:
  - Tactical simulator to train the all crew (technical and operational personal);
  - Virtual Reality (VR) simulator;
  - Tactical and VR being linked in common training scenario.

c. *The rMCM programme timeline*

With the rMCM programme, Belgian and the Netherlands will have the first Navies in the world deploying a new MCM integrated capability combining modern MCMPF, deploying a MCMTB and supported by a MCMSIM. The rMCM programme timeline is presented in figure 8:

- Delivery of the first MCMPF at the end of 2024;
- rMCM Initial Operational Capability (IOC) at the end of 2025 with the first MCMPF being operational after 1 year of training and tests through the Safety And Readiness Checks (SARC) process [Ford G. McMahon C., Rowley C, 2013];
- Delivery of first MCMSIM version and of MCMTB in batches as soon as 2023, before the MCMPF to secure Education & Training of the first crews;
- Start of the ISS contract as soon as in 2023, before the MCMPF to ensure readiness of the maintenance process;
- rMCM Final Operational Capability (FOC) current 2030 after the delivery of the last MCMPF.

The rMCM capability will replace the current MCM (cMCM) capability of ABNL. As explained, the rMCM programme will ensure that the new MCM capability solves the shortfalls of the cMCM and surpasses the cMCM in many ways. However, it is difficult to compare the rMCM and the cMCM capabilities as the CONOPs are very different. We choose to take the speed at which a MCMPF from the rMCM will be able to detect mines in a MTA. The rMCM is always at least twice quicker than a cMCM ship.

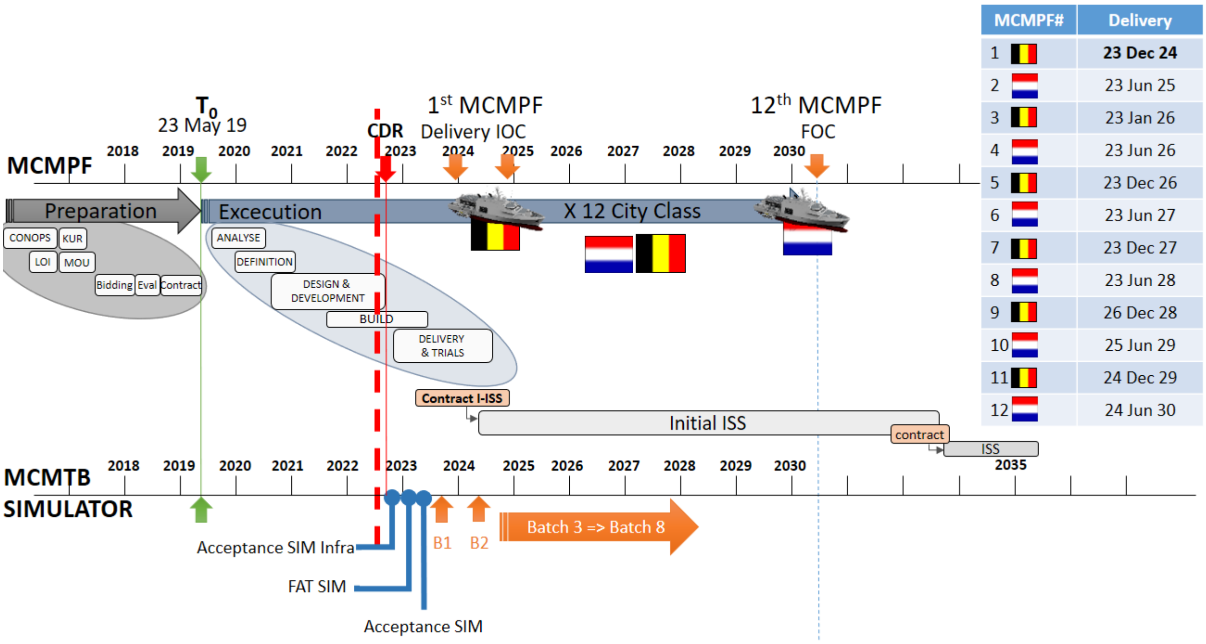

Figure 8 – rMCM programme timeline

The figure 9 shows the transition planning from the cMCM to the rMCM capability of ABNL in number of ships while the red line represents the MCM overall capability.

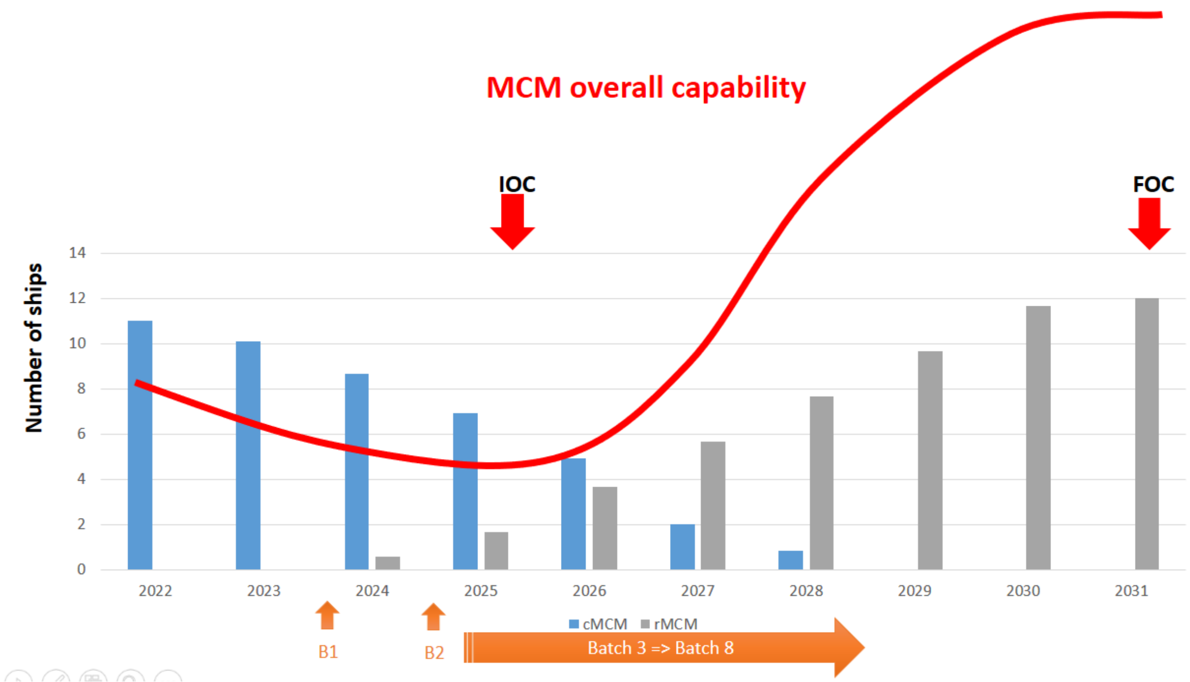

Figure 9 – MCM overall capability transition

d. The rMCM programme challenges and opportunities

The rMCM programme has many challenges, namely (non-exhaustive list):

- New CONOPS;
- Binational programme;
- Operating vs operational risk balance;
- Delivering reliable, robust, available and trustable equipment;

- Trust in autonomous systems and autonomous-manned work acceptance allowing long-term business transformation;
- Security (incl. cybersecurity) of a system-of-systems architecture with large operating range: from LoS to OTHo;
- Data security and handling;
- Regulatory clearance and safety assurance (step-by-step);
- Pace of technology development.

But many of those challenges come with opportunities, for example:

- The fact that this is a brand new CONOPS that comes with a challenge of finding a balance between operating and operational risk. This creates us opportunities to enhance our links with industry and to develop trust in unmanned system in general. For that reason, two development and innovation labs have been created in the framework of the rMCM programme, namely
    - MCMLab for the development of innovative projects on future MCM capabilities and tools;
    - CyberLab for the development of innovative projects in cybersecurity in the Maritime world and on systems-of-systems architecture including autonomous drones.
- A full binational programme, that is completely integrated, is a big challenge that comes with multiple opportunities, one being taking the best of the systems of both countries. Belgium is leading the programme and the Netherlands supports it by being integrated into the Project Office team but also through other channels such as the Dutch OT&E contract. This OT&E contract is very similar to what other countries are currently doing: testing a MCMTB. The strength of Belgium and the Netherlands is therefore to do both: building a fully integrated solution to be IOC as earlier as end 2025 while testing technological development and prototyping. Those tests will allow us to improve much faster the MCMTB, MCMSIM and ultimately the MCMPF.

4. Conclusion:

This paper shows how the Belgian and Dutch Navies have developed innovative & (r)evolutionary CONOPS and associated rMCM programme for Naval Mine Warfare (NMW) based on a modern standoff solution and a system-of-systems solution that will overcome the recognized shortfalls of current MCM solutions. Figure 10 summarizes the methodology followed by Belgium and Netherlands to ensure that the rMCM programme will deliver an effective and safe new MCM capacity to ABNL.

As demonstrated, Belgium and the Netherlands, together with the industry, intend to optimize the balance between “operating risk” and “operational risk” to produce a paradigm shift in NMW that would be as important as the shift that replaced the cruiser for the aircraft carrier in WWII. This rMCM programme is and will be an example for all navies worldwide in all warfare domains. The methodology used will ensure that the future rMCM capacity continue to provide an effective, efficient and safe solution in NMW for years to come.

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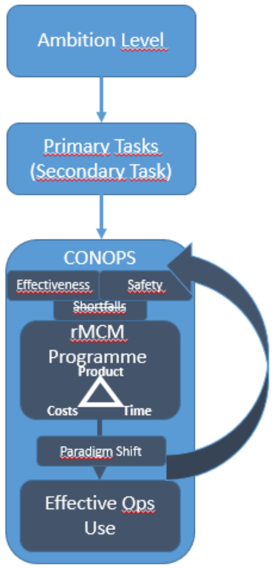

Figure 10 – Methodology

Acknowledgements:

The success of the rMCM programme lies in ABNL’s success and the support offered by organizations in both countries:

- the Directorate General Material Resources from Belgian Defence, home to the Project Office leading on the rMCM programme;
- the Defensie Materieel Organisatie from the Netherlands, through inclusion of experts into the Project Office and its support of the rMCM programme;
- Belgian and Dutch Navies;
- The NATO Center of Excellence (CoE) of Eguermin in Belgium.

Belgium and the Netherlands intend to pave the way through the paradigm shift which all navies will need to embrace worldwide: namely an autonomous-manned work acceptance allowing long-term business transformation toward new CONOPSs in all warfare based on autonomous systems-of-systems. For that, we need to trust our people to continue to innovate and deliver for a higher purpose: a safe and secure environment.

References:

a. Belgian Defence (2016). La Vision Stratégique pour la Défense. Belgian Ministry of Defence, Cellule stratégique et secrétariat de la Ministre de la Défense. Brussels, Belgium. https://www.cdsca-ocasc-website.be/wp-content/uploads/2020/organisation/vision_strategique-defense.pdf

b. Belgian Defence (2019). Contract MRMP-N/P 19NP002 – rMCM. Directorate General of Material Ressource, Evere, Belgium

c. Doroftei, D., De Vleeschauwer, T., Bue, S. L., Dewyn, M., Vanderstraeten, F., & De Cubber, G. (2021). Human-agent trust evaluation in a digital twin context. In 2021 30TH IEEE INTERNATIONAL CONFERENCE ON ROBOT AND HUMAN INTERACTIVE COMMUNICATION (RO-MAN) (pp. 203–207). Vancouver, BC, Canada: IEEE. https://doi.org/10.1109/ro-man50785.2021.9515445

d. Ford G. McMahon C., Rowley C 2013. Naval Surface Ship In-Service Information Exploitation. In 2nd International Through-life Engineering Services Conference. Procedia CIRP 11 (2013) 92 – 98. Elsevier B.V. Naval Surface Ship In-service Information Exploitation (sciencedirectassets.com)

e. Kalajzic E., Struye de Swielande T. Belgian Defence (2021). Mise à jour de la vision stratégique 2030 : Recommandations. Belgian Ministry of Defence, Cellule stratégique et secrétariat de la Ministre de la Défense. Brussels, Belgium. https://www.defence-institute.be/wp-content/uploads/2021/06/200622-Strategic-Vision-2021-FR.pdf

f. Kimber A., Giles W. (2008). Minor Warship Roles - How technology is leading to a new vessel type. BMT Defence Services Limited, Bath UK.

g. Royal Netherlands Navy (2014). Fundamentals of Maritime Operations Netherlands maritime military doctrine. Project Manager Doctrine & Tactics. Royal Netherlands Navy, Directorate of Operations, Maritime Warfare Centre. Den Helder. The Netherlands.

h. Schwarz M. (2013). A future Naval Mine Warfare Vessel – the chance for a European system? JOINT SERVICES COMMAND AND STAFF COLLEGE. ADVANCED COMMAND AND STAFF COURSE NUMBER 16 (SEPT 12 - JUL 13). UK.

Bibliography:

a. Docherty M. (2002). Modern MCM Concepts. Warfare Concepts. Naval Forces.

b. Griner, J. T. Jr.. (1997). The Paradigm of Naval Mine Countermeasures: A Study in Stagnation. United States Marine Corps,Command and Staff College, Marine Corps University,2076 South Street, Marine Corps Combat Development Command,Quantico,VA, USA.

c. Keddie I. (2013). MCM goes unmanned. HIS Jane Defence Weekly (03 June 2013 – Page 25-31). IHS Global Ltd.

d. NATO 2015. Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms Archived October 12, 2009, at the Wayback Machine, 8 November 2010 (As Amended Through 15 March 2015). www.dtic.mil/doctrine/jel/new_pubs/jp1_02.pdf

e. Schwarz M. (2014). Future Mine Countermeasures – No Easy Solutions. Naval War College Review. Newport, Rhode Island. USA

f. Truver S. C. (2011). Taking Mines Seriously – Mine Warfare in China's Near Seas. China's Strategy for the Near Seas. China Maritime Studies Institute. Naval War College in Newport (10-11 May 2011, USA.

5. Glossary of terms:

A2/AD: Anti-Access/Area-Denial
ABNL: Admiraal Benelux
ACD: Automated Change Detection
ATR: Automatic Target Recognition
AUV: Autonomous Underwater Vehicles
C2: Command and Control
C4I: Secured Computerized Command, Control, Communications & Intelligence
CDR: Critical Design Review
CIA: Confidentiality, Integrity and Availability
CMS: Combat Management System
CoE: Center of Excellence (NATO)
CONOPS: Concept Of Operations
CONTTB: Containerized TB
CP: Choke Points
DOTMLPF: Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities
DW: Deep-Water
Eguermin: *Ecole de Guerre des Mines*
FIAC: Fast Inshore Attack Craft
FOC: Final Operational Capability
FP: Force Protection
IED: Improvised Explosive Devices
IOC: Initial Operational Capability
ISS: In-Service Support
LoS : Line of Sight
LSF: Low Slow Flyer
MA: Maritime Assistance
MAS: Mine Avoidance Sonar
MCCM: Mine Counter-Counter Measures
MCM: Mines Counter Measures
MCMPF: Mines Counter Measures Platform
MCMSIM: MCM Simulator
MCMTB: Mines Counter Measures ToolBox
MCO: Maritime Combat Operations
MIDS: Mine Identification and Disposal System
MMS: Mission Management System
MoD: Ministry of Defence
MSO: Maritime Security Operations
MTA: Mine Threat Area
NMW: Naval Mine Warfare
NATO: North Atlantic Treaty Organization
OTHo: Over The Horizon
PF: Platform
PW: Principal Warfare
REA: Rapid Environmental Assessment
rMCM: replacement MCM (programme)
ROV: Remotely Operated Vehicles
SARC: Safety And Readiness Checks
SD: Self Defence
SLOCs: Sea Lines Of Communication
SOR(-M): StandOff Range MCM

SPM: Self Protective Measures
SW: Shallow-Water
SZ: Surf Zone
TB: ToolBox
TRL: Technology Readiness Level
TTP: Tactics, Techniques, and Procedures
TTW: Territorial Waters
UAV: Unmanned Aerial Vehicle
USV: Unmanned Surface Vehicles
UUV: Unmanned Underwater Vehicles
UW-IED: Underwater Improvised Explosive Devices
UXO: Unexploded Explosive Ordonnance
VR: Virtual Reality
VSW: Very Shallow Water
WWII: World War II