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China Maritime Report No. 29: PLAN Mine Countermeasures, Platforms, Training, and Civil-Military Integration

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PLAN Mine Countermeasures

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Summary

The People's Liberation Army Navy (PLAN) has made incremental progress in its mine countermeasures (MCM) program in recent years. The PLAN's current inventory of about 60 MCM ships and craft includes classes of minehunters and minesweepers mostly commissioned in the past decade as well as unmanned surface vessels (USVs) and remotely operated vehicles with demonstrated explosive neutralization capability. Despite the addition of these advanced MCM platforms and equipment, experts affiliated with the PLAN and China's mine warfare development laboratory have serious reservations about the PLAN's current ability to respond to the full range of likely threats posed by naval mines in future contingencies. The PLAN's MCM forces are currently organized for operations near China's coastline, but writings by Chinese military and civilian experts contend that to safeguard Beijing's expanding overseas interests, the PLAN must develop MCM capabilities for operations far beyond the First Island Chain. PLAN and civilian mine warfare experts have proposed various solutions for offsetting perceived shortcomings in the PLAN's MCM program, including the development of autonomous USVs and unmanned underwater vehicles (UUVs), deployment of modularized MCM mission packages on ships such as destroyers and frigates, and mobilization of civilian assets such as ships and helicopters in support of MCM operations. Although there appears to have been little to no adoption of these proposed solutions to date, the PLAN recognizes MCM as one of its biggest challenges, and one can expect the PLAN to continue making measured progress in its MCM program in the years ahead.

Introduction

This report provides an overview of Chinese People's Liberation Army Navy (PLAN) mine countermeasures (MCM) capabilities, with a focus on related naval platforms and equipment, civil-military integration, and training activities. This report updates previous Western research on PLAN MCM, with an eye toward developments since 2010.[1]

The detection and neutralization of adversary naval mines is an important capability for all maritime powers, and China is no exception. Minefields deprive enemy ships of freedom of maneuver and eliminate their mobility. The laying of mines, or even the suspicion that mines have been laid in a strategic waterway such as a harbor or strait, can be enough to deter a country lacking in MCM capability from transiting that waterway. It is more difficult to clear mines than to lay mines, and mines are significantly cheaper per unit than the enemy combatants they threaten to cripple or destroy. To retain freedom of maneuver, it is imperative for maritime powers to develop MCM capability to ensure the safe passage of their commercial shipping and naval forces, especially during crisis and conflict.

In this report, we argue that the PLAN recognizes the importance of modernizing and expanding its MCM capability to operate in both "near seas" and "far seas" environments, but that evidence to date shows they have made limited progress toward this goal, possibly due to competition for resources with other naval warfare communities. We find that most or all of the PLAN's current inventory of about 60 dedicated mine warfare ships and craft, as well as MCM equipment including remotely operated vehicles (ROVs), is likely intended for operations within the First Island Chain. We also note People's Republic of China (PRC) interest in using civilian platforms to augment its MCM

[1] See Andrew S. Erickson, William S. Murray, and Lyle J. Goldstein, *Chinese Mine Warfare: a PLA Navy "Assassin's Mace" Capability* (Newport, RI: U.S. Naval War College, 2009); Scott C. Truver, "Taking Mines Seriously: Mine Warfare in China's Near Seas," *Naval War College Review*, volume 65, no. 2 (2012), https://digital-commons.usnwc.edu/nwc-review/vol65/iss2/5/ .

capability, although there is little evidence of recent training or investments in this area. We found that the PLAN currently maintains an inventory of remotely-controlled mine sweeping USVs but appears to lack minehunting UUVs, despite the fact that PRC shipbuilders are clearly capable of building related platforms.

The data analyzed for this report was drawn primarily from Chinese-language technical journal and newspaper articles published between 2010 and 2022. Priority was given to articles authored by individuals with credible ties to China's MCM program, namely authors with institutional affiliations to the PLAN and to the state-owned China State Shipbuilding Corporation's (CSSC) No. 710 Research Institute, China's mine warfare development laboratory.[2] As with any analysis of PLA capabilities based on publicly available writings, this report presents a partial and likely incomplete picture of the initiatives underway in China's MCM development, some of which may be classified or otherwise deemed too sensitive for public disclosure.

The remainder of this report is organized as follows. Section one examines PRC military and civilian authors' views of the naval mine threat environment and motivations for expanding the PLAN's MCM capability outside the First Island Chain. The second section lays out what is currently known from publicly available sources on the PLAN's current MCM capability (platforms, equipment, etc.) as well as capabilities it may be developing based on evidence from PRC writings. In the third section, we discuss PRC views on incorporating civilian platforms such as ships, helicopters, and UUVs into MCM operations and the types of tasks those civilian platforms could potentially undertake. The fourth section offers a brief overview of MCM training exercises carried out within the PLAN and with foreign militaries. The final section summarizes observed progress in the PLAN's MCM capability since 2010 and compares the differing approaches to MCM in the PLAN and U.S. Navy.

The Naval Mine Threat Environment

PRC military and civilian writings describe MCM as one of the "three big challenges of 21st century naval warfare" (the other two being antisubmarine warfare [ASW] and missile defense).[3] A common and longstanding formulation used by PRC authors to encapsulate the MCM challenge is that naval mines are "easy to lay and hard to sweep."[4] PRC subject matter experts describe MCM operations as complex to organize, tedious to execute, and highly dangerous. In one account of the relative danger,

[2] 飞行器工程（航空发动机）学院与中船七一〇研究所开展党支部共建 ("School of Aircraft Engineering (School of Aero-Engine) and CSSC's No. 710 Research Institute Carry Out Party Branch Joint Building"), 南昌航空大学飞行器工程学院（航空发动机学院） (Nanchang Hangkong University School of Aircraft Engineering (School of Aero-Engine)), 7 December 2021, http://fxq.nchu.edu.cn/hfxy/content_115427. The No. 710 Research Institute was formerly subordinate to the state-owned China Shipbuilding Industry Corporation (CSIC) and, following CSIC's merger with China's other state-owned shipbuilding conglomerate in 2019, is now part of China State Shipbuilding Corporation (CSSC).

[3] See for example 王松 [Wang Song], 无人水下航行器在反水雷中的应用探讨 ["Discussion on Application of Unmanned Underwater Vehicle in MCM"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], vol. 5, no. 3 (2022), pp. 260-261; 衡辉 [Heng Hui]，黄波 [Huang Po]，王新华 [Wang Xinhua]，and 曹晓明 [Cao Xiaoming], 反水雷体系建设探讨["Discussion on Construction of MCM System"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], no. 5 (October 2020), p. 416; 水雷易布难扫 与反导、反潜一起并称为世界海军三大难题 ["Naval Mines Are Easy to Lay and Difficult to Sweep, and Along with Missile Defense and ASW Have Been Called the Three Big Difficult Topics of World Navies"], 兵器面面观 [*Bingqi Mianmian Guan*], CCTV-7, 20 October 2020, https://tv.cctv.com/2020/10/20/VIDEmqieQuSiF44IJMLd5tQq201020.shtml.

[4] The term "easy to lay, hard to sweep" (易布难扫) is ubiquitous and has long been used in PRC writings on mine warfare as Erickson et al. observed in their 2009 *Assassin's Mace* study.

a PRC state television program likened MCM forces to "maritime expendables." Speaking on that program, a PLAN minesweeping unit's commanding officer recounted how a crewmember had achieved peace of mind by making advance arrangements for their younger brother to look after the family should the worst come to pass.[5]

It is likely for reasons such as these that PLA writings portray mine warfare as not among the top career choices of China's sailors. As a 2021 *PLA Daily* article noted, a common saying that has circulated among PLAN units begins with "if you get on a ship, don't get on a minesweeping ship."[6]

Challenges and dangers notwithstanding, PRC authors articulate the need for a stronger and more expeditionary MCM capability that can safeguard China's territorial security and expanding interests abroad. They note that China's growing reliance on maritime shipping for trade and energy imports, accelerated under Xi Jinping's Belt and Road Initiative, has increased the frequency and scale at which PRC civilian and military vessels operate outside the First Island Chain, at increasing distances from the mainland. For one, Hu Guanglan, a mine warfare researcher at CSSC's No. 710 Research Institute, attests that "following the development of the globalized economy, the areas of operation of China's ship formations have gone from the near seas to the globe as a whole."[7]

The stated need for greater MCM capability comes as PRC subject matter experts envision extensive and growing naval mine threats to China's military and civilian ships operating at home and abroad. In one representative analysis, Zhao Zhiping, an MCM equipment and technology researcher at the No. 710 Research Institute, groups foreign naval mine threats into three categories:

> Near seas threats**:** Zhao notes risks to PLAN maneuver posed by "minelaying blockade [threats] in China's ports, shipping lanes, islands/reefs, and sensitive waters" within the First Island Chain. The author associates these threats with potential adversaries including the US, Japan, "Taiwan independence forces," and certain Southeast Asian countries who have "occupied Chinese islands/reefs in the South China Sea."
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> Far seas threats**:** According to Zhao, PLAN oceangoing formations face potential "minelaying blockades in key straits and important lines of communication" in waters outside the First Island Chain, such as the northern Indian Ocean and Western Pacific.
>
> Overseas base threats**:** Zhao identifies the Port of Djibouti and Pakistan's Gwadar Port as "important supports" for China's foreign trade and energy security and says that these "overseas bases and ports" will also face naval mine threats.[8]

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[5] 新闻联播 [*Xinwen Lianbo*], CCTV-13, 9 February 2021, https://news.cctv.com/2021/02/09/ARTIMxakQHK4tyKCz8aOHC1R210209.shtml?from_source=www.cbg.cn.

[6] 高德政 [Gao Dezheng], 一级军士长的 26 本工作笔记 ["A Master Sergeant Class One's 26 Work Journals"], 解放军报 [*PLA Daily*], 18 August 2021, http://www.81.cn/jfjbmap/content/2021-08/18/content_296810.htm.

[7] 胡光兰 [Hu Guanglan]，王久法 [Wang Jiufa]，and 李晓东 [Li Xiaodong], 建制式反水雷装备发展特点分析及建议 ["Analysis and Recommendation on the Development of Organic MCM Equipment"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], no. 4 (August 2020), pp. 331-332.

[8] 赵治平 [Zhao Zhiping]，官红 [Gong Hong]，艾艳辉 [Ai Yanhui]，and 王久法 [Wang Jiufa], 无人化时代反水雷装备体系构想 ["Conception of MCM Equipment System in Unmanned Era"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], no. 1 (June 2018), p. 1.

PRC military and civilian authors offer rather bleak assessments of the PLAN's existing capability to neutralize enemy mine threats, particularly as the PLAN operates at greater distances from mainland China. In one 2017 assessment, Hu Ce, an individual affiliated with the No. 710 Research Institute, said that due to shortcomings, including MCM forces' reliance on mainland bases and general lack of unmanned MCM capability, in the event that China faced a naval mine blockade, "it would be difficult to achieve rapid, mobile MCM operations, the survivability and operations of the Chinese navy's forces would be seriously challenged, and the national economy and even the strategic overall situation could be affected."[9]

Echoing Hu, a 2019 article by Ni Hua, a senior engineer at the PLAN's Yichang Area Military Representative Office, explained that due to the PRC's historic preoccupation with "near seas defense," the PLAN has concentrated its MCM capability in unspecified "important sea areas" near the mainland. Ni contended that China's existing MCM capability is "still insufficient for near seas operational requirements" and that it is "even more seriously inadequate… for supporting mid- and far seas protection operations."[10]

PLAN MCM Capabilities and Organization

This section provides an overview of the PLAN's existing MCM capabilities and how they are organized under the PLA's three theater command navies. We also highlight several MCM capabilities that the PLAN appears to be developing but may not yet be operational, based on writings by PRC military and civilian authors.

Limitations in credible publicly available data pose significant challenges to constructing a PLAN MCM order of battle. The PLA and China's defense industry generally releases less specific data on current platforms or capabilities under development than Western countries such as the U.S. The challenge is further compounded by the fact that PRC writings devote considerably less attention to mine warfare and dedicated MCM platforms than to "sexier" missions like anti-surface warfare and ASW and to surface combatants such as cruisers, destroyers, and frigates.[11] It should be noted that MCM's lack of prominence in PRC media and analysts' writings is by no means unique—the topic receives comparatively limited discussion in the U.S. and NATO as well.

The PLAN's current MCM capabilities include four classes of minehunting and minesweeping ships and craft designed primarily for operations near the Chinese mainland. A portion of these ships carry remotely operated underwater vehicles used to neutralize underwater mines. PLAN MCM assets are

[9] 胡测 [Hu Ce]，孙海涛 [Sun Haitao]，and 张建军 [Zhang Jianjun], 一种基于无人平台的协同反水雷系统及方法 ["A System and Method of Cooperative MCM Based on Unmanned Platform"], 水雷战与舰船防护 [*Mine Warfare & Ship Self-Defence*], no. 4 (November 2017), pp. 15-16.

[10] 倪华 [Ni Hua]，赵治平 [Zhao Zhiping]，官红 [Guan Hong]，and 艾艳辉 [Ai Yanhui], 我国反水雷支援舰能力建设探讨 ["Discussion of Capacity Building of Our Country's MCM Support Ships"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], no. 2 (2019), pp. 1-2.

[11] To illustrate this point, we searched *PLA Daily*—the PLA's official newspaper—to compare the number of articles containing MCM-related terms with those of other naval missions and platforms. In a search of *PLA Daily* issues from October 2017 to January 2023, we found 66 articles containing the term "mine countermeasures" (反水雷) and 128 containing the term "minesweeping ship" (扫雷舰). These results were five to ten times fewer than terms corresponding to other naval missions (e.g., ASW, ASuW, naval missile defense) and five to twenty times fewer than terms corresponding to other types of naval platforms (aircraft carrier, destroyer, frigate, landing ship, etc.).

organized under minesweeping squadrons subordinate to the PLA's theater command navies based in Qingdao, Ningbo, and Zhanjiang, respectively.

Ships and Craft

The PLAN has a current inventory of about 60 mine warfare ships and craft, which includes Wochi-class mine countermeasures ships (MCM), Wozang-class minehunting ships (MHS), Wosao-class coastal minesweepers (MSC), and Wonang-class inshore minesweepers (MSI). The first three classes are manned ships, while the Wonang-class MSI are remotely operated unmanned surface vessels (USVs).

What is publicly known about the capabilities and ranges of these ships and craft, coupled with accounts of their shortcomings by PRC authors, suggest that they must operate relatively close to mainland bases (e.g., in harbors, along coastlines) and may lack the ability to achieve full coverage of waters within the First Island Chain.

Table 1. PLAN Mine Warfare Ships and Craft

Class	Type	Function	Number	Length(m)	Detail
Wochi	Type 081	MCM	4	66	Equipped for acoustic, magnetic, and mechanical sweeps. Type 081 entered service in 2007; 081A in 2012.
	Type 081A	MCM	10	70	
Wozang	Type 082II	MHS	10+	55-58	Can remotely operate up to 3 Type 529 unmanned minesweeping craft.
Wosao	Type 082	MSC	4	45	Equipped with mechanical, magnetic, acoustic, and infrasonic sweeps. 500 nm range.
	Type 082I	MSC	12	48	
Wonang	Type 529	MSI	15+	30	Unmanned vessels remote controlled by Type 082II minehunting ships. Commissioned in 2005; 6+ added since 2010.

Sources: unclassified recognition guide published by Office of Naval Intelligence; Janes; IISS.[12]

[12] "China People's Liberation Army Navy (PLAN), Coast Guard, and Government Maritime Forces: 2022-2023 Recognition and Identification Guide," Office of Naval Intelligence, December 2022, https://www.oni.navy.mil/Portals/12/2022_PLAN_Recognition_Poster_UNCLASSIFIED.pdf; "Wochi (Type 081/081A) class (MSC)," "Wozang (Type 082II) class (MCMV)," and "Wosao (Type 082/082I) class (MINESWEEPERS—COASTAL) (MSC)," Janes Fighting Ships, 11 August 2022, www.janes.com; "Chapter Six: Asia," in International Institute of Strategic Studies, *The Military Balance*, vol. 122, 2022, pp. 218-317.

Figure 1. Front and middle: Wosao-class MSCs *Xiangshan* and *Chongming* during a 2014 training exercise near the Yangtze River Estuary.[13]

Figure 2. Wochi-class MCM during an April 2021 training exercise in the South China Sea organized by the PLA Southern Theater Command.[14]

ROVs

The PLAN's MCM units employ at least two types of tethered remotely operated mine neutralization vehicles. Images of these ROVs appearing in PRC media as early as 2007 suggest that they are similar in design to the Pluto ROV produced by the Italian manufacturer Gaymarine. It is unclear from publicly available sources how many MCM ROVs are in the PLAN inventory.

A 2020 video shows PLAN sailors launching a large "Mine Neutralization Vehicle" and operating it from the deck of the Wozang-class mine hunting ship *Donggang* during an exercise.[15] A crew of six

[13] The ships' hull numbers have since been changed to 701 and 702, respectively. 骆上关 [Luo Shangguan]，潘剑雄 [Pan Jianxiong]， and 江山 [Jiang Shan], "海上敢死队"的使命突击 ["Mission Assault of the 'Maritime Expendables'"], 中国军网 [*China Military Online*], 8 December 2014, http://photo.81.cn/pla/2014-12/08/content_6259521.htm.

[14] 万松涛 [Wan Songtao], 砺兵南海！多型扫雷舰奋战五昼夜 ["Training Troops in the South China Sea! Multiple Types of Minesweeping Ships Fight Bravely Across Five Days and Nights"], 中国军网 [*China Military Online*], 12 April 2021, http://www.81.cn/tp/2021-04/12/content_10020358.htm?spm=0.0.0.0.YmcY6v.

[15] 曹海峰 [Cao Haifeng]，张震 [Zhang Zhen]， and 黄亮 [Huang Liang], 海军某基地聚焦实战背景组织反水雷演练 ["Unidentified Naval Base Organizes MCM Drill With Focus on Actual-Combat Setting"], 中国军视网 [China Military Video Net], 18 July 2020, http://www.js7tv.cn/video/202007_223789.html.

sailors launched the vehicle using a cart and a crane. The video shows the ROV getting underway and a winch being used to control the tether. Two detonations were shown after the vehicle launch. See Figure 3 below.

Figure 3. The Wozang-class MHS *Donggang* deploys a mine neutralization vehicle.[16]

The primary advantage of the larger-sized ROV is the vehicle's ability to neutralize deeper mines. The large vehicle has a physical resemblance to the Pluto in its construction. It is not known whether the vehicle was constructed by the Italian company, but the vehicle was probably built in China. The

[16] Ibid.

PRC has an excellent ocean engineering capability, as demonstrated by their civilian deep submersible program.[17]

A second type of MCM ROV was briefly shown in footage from a February 2021 state media report on an exercise by a minesweeping squadron under the PLA Eastern Theater Command Navy. The footage shows PLAN sailors loading a bomblet onto an ROV that is smaller than the abovementioned ROV and lacks outer rails used for handling.[18] See Figure 4 below.

Figure 4. ROV shown in a February 2021 CCTV-13 report on a PLAN minesweeping exercise.[19]

Minesweeping Equipment

The PLAN uses what appears to be standard equipment for influence sweeping, based on secondary literature and related footage in PRC state media.[20] For example, a February 2021 report on a PLAN minesweeping squadron's training exercise showed floats and acoustic devices among the gear launched and towed.[21] Large magnetic sweep cables were shown being reeled in, but the report provided no information on electrodes or other components of the magnetic sweep and no indication of the amperage pulsed. Winches were shown that were available to launch and recover wire sweeps, but no information was provided on the sweep configuration.

Organization

Minesweeper squadrons. The PLAN's mine warfare ships and craft are organized into "minesweeper squadrons" (扫雷舰大队). Each of the PLA's three theater command navies has at least one

[17] Yan Weijue, "Submersible's Developers Discuss 'Incredible' Mission," *China Daily*, 8 December 2020, http://www.chinadaily.com.cn/a/202012/08/WS5fcecf7da31024ad0ba9a702.html.

[18] *Xinwen Lianbo*.

[19] *Xinwen Lianbo*.

[20] Janes, for example, notes that Wosao-class coastal minesweepers are equipped with mechanical, magnetic, acoustic, and infrasonic sweeps, while Wochi-class mine countermeasures ships are equipped with mechanical, magnetic, and acoustic sweeps. See "Wosao (Type 082/082I) class (MINESWEEPERS—COASTAL) (MSC)" and "Wochi (Type 081/081A) class (MSC)," Janes Fighting Ships, 11 August 2022.

[21] *Xinwen Lianbo*.

minesweeper squadron. The names of ships assigned to these squadrons correspond to municipal-level administrations within their respective theater command. For example, the Wochi-class *Wudi* (hull number 849), part of a Northern Theater Command Navy minesweeping squadron, is named after Wudi County in Shandong Province (units based in Shandong are under the operational control of the Northern Theater Command).

Some minesweeping squadrons appear to be more capable than others, with more elite forces likely concentrated in the Eastern Theater Command, which is oriented toward Taiwan and the East China Sea. A 2016 report on China Military Online noted that the minesweeping unit at the Shanghai Naval District "was established earliest and has the most equipment" and that the naval district had "always been at the forefront of research on naval MCM operations."[22] It is notable that the February 2021 footage of a second type of ROV (see Figure 4 above) occurred at an Eastern Theater Command minesweeping squadron, which may have been the first PLAN unit to receive this new MCM equipment.

Naval divers. PLAN minesweeper squadrons contain teams of naval divers, or "MCM frogmen" (反水雷蛙人), who are trained to neutralize and recover mines at depths of at least 20 meters.[23]

Officer and NCO education. The PLAN's junior mine warfare officers are educated at the Dalian Naval Academy in Dalian, Liaoning province. They receive education under the "ship water weapons command" specialty. Their coursework includes ship physical-field signals and their detection, principles of MCM weapons systems, and the use of naval mine weapons in combat.[24] At least some of the noncommissioned officers (NCOs) in the PLAN's minesweeping squadrons receive education at the PLAN's Naval NCO School in Bengbu, Anhui province before they are assigned to MCM units.[25]

Technical support. PLAN MCM squadrons likely receive technical support from CSSC's No. 710 Research Institute for issues related to MCM platforms and equipment.[26]

Unmanned Systems

USVs. The PLAN currently maintains 15 or more MCM USVs in service, namely its Wonang-class MSI craft. These craft are not capable of independent operations and are controlled remotely from Wozang-class minehunting ships.

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[22] 徐巍 [Xu Wei] and 张帅 [Zhang Shuai], 海上惊雷 "扫雷先锋"猎杀 2 枚新型水雷 ["Maritime Thunderclap, 'Minesweeping Vanguard' Hunts and Kills Two New-Type Naval Mines"], 中国军网 [*China Military Online*], 19 August 2016, https://photo.81.cn/pla/2016-08/19/content_7215173.htm.

[23] See "Naval Divers Simulate Mine Disposal and Recovery" in *PLA Update*, Brian Waidelich and Patrick deGategno, eds., issue 11, 20 June 2023, https://www.cna.org/Newsletters/PLA%20Update/Issue-11/PLA-Update-Issue-11-June-20-2023.pdf.

[24] 海军大连舰艇学院 2019 年招生专业介绍 ["Overview of Specialties for Dalian Naval Academy's 2019 Admissions"], 中国军网 [*China Military Online*], 10 April 2019, http://www.81.cn/jpdbfy2019/zgjx_207227/bkzs/9472582.html.

[25] 陈典宏 [Chen Dianhong], "海上工兵"被院校聘为"部队专家" ["'Maritime Engineer' Appointed by Academic Institution as 'Unit Expert'"], 解放军报 [*PLA Daily*], 27 March 2023, http://www.81.cn/yw_208727/16212223.html.

[26] CSSC's No. 710 Research Institute is described as a "five-in-one" organization in which "service support" is one of its five functions. The other four functions are the top-level research, overall design, systems integration, and assembly and construction of mine warfare equipment. "School of Aircraft Engineering (School of Aero-Engine) and CSSC's No. 710 Research Institute Carry Out Party Branch Joint Building)."

PRC military and civilian authors identify the PLAN's existing MCM USV capability as insufficient and call for the development of new MCM USVs, to include those equipped with autonomous technologies. In one journal article published in 2021, Wang Jin, an engineer at the PLAN Equipment Department, calls USVs the "most suitable unmanned platform for MCM operations." Wang notes that the PLA is currently upgrading its MCM equipment while "taking steps in the direction of unmanned MCM" and that China currently has "various" unspecified organizations that are developing MCM USVs.[27] In a separate journal article published in 2021, authors from the PLA Naval University of Engineering stressed the need to step up R&D in autonomous technologies for MCM USVs, including autonomous identification and automatic obstacle avoidance technologies.[28] Neither author discusses specific USV manufacturers or platforms under development for the PLAN.

Figure 5. Wozang-class MHS *Kunshan* (now hull number 707) and three remote-controlled Wonang-class craft.[29]

UUVs. Writings by PRC military and civilian subject matter experts demonstrate interest in finding ways to use autonomous UUVs to replace or complement manned MCM operations in order to improve the efficiency and safety (to humans) of related tasks. For example, Wang Song, an engineer and specialist in UUV technology validation at CSSC's No. 710 R&D Institute, noted that desires to "reduce the expenditures of costly platforms and minimize human casualties" had caused many countries to seek means of using UUVs to achieve the "unmanned-ization" (无人化) of operations in mine areas. Wang said that "existing MCM measures" mainly consist of manned surface ships and that going forward, China should "draw lessons from other countries" and accelerate the development of its own UUVs for MCM missions.[30]

The UUVs envisioned by PRC authors for MCM tasks could potentially conduct searches on their own or in groups. With an eye toward the latter, a journal article by engineers from the PLA's Northern Theater Command, Naval Submarine Academy, and an unidentified unit based in Sanya,

[27] 王进 [Wang Jin] and 王慧 [Wang Hui], 反水雷无人艇的发展趋势分析 ["Analysis on Development Trend of MCM Unmanned Surface Vehicle"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], vol. 4, no. 2 (Apr. 2021), pp. 113-116.

[28] 杨全顺 [Yang Quanshun], 尹洋 [Yin Yang], and 陈帅 [Chen Shuai], 基于强化学习的反水雷无人艇局部路径规划 ["Local Path Planning of Mine Countermeasures USV Based on Reinforcement Learning"], 电光与控制 [*Electronics Optics & Control*], no. 7 (2021), pp. 11-12.

[29] "Photo of the day: Type 082II minesweeper and her three little unmanned drones," China Defense Blog, 31 July 2018, http://china-defense.blogspot.com/2018/07/.

[30] Wang, "Discussion on Application of Unmanned Underwater Vehicle in MCM," pp. 260-265.

Hainan Province proposed a means of identifying optimal naval mine search methods for groups of autonomous UUVs. The authors constructed an index system that evaluated the relative effectiveness of four search methods (Z-shape search, Z-shape cross-search, trapezoid search, and orthogonal trapezoid search) according to five factors (detection probability, search time, UUV quantity, grouping method, and ease of implementation). They determined that orthogonal trapezoid search, which U.S. Navy tacticians would call crosshatched parallel track patterns, was the best method for groups of two or more autonomous UUVs conducting coordinated MCM tasks.[31]

PRC writings suggest that the PLAN may be envisioning a future role for autonomous UUVs in MCM missions that extend beyond the First Island Chain. One researcher at the No. 710 Research Institute proposed that minehunting UUVs be developed to offset deficiencies in existing MCM assets' range and be capable of operating "over a long range and in a concealed manner."[32] (The author does not note the potential drawbacks of long-range UUVs, such as their larger sizes and greater costs, which could limit acquisition of greater numbers of smaller, more flexible UUVs.) In a separate article, an engineer from the same institute noted how foreign countries had developed "coastal, near-sea, and mid/far-sea UUVs" for MCM missions and called for drawing lessons from those countries in China's own UUV development.[33]

Potential carrier of unmanned MCM platforms: drone mothership. The *Zhu Hai Yun*, billed by PRC media as "the world's first intelligent unmanned system mother ship," was put into operation on 12 January 2023 at its home port in the southern city of Zhuhai. Although PRC writings have not associated the ship with MCM missions, descriptions and images of the *Zhu Hai Yun* suggest that it could easily be used as an MCM mothership,[34] launching and recovering MCM UUVs, USVs, and/or UAVs. As PRC media reports have put it, the ship, which itself is manned, is intended as a scientific research vessel with remote control and open water autonomous navigation functions.[35]

[31] 高杰 [Gao Jie]，田云飞 [Tian Yunfei]，许莹 [Xu Ying]，初磊 [Chu Lei]，and 程建波 [Cheng Jianbo], 主成分分析法在 UUV 集群反水雷搜索中的应用 ["Application of Principal Component Analysis in MCM Search by UUV Group"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], vol. 5, no. 1 (2022), pp. 6-10.

[32] Zhao, Gong, Ai, and Wang, "Conception of MCM Equipment System in Unmanned Era," pp. 5-7.

[33] Wang, "Discussion on Application of Unmanned Underwater Vehicle in MCM," pp. 264-265.

[34] Instead of manned ships going into the minefield, it is possible to build a larger ship that can handle unmanned or lightly manned systems that can travel from the mother ship to the minefield for MCM work and return for turn-around and planning. The U.S. Navy applied the concept with modest success during Vietnam. The best known example was USS Catskill, designated MCS-1 MCM Support Ship, and the idea of an MCM mother ship became known as the "Catskill Concept." USS Catskill used mainly small helicopters for aerial search and small remotely controlled launches for minesweeping. The launches were unseaworthy in moderate sea states and for that reason the approach was discontinued. But the concept remained with ships like the LCS and the new Belgian-Netherlands MCM ship following the same principle.

[35] "World's 1st Smart Unmanned Vessel Starts Operations in Zhuhai," City of Zhuhai, 16 January 2023, http://www.cityofzhuhai.com/2023-01/16/c_848196.htm.

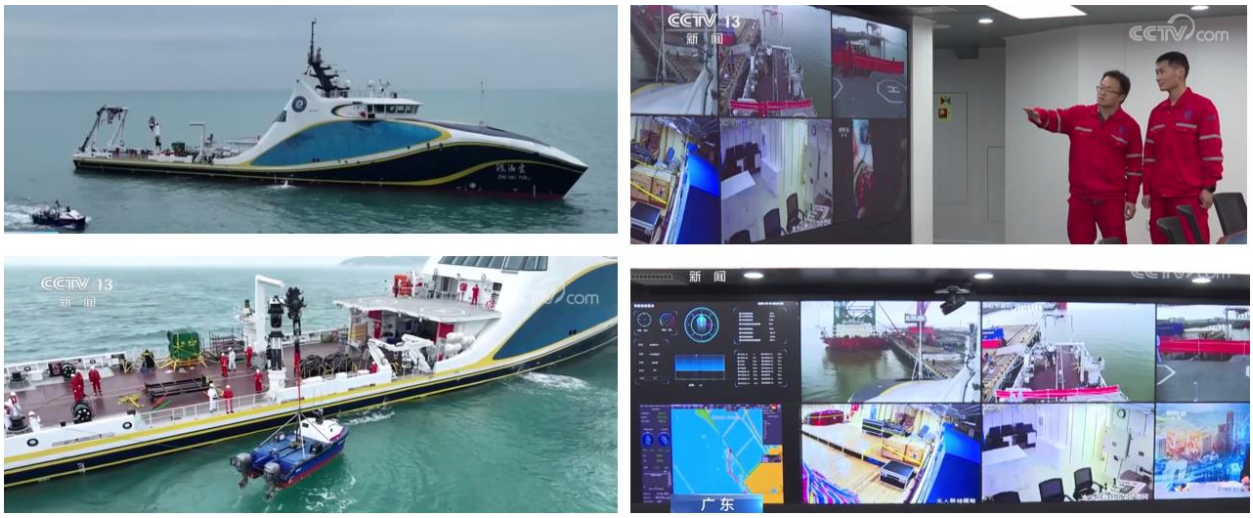


Figure 6. PRC state television reporting on the *Zhu Hai Yun*.[36]

Organic MCM

In the PRC MCM literature, several authors have referred to the need for China to develop more organic MCM capability. A so-called organic MCM capability refers to the equipping of a non-specialized platform (such as destroyers or frigates) with modular equipment to be used for naval mine avoidance or clearing. The objective is for ships to carry out MCM operations quickly under emergency conditions and to have capabilities to detect and clear naval mines, thereby reducing their own casualties to the greatest extent.

Having this capability could be especially important outside the First Island Chain, beyond the range of existing PLAN mine warfare ships. As one PLAN author puts it, during far-seas operations, specialized MCM forces are usually unavailable, so forces must "save themselves" by relying on their own capabilities to counter naval mines.[37]

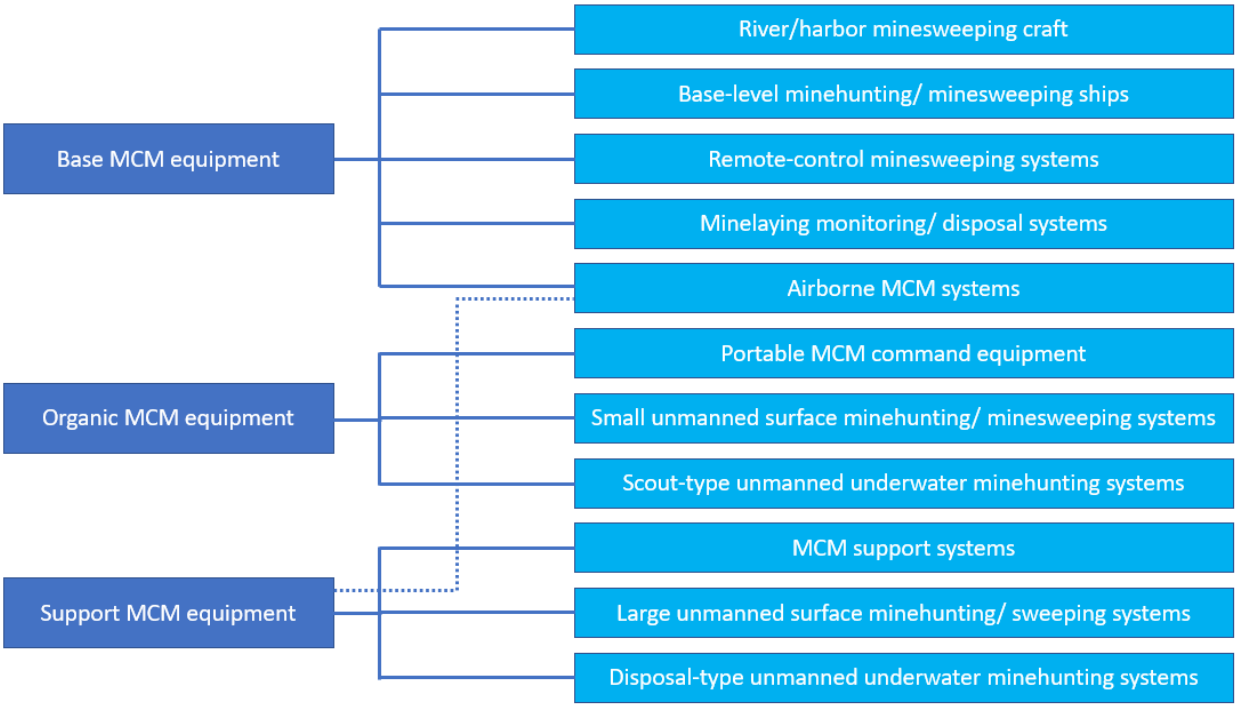
Ships equipped with mine avoidance sensors can detect and avoid mine-like contacts as they transit, so long as the density of mines is not too great. A mine-like object detected well ahead of a ship can be avoided by a turn of a few degrees. ASW sonars can be modified to provide a small object detection mode for objects in the ship's path. Optical and infrared sensors can detect floating mines. An embarked helicopter can search ahead of the ship in areas suspected to be mined, providing aerial visual search and search with other sensors, such as thermal imaging and multi-spectral optics. The common feature for all these techniques is that they use systems that are already available in some form aboard the ship or are small and simple enough to be carried until needed. Figure 7 (below) shows the components of organic MCM equipment in the context of an overall MCM equipment system, based on a 2018 study by experts at the No. 710 Research Institute.

[36] 全球首艘智能型无人系统科考母船"珠海云"交付使用 ["Zhu Hai Yun, The World's First Intelligent Unmanned System Scientific Research Mother Ship, Is Delivered and Put Into Use"], 央视网 [CCTV], 13 January 2021, https://ocean.cctv.com/2023/01/13/ARTImGURU4hHruwlzW5X2BBR230113.shtml.

[37] Heng, Huang, Wang, and Cao, "Discussion on Construction of MCM System," pp. 416-417.

Despite the advocacy for organic MCM capability in PRC writings, the accessible literature does not state that the PLAN has actually been developing related systems for PLAN ships to use in the far seas.

Figure 7. Conception of MCM Equipment System by MCM Researchers at PRC's No. 710 Research Institute[38]



Non-Naval MCM Forces

PLAN MCM capability need not be limited to its own inventory of platforms, equipment, and personnel. Writings by PRC military and civilian subject matter experts contend that the use of non-naval forces, including civilian platforms and personnel, could be used to augment the PLAN's MCM capability and to ensure it can more effectively execute MCM missions in China's near and far seas.

Civilian ships

PLA writings identify civilian ships as an important component of China's planning for future maritime contingencies. Such writings identify MCM as one among many missions that mobilized civilian ships could be called upon to support in the context of large-scale PLA maritime operations. For example, in a 2019 journal article, Colonel Chen Weiguo, a staff officer at the PLA's Shanghai Garrison, stated that coastal regions should organize and prepare civilian ships to support wartime

[38] Although the authors depict "Airborne MCM (AMCM) systems" as a component of "base MCM equipment," we found no evidence in publicly available sources that such systems are currently included within the PLAN MCM order of battle. The author implies—though does not state definitively—that organic MCM capabilities should be employed primarily outside the First Island Chain. Zhao, Gong, Ai, and Wang, "Conception of MCM Equipment System in Unmanned Era," p. 5.

missions including "laying and clearing mines" in addition to transportation and shipping, personnel rescue, and ship repair.[39]

Although PLA writings on civilian ship mobilization often lack specificity on the platforms that would be used for minesweeping or minehunting tasks, they commonly identify the following ship types as those that would be useful in support of military operations in general: roll-on/roll-off (RO/RO) ships, tankers, container ships, bulk freighters, semi-submersibles, and fishing boats.[40]

PRC writings reviewed for this report generally lack specificity on the types of personnel who would operate civilian ships mobilized for MCM tasks. Related personnel could theoretically be "pure" civilians (i.e., crewmembers with no current ties to China's armed forces), members of China's militia forces (namely the maritime militia),[41] or PLA personnel (active or reserve duty) who commandeer civilian ships at a time of need.

Of note, the PLAN established one reserve duty minesweeping squadron in 2005 that operated civilian fishing ships and was reportedly responsible for tasks including MCM reconnaissance and mine clearing.[42] The squadron was located in Ningbo, Zhejiang province and subordinate to the former East Sea Fleet.[43] The absence of PLA writings on the squadron since early 2015, however, suggest that it may have been abolished in the extensive PLA-wide organizational reforms that kicked off at the end of that year.

Civilian Helicopters

One PRC journal article reviewed for this paper discussed in detail the potential for mobilizing civilian helicopters in support of MCM missions. In a 2020 paper, Zhang Wei of the PLA Naval Research Academy presented a case for using civilian helicopters in support of PLAN MCM missions, drawing inspiration from the Royal Navy's Ships Taken Up from Trade (STUFT) program and the U.S. Navy's Craft of Opportunity project, which envisioned commandeering vessels in an area of interest that are capable of carrying small MCM systems such as ROVs. Zhang portrays helicopters as having several advantages over surface ships in MCM execution, including their relative safety from direct contact with naval mines, higher speeds, and greater "efficiency" in completing MCM tasks. Zhang asserts that China has "large numbers" of civilian helicopters in the country (around 1,000) that could be used for MCM missions such as "airborne minesweeping, detection, neutralization, laser detection, and rapid neutralization." The author singles out several

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[39] 陈卫国 [Chen Weiguo], 关于加强濒海地区民船支前动员建设的思考 ["Thoughts on Strengthening the Building of Mobilizing Civilian Ships to Support the Front in Coastal Areas"], 国防 [*National Defense*], no. 12 (2019), p. 65.

[40] Brian Waidelich, Patrick deGategno, Timothy Ditter, and Thomas Bickford, *Chinese Views of Civilian Ship Mobilization*, CNA, November 2021, DSI-2021-U-030614-Final, p. 1, https://www.cna.org/reports/2021/11/chinese-views-of-civilian-ship-mobilization.

[41] We noted some evidence in pre-2010 PRC writings of militia units being involved in MCM training. See for example 朱明江 [Zhu Mingjiang] and 陈道凡 [Chen Daofan], 海南省军区着力提升民兵反水雷、反潜能力 ["Hainan Provincial Military District Strives to Increase Militia's MCM, ASW Capabilities"], 国防 [*National Defense*], no. 6 (2008), p. 27.

[42] 敬小红 [Jing Xiaohong] and 伍尚锐 [Wu Shangrui], 东海渔船建预备役扫雷部队 曾助海军应对异常 ["East China Sea Fishing Ships Build Reserve Minesweeping Unit, Strengthen Navy's Response to Anomalies"], 中国国防部 [*China Defense News*], 11 March 2015, https://www.chinanews.com.cn/mil/2015/03-11/7119110.shtml.

The authors would like to thank Conor Kennedy for drawing their attention to this article.

[43] 走进中国人民解放军海军预备役部队 ["Enter Into the PLA Navy Reserve Forces"], 中国军网 [*China Military Online*], 12 March 2015, http://www.81.cn/jmbl/2015-03/12/content_6390764_2.htm.

types of civilian helicopters operated in China—the AC313, Mi-17/171, and Mi-26—as being particularly suited for MCM due to these platforms' comparatively high lift capacity (over four tons), towing power, and endurance.[44]

Zhang's focus on lift capacity is understandable given that helicopters must be rather large in order to support mine clearing operations that make use of equipment such as tow sweeps. Unless helicopters are capable (and willing) to tow, the main advantages of airborne MCM are the ability to operate safely in mined areas and to search ahead of ships transiting potentially mined areas. Helicopters can complete MCM support tasks on an ad hoc basis through means such as aerial visual search for mines, Forward-Looking Infra-Red (FLIR) sensors, and lowering divers into the water for mine neutralization.

Civilian-Operated Unmanned Platforms

Various journal articles reviewed by PRC subject matter experts discuss the potential of incorporating USVs and UUVs into future MCM operations.[45] Authors of related articles often do not specify the organizations to which such USVs or UUVs would pertain, inviting the possibility that the PLA could make use of mobilized government or commercial unmanned platforms in support of MCM tasks. For example, a small minehunting UUV can be carried onboard a civilian vessel and used to search areas suspected of being mined. Mines found can be neutralized using ROVs. Both systems are small enough to be carried as ancillary equipment.

At least one PRC company has recently advertised a UUV as having MCM capability.[46] The website of Xi'an Tianhe Defense Technology Co., Ltd. has a page with a short description of a "medium UUV" that the company says is capable of various civilian applications as well as certain military missions, including "naval mine detection." The webpage does not specify whether the UUV has been sold to or tested by the PLAN or any other users.[47]

Missions of Non-Naval Forces

PRC writings portray MCM support missions as a natural avenue of civil-military cooperation that builds upon decades of past practice. Heng Hui, a lecturer at the PLA's Naval Submarine Academy, argued in a 2020 article that China's MCM operations have "always been inextricably tied to people's warfare" and that China should build on this foundation to develop "auxiliary MCM forces" that include "local enterprises and military reserve forces."[48] Heng did not specify whether any forces of this nature were currently in existence.

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[44] 张炜 [Zhang Wei]，张修志 [Zhang Xiuzhi]，and 王久法 [Wang Jiufa], 民用直升机在反水雷中的应用探讨["An Examination of the Use of Civil Helicopters in Mine Countermeasure Operations"], 数字海洋与水下攻防[*Digital Ocean & Underwater Warfare*], vol. 3, no. 5 (October 2020), pp. 367-371.

[45] Representative articles include Wang, "Discussion on Application of Unmanned Underwater Vehicle in MCM," pp. 260-265, Wang and Wang, "Analysis on Development Trend of MCM Unmanned Surface Vehicle," pp. 113-116, and Yang, Yin, and Chen, "Local Path Planning of Mine Countermeasures USV Based on Reinforcement Learning," pp. 11-15.

[46] The authors would like to credit Amanda Kerrigan and Alexander Stephenson for this observation.

[47] 中型水下航行器 ["Medium Unmanned Underwater Vehicle"], 西安天和防务技术股份有限公司 [Xi'an Tianhe Defense Technology Co., Ltd.], accessed 16 April 2023, http://www.thtw.com.cn/product/48.html.

[48] Heng, Huang, Wang, and Cao, "Discussion on Construction of MCM System," pp. 416-417.

A logical civil-military cooperation for MCM would be to use fishing craft to perform MCM functions, such as dragging nets to scoop up mines on the bottom, towing wire sweeps, or operating small boats remotely to detonate mines. The British used many fishing craft for MCM during WWI. Other supporting equipment might include commandeered platforms to support AMCM or diver operations, work boats for launching and recovering UUVs and ROVs, and larger vessels to provide fuel, sweep gear, and other materials to any and all MCM forces.

PRC authors envision a range of MCM tasks that non-naval personnel and platforms could potentially support. Chen Wenchao, an MCM specialist and graduate student at PLA Dalian Naval Academy, argued that unspecified types of civilian ships could be used as covert carriers of MCM UUVs, an application they claimed was a "blank slate" or untested. Chen said that civilian ships could be used to "slip into" a sensitive maritime area and release a UUV to collect intelligence, serve as communications relays between naval ships and unmanned platforms, or conduct other surreptitious MCM tasks. The advantage of civilian ships in this regard, argued Chen, was that they could draw close to an enemy mine area during conditions in which it would be difficult to do so with military ships or aircraft, such as times of heightened political tensions or when an enemy force was exerting control over the area in question.[49]

Heng Hui contended that civilians and reservists in the proposed "auxiliary MCM forces" should be trained and equipped to perform operations focused on preventing enemy minelaying or responding to its aftermath, to include reconnaissance, monitoring, camouflage, salvage and rescue, and shipping.[50] This auxiliary is analogous to the U.S. Navy's Craft of Opportunity program that was temporarily manned by Reservists. Training craft were requisitioned and used for training for a brief period. The U.S. Navy and Coast Guard conducted cross-department exercises with civilian law enforcement agencies in the late 2000s to prepare for terrorist events that included mining.

Missions Not Discussed in PRC writings

One potential application of civilian ships that we did not observe in PRC writings on MCM is that of "Guinea Pigs." Guinea Pigs are typically large, but low-value, hulls of opportunity that happen to be available near the mined area and that can be driven through minefields to detonate mines. If time permits, a Guinea Pig can be modified to protect the crew, to drive the ship remotely, and/or to provide additional buoyancy to the hull. A Guinea Pig is typically operated by a skeleton crew strapped into a secure bridge. Guinea Pigs have the advantages that they can sweep pressure mines and require no prior preparation in order to serve the Guinea Pig function in wartime. A Guinea Pig typically detonates one mine, but with added buoyancy, it may detonate two or more before becoming inoperative. (A common saying in the mine force is that "Every ship is a minesweeper once.") To break out of a harbor, it is necessary to clear only a channel. Not all mines need be cleared immediately after the mining event. For narrow choke points, it is important to ensure that a damaged Guinea Pig does not block the channel. For this reason, Guinea Pigs may be accompanied by tugs that can push the ship out of the channel before it sinks. Preparation of Guinea Pigs can be made part of a Craft of Opportunity-like program.

[49] 陈文超 [Chen Wenchao]，张旭 [Zhang Xu]，and 欧阳博文 [Ouyang Bowen], 信息化条件下无人反水雷作战的探讨 ["Discussion of Unmanned MCM Operations Under Informatized Conditions"], 科技视界 [*Science & Technology Vision*], no. 23 (2021), p. 84.

[50] Heng, Huang, Wang, and Cao, "Discussion on Construction of MCM System," pp. 416-417.

PLAN MCM Training

PRC media reports indicate that PLAN MCM forces engage in a variety of training activities. The most complex exercises and training, which include opposing forces exercises, are conducted with other PLAN surface, subsurface, and airborne units, with PLA Air Force (PLAAF) assets serving as simulated adversaries.[51] To at least a limited degree, PLAN MCM squadrons engage in training activities with civilian ships, although it is unclear from related reporting how civilian ships are used (if at all) for minesweeping or clearing tasks. PRC media has also reported several examples of the PLAN conducting simple mine warfare exercises with the navies of Russia and Singapore.

Training with the PLAN

The PLAN conducts opposing force MCM drills aimed at improving the MCM forces' ability to conduct minesweeping and minehunting tasks under conditions resembling actual combat. For example, a September 2021 *PLA Daily* report described a "recent" MCM drill conducted by an unspecified base of the Southern Theater Command Navy in which MCM troops sought to clear a mine threat while facing "enemy" aircraft harassment. During the drill, the red force (i.e., PLAN) command post dispatched a frigate formation to provide air defense for the MCM ships, which in turn released an ROV that neutralized multiple blue-force (i.e., enemy) naval mines.[52]

One notable PLAN MCM training event in terms of its scale was the "'Bravery Cup' naval mine warfare competitive evaluation" ("勇敢杯"水雷战竞赛考核) in 2018 that incorporated dozens of ships from minesweeping squadrons of the Northern, Eastern, and Southern Theater Command Navies.[53] In this opposing force training activity, PLAAF bombers "covertly" dropped mines into an unspecified area of the East China Sea, and MCM forces were tasked with identifying and clearing mine obstacles. The minesweeping squadrons were split up into multiple "MCM operations groups" and reportedly "swept and hunted nearly 20 mines of various types."[54] Although "Bravery Cup" was described in PRC media reports as an inaugural event, we did not observe reporting to indicate that it has been carried out since.

More recent PRC media reporting on PLAN training has drawn attention to efforts to improve "manned/ unmanned coordination" (有人无人协同) in MCM operations. For example, a July 2023 PRC state media report claimed that a minesweeping squadron of the Northern Theater Command Navy was exploring a new MCM operational mode that employed manned and unmanned platforms task-organized for mine reconnaissance, sweeping, hunting, and clearing. The media report showed footage of related drills that involved the *Huimin* (probably a Wozang-class MHS, though not identified as such), at least one shipborne ROV, two unmanned Wonang-class MSI craft, and two smaller craft carrying naval divers. During the drills, MSI craft operated in a column formation ahead

[51] Despite the inclusion of PLAAF assets, these should not be viewed as examples of joint training, as PLAN and PLAAF assets act in opposition of each other rather than coordinate their actions toward broader operational objectives.

[52] 王栋 [Wang Dong] and 郭兴 [Guo Xing], 南部战区海军某基地扫雷演练嵌入实战背景 ["Unidentified Base of Southern Theater Command Navy Inserts Warfighting Backdrop in Minesweeping Drill"], 解放军报 [*PLA Daily*], 13 September 2021, http://www.81.cn/jfjbmap/content/2021-09/13/content_298975.htm.

[53] 海军"勇敢杯"水雷战竞赛考核结束 ["Navy's 'Bravery Cup' Naval Mine Warfare Competitive Evaluation Concludes"], CCTV, 18 June 2018, http://news.cctv.com/2018/06/18/ARTIPrOSs46Aoy0NzwD06o3U180618.shtml.

[54] 张天南 [Zhang Tiannan], 海军首次举行水雷战竞赛性考核 ["Navy Carries Out First Naval Mine Warfare Competitive Evaluation"], 解放军报 [*PLA Daily*], 17 June 2018, http://www.81.cn/jfjbmap/content/2018-06/17/content_208771.htm.

of *Huimin* to conduct "preliminary detection" of underwater mines (possibly simulated), and mines were "cleared" by the ROV and naval divers. (See Figure 8 below.)[55]

Training with MCM forces need not focus exclusively on naval mines. For example, in early 2021, four ships from a minesweeper squadron of the Southern Theater Command Navy kicked off a five-day training period in the South China Sea with fires against a simulated enemy surface combatant (the Wochi- and Wozang-class ships that participated are equipped with 25-37 mm guns). It was reportedly only after the "enemy" ship was struck that the minesweeping squadron detected nearby floating mines and targeted them with naval artillery rounds.[56] This type of training suggests that the PLAN may be preparing to use its minesweeping squadrons for a broader range of missions than hunting and sweeping mines.

Figure 8. PRC state media reporting on PLAN MCM manned/ unmanned coordination drills.[57]

Training with Civilian Assets

Active duty PLAN units appear to conduct some MCM training with civilian assets—namely civilian ships—but it is unclear from related reporting how frequently such training occurs, the roles which civilian assets play, and who crews those assets. For example, a July 2018 *PLA Daily* report described how a naval base of the Southern Theater Command Navy organized an opposing forces drill that involved "more than 10 military and local civilian units" and which included "offensive mine-laying and minesweeping operations," among other training topics. The only civilian entity named in the report was a local branch of the Maritime Safety Administration (a PRC government agency responsible for tasks including maritime search and rescue) and did not specify whether civilian assets were involved in minesweeping drills.[58]

Combined Training with Foreign Militaries

The PLAN has conducted MCM drills with at least two foreign forces in recent years, including Singapore and Russia.

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[55] 深化练兵备战 加快转型建设 协同训练 探索反水雷作战新模式 ["Intensify Training and Combat Readiness, Accelerate Transformative Building, Coordinate Training, Explore a New Mode of Mine Countermeasures Operations"], 军事报道 [*Military Report*], CCTV-7, 11 July 2023, https://tv.cctv.com/2023/07/11/VIDEQYn1vf1GciNtjivEBzqv230711.shtml?spm=C52346.PiumOrlYLNUM.E0VXtwLj8YU7.14.

[56] Wan, "Training Troops in the South China Sea! Multiple Types of Minesweeping Ships Fight Bravely Across Five Days and Nights."

[57] *Military Report.*

[58] 刘鑫 [Liu Xin] and 潘小员 [Pan Xiaoyuan], 南部战区海军某基地组织防卫作战演练 ["Naval Base of the Southern Theater Command Navy Organizes Defensive Operations Drills"], 解放军报 [*PLA Daily*], 14 July 2018, http://www.81.cn/jfjbmap/content/2018-07/14/content_210908.htm.

Singapore. From 28 April to 1 May 2023, the PLAN and Singaporean Navy (RSN) included MCM topics in the second iteration of their bilateral exercise Maritime Cooperation. Each side sent one mine warfare ship to the exercise, namely the PLAN's Wozang-class MHS *Chibi* and the Singaporean Navy's Bedok-class Mine Countermeasure Vessel RSS *Punggol*. Official readouts from the exercise stated that the two sides had conducted "simulated minefield transits," without further elaboration. [59] One photo of the exercise released by the PLAN suggests that the mine warfare ships may have been exercising the use of sonar to detect and avoid moored mines, with value ships in their wake (see Figure 9 below).

Figure 9. PLAN and RSN vessels participate in Maritime Cooperation 2023.[60]

Russia. The PLAN has conducted relatively simple MCM training with the Russian Navy. For example, combined drills carried out between the two navies during exercise Vostok 2022 saw several surface combatants on each side "destroying floating mines" in the Sea of Japan.[61] The focus on floating mines—easier to detect and neutralize than mines below the water's surface—is understandable given that reports did not identify participation of specialized mine warfare ships and craft from either side.

Use of Simulated Training Systems

One journal article reviewed for this report included a discussion of the PLAN's development and use of MCM simulation training systems. Writing in 2019, Yang Zhenyu, an engineer and undersea warfare expert at the PLA Naval Research Academy, noted that MCM simulated training systems had become a "hotspot" in domestic research in "recent years" given their cost-saving and safety-enhancing benefits. As Yang argued, MCM forces must prepare to counter "increasingly high-tech,

[59] The first iteration of Maritime Cooperation, held in 2015, did not appear to include MCM topics, based on official statements and media reporting. "Singapore and Chinese Navies Strengthen Maritime Cooperation in Maritime Bilateral Exercise," MINDEF Singapore, 1 May 2023, https://www.mindef.gov.sg/web/portal/mindef/news-and-events/latest-releases/article-detail/2023/May/01may23_nr.

[60] "中新合作-2023"海上联合演习圆满结束 ["Combined Maritime Exercise 'Maritime Cooperation 2023' Successfully Conclude"], 央广网 [China National Radio], 2 May 2023, https://news.cnr.cn/native/gd/20230502/t20230502_526238448.shtml.

[61] "Vostok-2022: Joint Live-Fire Drill Kicks Off," *China Military Online*, 5 September 2022, http://eng.chinamil.com.cn/view/2022-09/05/content_10182716.htm.

precise, and sharp weapons," which makes setting up training with actual equipment "very costly" and "complex," and also carries "rather high safety risks."[62]

Yang Zhenyu cited several examples of MCM simulation systems that had been developed or proposed by PLA and civilian academic and research institutions. One was "naval mine/MCM weapons simulation confrontation software" that had been jointly developed by Huazhong University of Science and Technology and the PLA National University of Defense Technology. The simulation training system supported by the software included "actual objects" such as naval mine fuzes and simulated components such as mine warfare ships and "various types of naval mines." Yang also cited examples of domestic academic research proposing new types of MCM simulation systems, including a "naval mine battlefield environment simulation system" proposed by authors from the Naval Bengbu NCO School, who sought to simulate marine environmental variables such as tides, currents, sea temperature and salinity, and water transparency.[63] Yang's article did not specify whether this simulation system had been developed and put into use.

Issues in PLAN MCM Training

PRC writings on the PLAN's MCM training identified several shortcomings and areas for improvement. These include a lack of realistic simulation training equipment to prepare MCM personnel for real-world tasks and a lack of civilian ships built to national defense standards that could ostensibly be used for MCM missions.

Simulation training problems. Two articles in technical journals by PLAN-affiliated authors contend that the PLAN's existing simulation training systems are insufficient in number and do not adequately represent real-world conditions. Heng Hui of the PLA Naval Submarine Academy calls for "greatly expanding investments" in "support equipment" for MCM training, to include the establishment of new "MCM simulation training rooms and teaching rooms."[64] In a more detailed assessment, Yang Zhenyu of the PLA Naval Research Academy argues that shortcomings in systems design and integration of key technologies is holding back the level of realism in the PLAN's MCM simulation training systems. Yang identifies three types of key technologies that should be incorporated in the design of future systems: (1) virtual reality technology; (2) embedded technology, which the author defines as the integration of "actual objects of weapons and equipment such as MCM consoles and naval mine fuzes" into simulated training systems; and (3) "comprehensive battlefield simulation technology," to include means for simulating electronic, electromagnetic, and acoustic jamming.[65]

Lack of suitable civilian ships. Inadequate training is one among several issues that could limit China's ability to mobilize civilian ships in support of MCM missions. PLA-affiliated authors have noted that few civilian ships to date have been built to national defense standards to make them suitable for military operations, and little routine training has been done with civilian ships apart

[62] 杨振宇 [Yang Zhenyu] and 唐君超杰 [Tang Junchaojie], 国内外反水雷装备模拟训练系统综述 ["Review of Mine Countermeasures Simulation Training Systems at Home and Abroad"], 数字海洋与水下攻防 [*Digital Ocean & Underwater Warfare*], no. 4 (October 2019), p. 50.

[63] Ibid., pp. 52-53. For the article referenced by Yang from authors at the Naval Bengbu NCO School, see 李鸿雁 [Li Hongyan]，周开华 [Zhou Kaihua], and 李志华 [Li Zhihua] 水雷战场环境仿真系统 ["Mine Battlefield Environment Simulation System"], 水雷战与舰船防护 [*Mine Warfare & Ship Self-Defence*], vol. 23, no. 4 (2015), pp. 31-34.

[64] Heng, Huang, Wang, and Cao, "Discussion on Construction of MCM System," p. 419.

[65] Yang and Tang, "Review of Mine Countermeasures Simulation Training Systems at Home and Abroad," pp. 52-53.

from practicing the transport of military personnel and equipment. Furthermore, PLA subject matter experts have suggested that sealift is the most important task for civilian ships in military operations and that they may be used primarily toward this end.[66]

Conclusion

The PLAN's General View of MCM

PRC military and civilian authors offer rather bleak assessments of the PLAN's existing capability to neutralize enemy mine threats, particularly as the PLAN operates at greater distances from mainland China. As Hu Ce, an author from the No. 710 Research Institute put it, a naval blockade could stress the PLAN's existing MCM capability to the point that "the survivability and operations of the Chinese Navy's forces would be seriously challenged" and that "the national economy and *even the strategic overall situation could be affected*" (emphasis added).[67] A senior engineer from the PLAN's Yichang Area Military Representative Office, emphasized the near seas-centric role of existing PLAN MCM forces, stressing that they are "seriously inadequate [for] supporting mid- and far seas protection operations."[68]

Despite PRC authors' self-acknowledged shortcomings, a comparison with past Western analyses of PLAN MCM capability demonstrates that the PLAN has in some respects made progress in fielding more advanced MCM platforms and equipment. PRC military and civilian subject matter experts have also advocated for advancements in a variety of unmanned MCM capabilities and the integration of civilian assets, although little or no evidence of progress in these areas has been observed in publicly available sources. We summarize related developments since 2010 in Table 2 below.

[66] Waidelich, deGategno, Ditter, and Bickford, *Chinese Views of Civilian Ship Mobilization*, p. 2.

[67] Hu, Sun, and Zhang, "A System and Method of Cooperative MCM Based on Unmanned Platform," pp. 15-16.

[68] Ni, Zhao, Guan, and Ai, "Discussion of Capacity Building of Our Country's MCM Support Ships," pp. 1-2.

Table 2. Summary of PLAN MCM Progress by Capability Type Since 2010

NOTE: Yellow highlighting denotes capabilities with the most apparent improvement

MCM Capability	Trend since 2010
MCM Vessels	Modest improvement with approximately 60 manned and unmanned craft. New variant of Wochi-class MCM ships added in 2012. Most vessels are sweepers, as opposed to hunters.
ROVs	Larger, more robust ROVs with demonstrated explosive neutralization.
UUVs	No apparent capability, but PRC experts are interested in developing MCM UUVs as organic systems capable of operating outside the First Island Chain.
USVs	Addition of *Wonang* craft since 2010; these craft are remotely controlled in a manner similar to the German Troika remote sweepers.
Mother Ships	PRC mother ships can support unmanned systems, but no known mother ship is assigned an MCM function.
Sweep Gear	Influence sweep gear appears modern—no novel devices noted.
Military Helicopters	No statements that AMCM systems exist, although one author listed AMCM as current "base" equipment.
Organic MCM	Advocacy only: no PRC author states that organic MCM is in development.
Civilian Helicopters	Advocacy for commandeering civilian helicopters.
Civilian Water Craft	Advocacy, but limited evidence that the PLAN has exercised this capability, particularly since 2015.

Autonomous Platforms

There is much advocacy in PRC writings for the integration of military or civilian autonomous platforms, including USVs and UUVs, for MCM operations. Apart from the PLAN's existing Wonang-class remotely-controlled craft, however, we saw no evidence of the PLAN fielding such platforms for MCM purposes or bringing analogous civilian platforms in for demonstrations or training exercises.

Conventional Minehunting

The press has noted that Chinese MCM ships are not modern ships made from fiberglass, as are Western MCM ships, and that emphasis has been placed on mine sweeping over mine hunting. With China's technical skill in automation and with the emphasis in PRC writings on increasing the use of unmanned platforms throughout the force, it seems plausible that in the future the PLAN may skip further development of conventional minehunting and go directly to highly automated unmanned minehunting.

Range of Operations

What is publicly known about the capabilities and ranges of PLAN MCM ships and craft, coupled with accounts of their shortcomings by PRC authors, suggests that current MCM craft must operate relatively close to mainland bases. They may lack the ability to achieve full coverage of waters within the First Island Chain.

Organic MCM

One PRC author claims it is especially important for the PLAN to have "organic MCM" capabilities for "far-seas missions," i.e., for PLAN missions outside the First Island Chain in which dedicated MCM platforms are less likely to be available. As they pointed out, during far-seas operations, specialized MCM forces are usually unavailable, so forces must "save themselves" by relying on their own capabilities to counter naval mines.[69] However, it has not been explicitly stated in the literature that the PLAN has been developing systems for organic MCM for ships in the far seas. PRC media reviewed for this report did show examples of PLAN destroyers or frigates conducting MCM training, but this was limited to relatively simple fires against floating mines.

Use of Civilian Assets

PRC writings portray MCM support missions as a natural avenue of civil-military cooperation that builds upon decades of past practice. However, the writings did not reference recent examples of the actual use or training in the use of non-PLAN platforms. A logical civil-military cooperation for MCM would be to use fishing craft to perform MCM functions, as the British did in World War I. Civilian ships are available that could tend multiple unmanned systems as mother ships, but PRC civilian and military authors have not stated any intention of using mother ships, military or otherwise, for mine countermeasures. PLA-affiliated authors have noted that few civilian ships to date have been built to national defense standards. There are advocates within the Chinese MCM community for using civilian helicopters; but again, PRC writings have not mentioned any intention to use them.

Training

The spotty and often vague nature of PRC media reporting on PLAN training makes it difficult to generalize about PLAN MCM forces' levels of capability and readiness. What is clear from PRC subject matter experts' writings is that they find the state of training to be less than ideal and believe that improvements need to be made. One such area for improvement is simulation training, in which organizations throughout the PLA have been making investments in recent years.[70] As one PLAN engineer argued, better MCM simulation training is necessary given the increasingly high costs and risks of conducting training with modern MCM assets and high-tech naval mines.[71] Despite the advocacy, it is unclear whether PLAN leaders have the budget or inclination to build such training systems for MCM forces. Although the PLA as a whole continues to enjoy annual budget increases—7.2 percent in 2023—decision-makers are also likely facing hard budgetary choices as they commission more advanced capabilities, like aircraft carriers, and seek to use monetary incentives to improve retention and professionalism of the force.

Comparison with the U.S. Navy

Some parallels exist between the PLAN and the U.S. Navy in their attitudes toward mine warfare. In both cases, MCM is at the bottom of the priority list for assignments and careers. As a PLAN ditty begins, "if you get on a ship, don't get on a minesweeping ship."[72] In both services, there are advocates for needed MCM capabilities, but little action is taken beyond the building of hulls.

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[69] Heng, Huang, Wang, and Cao, "Discussion on Construction of MCM System," pp. 416-417.

[70] Kevin McCauley, "China's PLA Increasing Use of Simulators and Simulations," *OE Watch*, no. 5 (2022), pp. 4-5.

[71] Yang and Tang, "Review of Mine Countermeasures Simulation Training Systems at Home and Abroad," p. 50.

[72] Gao, "A Master Sergeant Class One's 26 Work Journals."

The main contrast between the U.S. Navy and PLAN is in the placement of their MCM assets: the U.S. Navy stations its MCM assets forward to protect the fleet, whereas the PLAN stations its assets at home to protect waters within the First Island Chain. This could change in the future as the PLA develops its existing base in Djibouti and expands its military footprint in other countries. Another difference between the two militaries is that the PLAN recognizes MCM as one of its major challenges—with some authors calling it the greatest challenge—whereas the U.S. Navy seems relatively unconcerned, especially in terms of protecting CONUS ports.

About the Authors

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A former Air Force navigator, George Pollitt began work in mine countermeasures (MCM) in 1971 as Technical Agent for the Mine Neutralization Vehicle System at the Naval Ship Engineering Center. He programmed MCM tactical decision aids for OPERATION END SWEEP, the clearing of mines in Haiphong, and developed MCM tactics in Panama City, FL before transferring to the Commander Mine Warfare (COMINEWARCOM) Staff, where he worked as an MCM analyst, Advisor for Research and Analysis, and Technical Director. He participated in OPERATION EARNEST WILL, the Tanker War, testing systems in the Persian Gulf to enable warships to detect mines, and he analyzed the DESERT STORM Clean-Up Operation on scene for Commander Middle Eastern Forces. At the Johns Hopkins University Applied Physics Laboratory, he led studies on MCM platforms and systems and the Maritime 9-11 Study. Most recently he evaluated the MK 18 Mine hunting UUV system as the Independent Test and Evaluation Agent. George has an ME in Aerospace Engineering from the University of Florida and a BS in Mechanical Engineering from the University of Central Florida.

This report reflects the personal views of the authors and not the official assessments of the U.S. Navy or any other entity of the U.S. Government.