Testimony

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Maintaining the Edge?

The People's Liberation Army's Logistics and Maintenance Lessons Learned and Approaches Relevant for Counterintervention

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Maintaining the Edge? The People's Liberation Army's Logistics and Maintenance Lessons Learned and Approaches Relevant for Counterintervention

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In the event of a high-end contingency involving the People's Republic of China, the United States, and Indo-Pacific allies and partners, the ability of the People's Liberation Army (PLA) to project and sustain combat power beyond the Chinese mainland will depend on its logistics capabilities, systems, and processes. In particular, understanding the PLA's approach to maintenance management, a subfunction of logistics, is essential in assessing the PLA's ability to sustain its rapidly modernizing force in a potential conflict.[3]

After first noting the important role that logistics and maintenance play in the PLA's systems-of-systems thinking, this testimony will then examine key drivers of PLA logistics reforms to understand the lessons learned that the PLA has applied in modernizing its logistics capability. Because many elements of the Chinese military logistics system are not well understood, this testimony next focuses on assessing the PLA's approach to maintenance as one component of logistics and sustainment activities necessary to support the PLA's

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[3] This testimony draws on Joslyn Fleming, Cristina L. Garafola, Elisa Yoshiara, Sale Lilly, and Alexis Dale-Huang, *Kicking the Tires? The People's Liberation Army's Approach to Maintenance Management,* RAND Corporation, RR-A1995-1, 2023, https://www.rand.org/pubs/research_reports/RRA1995-1.html. The author thanks Nathan Beauchamp-Mustafaga, Joslyn Fleming, and Edmund Burke for their review and feedback on this testimony.

counterintervention efforts. The conclusion will focus on implications and recommendations for Congress and the broader federal government to consider.

Logistics and Maintenance Assessed as Integral to PLA Systems-of-Systems Confrontation

The PLA views logistics and maintenance as integral components of its approach to *systems-of-systems thinking* and *systems confrontation*—the foundational concepts by which the PLA seeks to organize and execute modern warfare to prevail against opponents.[4] Two dynamics regarding the PLA's approach to logistics and maintenance requirements, strengths, and weaknesses are particularly relevant for assessing implications for counterintervention and other high-end contingencies in the Indo-Pacific. By *counterintervention*, I mean PLA operations to defeat third-party intervention against a Chinese campaign or campaigns, such as by the United States and/or its allies and partners on behalf of Taiwan.[5]

First, the U.S. doctrinal approach to logistics and sustainment takes as a precondition that the likely requirement of most contingencies is to project power globally. The U.S. Department of Defense (DoD) defines *logistics* as "[p]lanning and executing the movement and support of forces," and *sustainment* as "[t]he provision of logistics and personnel services required to maintain and prolong operations until successful mission accomplishment."[6] Together, these two concepts provide options for commanders by facilitating the global deployment—and redeployment if necessary—of armed forces to fulfill military objectives.[7] As this testimony will discuss, however, current expectations for PLA logistics capabilities differ in that the PLA is not expected to deploy or fight globally for key contingencies but rather to support and sustain fighting to achieve the Chinese Communist Party's (CCP's) objectives on China's periphery.

Second, many of the PLA's logistics subfunctions are important enablers for high-end contingencies but remain understudied to date. Maintenance, however, has been the subject of recent research. The PLA's approach to maintenance is crucial in the broader context of PLA logistics and sustainment capabilities. This is because the PLA's rapid force modernization, combined with its lack of recent combat experience, means that its ability to conduct maintenance to sustain a high-end fight is not battle-tested. Authoritative PLA sources evince concern on this point. Regarding maintenance and support capability for high-technology weapons and equipment, one 2020 professional military education textbook states that "most of our new weapons and equipment have not been tested in actual combat, and under harsh battlefield conditions may have a higher failure rate." The textbook concludes that "it is

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[4] I thank Joel Wuthnow for raising this point. For more information on the role of the support system within the PLA's system-of-systems thinking, see Jeffrey Engstrom, *Systems Confrontation and System Destruction Warfare: How the Chinese People's Liberation Army Seeks to Wage Modern Warfare*, RAND Corporation, RR-1708-OSD, 2018, https://www.rand.org/pubs/research_reports/RR1708.html.

[5] For more discussion of counterintervention, see Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China*, DoD, 2023.

[6] DoD, *DOD Dictionary of Military and Associated Terms*, November 2021, pp. 132, 206.

[7] Joint Chiefs of Staff, *Joint Logistics*, Joint Publication 4-0, July 20, 2023, p. ix.

necessary to further strengthen the construction of equipment maintenance support teams, conduct targeted professional training and comprehensive drills, and effectively enhance the battlefield repair capabilities of high-tech weapons and equipment."[8]

PLA Lessons Learned and Reforms Likely Shape Current Logistics and Maintenance Requirements Relevant for High-End Contingencies

In line with the above statements, the PLA has long recognized weaknesses in its approach to logistics. Three key lessons learned spurred a 10-year effort begun in 1998 to reform the PLA's organization and approach to logistics and continue to shape its approach to improving relevant capabilities today.[9] The first driver of these reforms is PLA self-assessments of the logistics challenges it encountered during conflicts fought between the 1930s and the 1970s. During World War II and the Chinese Civil War, the infantry-centric PLA was sometimes able to compensate for the lack of a production base and logistics system through the capture of weapons and supplies from enemy forces and the seizure of food from local peasants. CCP leaders, including Mao Zedong, recognized the latter was particularly unpopular with the public, and, subsequently, military units adopted self-sufficiency measures to reduce these demands by growing crops and raising animals—roles Mao described as having "an army for fighting as well as an army for labor."[10] However, these roles detracted from the PLA's combat capabilities in subsequent conflicts, particularly during the Cultural Revolution, when self-sufficiency activities were at their peak and some PLA units were even deployed domestically to support factional struggles among China's top leaders. The time and effort spent on these activities degraded units' efforts to build and sustain operational capability.

Major logistics challenges emerged in key conflicts, such as the Korean War, including an understaffed regional logistics command; repeated American air raids on materiel storage stations, rail lines, and road networks that disrupted Chinese supply truck movements; inexperienced logistics officers and truck drivers; and rapidly lengthening supply lines, a particular challenge for maintenance.[11] Compensatory approaches, such as borrowing food and

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[8] Xiao Tianliang [肖天亮], ed., *Science of Military Strategy* [战略学], National Defense University Press [国防大学出版社], 2020, p. 443.

[9] Although China attempted to reform the structure of the PLA's logistics forces prior to 1998, Western analysts have argued that the military reforms that began under Jiang Zemin in 1998 were "a necessary precursor to real joint logistics command integration" (LeighAnn Luce and Erin Richter, "Handling Logistics in a Reformed PLA: The Long March Toward Joint Logistics," in Phillip C. Saunders, Arthur S. Ding, Andrew Scobell, Andrew N. D. Yang, and Joel Wuthnow, eds., *Chairman Xi Remakes the PLA: Assessing Chinese Military Reforms*, National Defense University Press, 2019, p. 262).

[10] As quoted in Dennis J. Blasko, "PLA Ground Forces Lessons Learned: Experience and Theory," in Laurie Burkitt, Andrew Scobell, and Larry M. Wortzel, eds., *The Lessons of History: The Chinese People's Liberation Army at 75*, Strategic Studies Institute, July 2003, p. 64.

[11] Hong Xuezhi, "The CPVF's Combat and Logistics," in Xiaobing Li, Allan R. Millett, and Bin Yu, eds., *Mao's Generals Remember Korea*, University Press of Kansas, 2001, pp. 123–130. See also John J. Tkacik, Jr., "From Surprise to Stalemate: What the People's Liberation Army Learned from the Korean War—A Half-Century Later," in Burkitt, Scobell, and Wortzel, eds., 2003, p. 305.

grain from the local Korean populace, failed in conflict zones that were already devastated by the war. During the 1979 Sino-Vietnamese War, of course, the PLA could not requisition supplies in hostile territory, and fighting units faced significant food and water shortages despite logistics forces spending months preparing for the invasion.[12] The inability of the PLA's logistics system to sustain operations in Vietnam prompted a 1980 assessment by the PLA General Logistics Department that reforms were needed to improve logistics support to operational units.[13]

The second driver of logistics reforms is the PLA's observations of logistics and maintenance advances by Western militaries, which PLA analysts have often identified in terms of successes by the U.S. armed forces and failures by U.S. opponents in a given conflict. Key logistics and maintenance lessons that the PLA drew included protecting supply lines between rear areas and front lines; optimizing timely and consistent arrival of goods, ammunition, and support equipment; pre-positioning supplies near front lines; leveraging strategic airlift for rapid mobility; conducting field maintenance; and proactively addressing long-term maintenance needs.[14] Of note, these PLA analyses date from the mid-1990s onward, indicating that PLA analysts have been drawing modern lessons learned and associated warfighting requirements even from conflicts as far back as World War II. In summary, the PLA has recognized that the United States could deliver supplies halfway around the world and perform timely maintenance for fighting in such places as Afghanistan even as the PLA has struggled to support forces at home in China at the scale, speed, and efficiency needed for modern combat.

The third driver of reforms is a desire to realize greater efficiencies within the logistics system. As the PLA began to rebuild its operational capability after the Cultural Revolution, it retreated from some of its civilian-type roles to refocus on military tasks and missions.[15] Key desired areas of logistics improvement and reform included reducing redundancy and improving efficiency in logistics organizations' capacity and staffing (along with associated cost-savings) and increasing reliance on civilian entities and the commercial sector. Curbing the corruption that persisted in the logistics system through the 1980s and 1990s was also a goal, given that corruption impeded logistics-specific efficiencies and undermined broader military operational effectiveness.

The reforms from 1998 to 2008 therefore sought to implement two major initiatives that would modernize logistics capabilities: (1) merging redundant but common support activities conducted by each service into a logistics department for each military region and (2) *socialization*, or moving non-military activities of the PLA to be performed by civilian

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[12] Edward C. O'Dowd, *Chinese Military Strategy in the Third Indochina War: The Last Maoist War*, Routledge, 2007, pp. 70–71; Susan M. Puska, "Taming the Hydra: Trends in China's Military Logistics Since 2000," in Roy Kamphausen, David Lai, and Andrew Scobell, eds., *The PLA at Home and Abroad: Assessing the Operational Capabilities of China's Military*, Strategic Studies Institute, 2010, p. 554.

[13] Nong Qinghua [农清华], "Reform of PLA Logistics Support System in the Past 40 Years" [人民解放军后勤保障体制改革攻坚 40 年], *Military History* [军事历史], No. 1, 2019, p. 11.

[14] For more information, see Fleming et al., 2023, pp. 14–19.

[15] Puska, 2010. Thanks go to Joel Wuthnow for highlighting this driver.

organizations.[16] However, since 2008, three dynamics have continued to challenge the PLA's progress in improving its logistics capability. First, China's military services continued to lack a robust capability to quickly respond and flow necessary supplies throughout the country, let alone outside China's borders. Examples include logistics deficiencies affecting PLA command centers following the 2008 earthquake in Sichuan and a mixed story regarding logistics support following the outbreak of the coronavirus disease 2019 pandemic.[17]

Second, corruption has lingered as a major issue for PLA logistics reforms because of the likely long-term consequences of poor acquisitions decisions. In a recent example, PLA officials currently or previously affiliated with the Equipment Development Department (EDD), as well as leaders of key aerospace and defense state-owned enterprises, were purged in 2023 as part of an anti-corruption investigation, and in July 2023, the EDD announced it was investigating corruption dating back to 2017, a period in which recently ousted defense minister Li Shangfu had led the department.[18] Although this bout of corruption appears to have been focused on the PLA's acquisition process, long-term sustainment and maintenance costs make up a considerable portion of a weapon system's overall cost, meaning that any impact of corruption on the sustainment and maintenance of fielded equipment could result in significant operational inefficiencies down the road.

Third, the PLA has also struggled to provide the necessary training for logistics personnel—a topic explored in greater detail in the next section.[19]

The PLA's Approach to Maintenance Incorporates a Hybrid Approach of Compensation and Improvement

To understand the strengths and weaknesses of the PLA's approach to maintenance in the broader context of its logistics capabilities, a 2023 RAND report developed logistics success factors leveraging organizational theory, military studies, and historical cases—and then applied them to the PLA with a focus on PLA Army (PLAA) ground combined arms units and PLA Air

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[16] Roger Cliff, *China's Military Power: Assessing Current and Future Capabilities*, Cambridge University Press, 2015, p. 148; Luce and Richter, 2019, p. 268; Dennis J. Blasko, *The Chinese Army Today: Traditions and Transformation for the 21st Century*, Routledge, 2012, p. 35; Lonnie Henley, "PLA Logistics and Doctrine Reform, 1999-2009," in Susan M. Puska, ed., *People's Liberation Army After Next*, Strategic Studies Institute, August 2000, p. 60; Erin Richter, Leigh Ann Ragland, and Katherine Atha, "General Logistics Department Organizational Reforms: 2000–2012" in Kevin Pollpeter and Kenneth W. Allen, eds., *The PLA as Organization v2.0*, Defense Group Inc., 2012, p. 178.

[17] Cliff, 2015, p. 150; Joel Wuthnow, "Responding to the Epidemic in Wuhan: Insights into Chinese Military Logistics," *China Brief*, Vol. 20, No. 7, April 13, 2020.

[18] Nectar Gan, "Xi's Latest Purge Targets the Military. Why Did Powerful Generals Fall Out of Favor?" CNN, January 5, 2024; Simone McCarthy, "China Names New Defense Minister Months After Removing Predecessor Without Explanation," CNN, December 29, 2023; William Yang, "China Launches New Wave of Purges Against Key Defense Industry Leaders," VOA, December 29, 2023; "China's Military Probes Slew of Graft Issues Going Back to 2017," Bloomberg News, July 26, 2023.

[19] Puska, 2010, pp. 568–569. See also Cliff, 2015, p. 149.

Force (PLAAF) combat aviation units.[20] I focus on four logistics factors below that are relevant for maintenance and for which PLA sources included relevant discussion:

- An **ability to recruit and retain quality personnel** can improve organizational performance and is linked to positive morale within the force.
- A **culture of learning** can bolster effectiveness when a military organization continuously analyzes procedures to identify improvements, invests in new technologies or processes, and applies lessons learned throughout the organization.
- By **routinizing and prioritizing maintenance functions**, a military can create, promulgate, and institutionalize organizational knowledge and procedures via a shared understanding of roles and responsibilities.
- Fostering **latitude for independent decisionmaking by logisticians** at the unit level can leverage flexibility and autonomy to enable problem-solving, contributing to higher reliability even in organizations operating complex and dangerous equipment.

In reviewing these logistics success factors within the PLA, four key themes emerged regarding maintenance strengths and weaknesses.[21]

First, a critical weakness in the PLA's maintenance system is the lack of a professionalized maintenance force. PLA operators and junior maintainers appear to lack the knowledge, skills, and abilities to perform routine maintenance functions, leading to an overreliance on senior maintainers. There is a particularly large divide between the skills of junior technicians and more-senior maintainers, who are predominantly senior noncommissioned officers (NCOs). Social and organizational biases within the PLA create separation between the enlisted and officer ranks, influenced by differences in compensation, trust issues, and quota systems that limit NCO participation on military party committees. One PLA media source reflected these dynamics by characterizing NCOs as "afraid . . . [and] unwilling to take action."[22]

The PLA recognizes the need for a skilled maintainer force and has made some progress in enhancing skill levels. Efforts include employing shifts of junior technicians for dedicated tasks to build their practical experience, improving NCO training, and imbuing NCOs with more responsibility. However, it is difficult to overcome the large differentiation in skill level between junior and skilled maintainers, particularly when the organizational culture does not prioritize innovation and knowledge-sharing. For example, when junior technicians are siloed into shifts focused on completing basic tasks, they have fewer opportunities to obtain ad hoc on-the-job training opportunities with the elite "hero maintainers" (so-described by PLA propaganda).

Some propaganda articles attempt to instill pride in the profession—and perhaps attract new recruits—by lauding maintenance heroes as "part of the team" just like pilots or other operators.

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[20] Fleming et al., 2023.

[21] This research leverages Chinese language articles published between 2018 and 2022 in the *PLA Daily*, professional military education texts, a wider array of PLA maintenance-focused articles published in the *PLA Daily* from 2008 to 2022, PLA academic research, other Chinese state media and military sources (such as the *People's Daily*), PLA service and theater command news sites, provincial and regional news outlets, select nonauthoritative Chinese media sources, and key English-language secondary sources.

[22] Marcus Clay and Dennis J. Blasko, "People Win Wars: The PLA Enlisted Force, and Other Related Matters," *War on the Rocks*, July 31, 2020.

These articles nevertheless reveal hardships faced by senior maintainers, noting that PLAAF senior maintainers can go over a year without returning home to their families or describing a PLAA senior maintainer working until 3:00 in the morning.[23] PLA sources also reveal a lack of institutionalized approaches for skilled maintainers to pass on their accumulated knowledge to the rest of the unit prior to retirement.[24] We also found few examples of sharing best practices and lessons learned across similar units, beyond short-term "internships" by maintenance instructors from the Air Force Engineering University's NCO School to some field units.[25]

Second, a lack of pride in the maintenance profession affects attention to detail and independent judgment. Soldiers and officers appear to take an outdated view of support services, believing that support services are in some respects lesser than those specialties that conduct more-traditional warfighting responsibilities, such as pilots. A lack of pride in the profession also leads to a tendency for maintainers to lack attention to detail. Articles that detail quality assurance processes include examples of procedure-cutting practices that affect the quality of maintenance and jeopardize safety. Related dynamics include risk aversion, which leads maintainers to fear innovation- and experimentation-related failures, and pressures to comply with a zero-defect mentality, which create incentives to maintain the appearance of perfect records and resent process reforms that strengthen quality assurance.[26] This dynamic is not unique to the PLA, but in the U.S. armed forces, for example, certain logistics specialties are prized as benefiting service members by providing options for their post-military service careers. U.S. Navy carrier aviation flight operations also provide an example of U.S. forces operating at a low error rate while eschewing a zero-defect mentality.[27]

Third, the PLA has prioritized improving its self-identified maintenance weaknesses by instituting process reforms and compensating for low skill levels by developing technological solutions. These solutions mitigate some gaps in PLA maintenance proficiency. Process reforms, such as transitioning from organizing maintenance repair teams by weapon systems (e.g.,

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[23] Li Weixin [李伟欣], Wei Yumeng [卫雨檬], Shu Xiquan [殳细泉], and Wu Lihua [吴李华], "'This Is My Fighter Jet!' Salute! Air Force Mechanic" ["这是 我的战机!" 致敬!空军机务兵], *PLA Daily* [解放军报], January 7, 2021; Liu Hanbao [刘汉宝], "Approaching 4 Soldiers 'Craftsmen' in Equipment Maintenance Posts: Dedication and Perseverance in the Rear Area of the Battlefield" [走近 4 名装备维修岗位的士兵"工匠":战场后方的执着与坚守], *PLA Daily*, April 12, 2022.

[24] See, for example, Jia Baohua [贾保华], Yang Lei [杨磊], and Xiang Shuangxi [相双喜], "Compiling an 'Encyclopedia' for Equipment Maintenance" [为装备维修编制"百科全书"], *PLA Daily*, April 5, 2018.

[25] Yang Fan [杨帆] and Li Jianwen [李建文], "Instructors from the Air Force Engineering University Aviation Non-Commissioned Officer School Arrive with the Troops to Follow the Flight Practice" [空军工程大学航空机务士官学校教员到部队跟飞实践], *PLA Daily*, August 30, 2020; Zhang Yuqing [张玉清], Zhou Zhengxin [周正信], and Yang Fan [杨帆], "Air Force Engineering University Aviation Non-Commissioned Officer School Organizes Teachers to Go Fly with the Troops" [空军工程大学航空机务士官学校组织教员赴部队跟飞 学习], Xinhua, August 15, 2019.

[26] Xu Xu [徐徐], Sun Qilong [孙启龙], and Xing Zhe [邢哲], "From One Person to a Team, Explore the 'Correct Way to Open' Equipment Maintenance Support" [从一个人到一个团队，探寻装备维修保障的"正确打开方式"], *PLA Daily*, May 28, 2021; "As the 'Gatekeeper' of Aircraft Safety, He Is Willing to Be the 'Bad Guy'" [作为机务安全"把关人"，他甘当"坏人"], *China Military Online* [中国军网], March 30, 2018.

[27] See Fleming et al., 2023, pp. 49–51.

vehicles) to organizing repair teams by objects (e.g., chassis) in the PLAA and separating maintenance and inspection teams in the PLAAF, are the most likely to improve PLA performance. As another example, PLAAF maintenance support teams at unit repair shops delineate simpler tasks, such as clearing and testing aircraft to the flight line, while a workshop with the most-skilled technicians conducts technically challenging maintenance tasks. One Eastern Theater Command Air Force air brigade using this approach reported reducing engine inspection and maintenance times by 130 minutes per engine.[28] However, the fast-paced evolution of Chinese weapon system technology might outpace some technology-based compensations. Articles may discuss the PLAA transitioning from paper to digital "medical records" for equipment or the PLAAF developing network-based solutions, but some sources still highlight maintainers' use of personal handwritten logbooks as sources of documentation for previous repairs.[29] Ad hoc practices may also be linked to the rapid rate of modernization, with one PLAA repair unit being responsible for maintaining over 40 vehicle types "spanning more than 60 years" of service.[30]

Fourth, reforms aimed at maintenance standardization are not institutionalized—both in terms of knowledge-sharing within and across units as previously mentioned and because of top-down dictation of maintenance procedures—which creates inefficiencies in the system and increases maintenance times. Multiple articles reference that the brigade party committee has the authority to institute changes to the maintenance procedures. Approval for certain maintenance fixes is retained further up the chain of command, adding time to the process and centralizing decisionmaking further up in the organization. Some maintainers, not trusting the allocation system, purchase materials required for maintenance tasks themselves.[31]

Implications for Counterintervention

Building on the previous sections, this section draws out implications for the PLA's maintenance performance during high-end conflict. Of note, the PLA may pursue counterintervention operations in conjunction with, or isolated from, other efforts, such as conducting a large-scale invasion of Taiwan. Efforts to expand the PLA's global presence are different in that they primarily occur in peacetime, for reasons described below. The following sections highlight PLA maintenance approaches that are especially relevant for counterintervention, as well as dynamics likely to affect its performance during a range of high-end scenarios.

High-end PLA operations, such as counterintervention activities, would levy significant requirements across the PLA maintenance and logistics apparatus, even at short distances from the mainland. Kinetic operations in support of counterintervention could leverage an anti-ship

[28] Kenneth W. Allen and Cristina L. Garafola, *70 Years of the PLA Air Force,* China Aerospace Studies Institute, April 12, 2021, p. 270.

[29] On logbooks, see Jia, Yang, and Xiang, 2018.

[30] Liu, 2022.

[31] Li, Wei, Shu, and Wu, 2021.

cruise missile from a modular multiple rocket launcher (PLAA),[32] out-of-area surface or subsurface naval operations (PLA Navy), long-range air packages (PLAAF), and cruise or ballistic missile strikes (PLA Rocket Force).

In all four examples, PLA operations to interdict and engage opposing forces may need to transition from initial "surge" activities to longer-term "sustained" field operations, patrols, or air sorties. Maintainers would be crucial for both phases, performing routine diagnostic checks prior to operations and conducting postmission maintenance, performing emergency maintenance on damaged platforms, and troubleshooting equipment failures.[33] Whether the PLA can sustain new types of maintenance challenges at scale—such as for increasingly-advanced platforms like the low-observable J-20 or for maritime and air assets operating from punishing locations like China's artificial islands in the South China Sea—could result in operational effects, such as lower platform availability rates, reduced sortie generation, or degraded platform performance. More broadly, approaches to such activities as resupply, the location of expected maintenance activities, and the extent to which maintenance trades near-term for long-term benefits (e.g., cannibalizing for parts versus swapping or repairing components) could provide indications as to the expected intensity and duration of wartime operations.

Although the Joint Logistics Support Force (JLSF) could play a key role in supporting broader logistics efforts during a major contingency, such as provisioning common-use food, fuel, and ammunition stores, it would likely have a limited role regarding maintenance.[34] A review of the position of maintenance organizations and units within the PLA's broader organizational structure and descriptions of unit-level maintenance activities indicates that most maintenance activities remain service-specific functions that are separate from the JLSF's activities.[35]

Maintenance dynamics that could differ for a large-scale invasion of Taiwan could include maintenance activities to support a large volume of ships (both naval and civilian), aircraft, and other platforms to transport and protect PLA ground forces crossing the Taiwan Strait as part of the joint island landing campaign. Recent research has detailed cross-strait logistics and mobilization needs, such as the leveraging of civilian maritime assets for cross-strait operations.[36] Although a portion of the PLA's logistics needs are intended to be supported by the

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[32] On the PLAA system, see Joshua Arostegui, *The PCH191 Modular Long-Range Rocket Launcher: Reshaping the PLA Army's Role in a Cross-Strait Campaign*, China Maritime Studies Institute, November 2023.

[33] For specific examples, see Fleming et al., 2023, pp. 29–31.

[34] On the JLSF, see Joel Wuthnow, "Joint Logistic Force Support to Theater Commands," in George R. Shatzer and Roger D. Cliff, eds., *PLA Logistics and Sustainment: PLA Conference 2022*, US Army War College Press, 2023; Joel Wuthnow, "A New Era for Chinese Military Logistics," *Asian Security*, Vol. 17, No. 3, September– December 2021; and Luce and Richter, 2019. Wuthnow (2023) notes that continued reforms to the JLSF could alter its role and includes PLA analyst discussion of other potential reform options for PLA joint logistics.

[35] For more discussion, see Fleming et al., 2023, pp. 27, 36–37.

[36] On cross–Taiwan Strait logistics and mobilization, see Chung Chieh and Andrew N. D. Yang, "Crossing the Strait: Recent Trends in PLA 'Strategic Delivery' Capabilities," in Joel Wuthnow, Arthur Ding, Phillip C. Saunders, Andrew Scobell, and Andrew N. D. Yang, eds., *The PLA Beyond Borders: Chinese Military Operations in Regional and Global Context*, National Defense University Press, 2021; Chieh Chung, "PLA Logistics and Mobilization

national defense mobilization system, given the service-specific and often platform-specific nature of maintenance, PLA maintenance needs are likely specialized enough that this support will be modest or even minimal.[37]

Requirements for maintenance and other logistics support for the PLA's expanding global presence operations would be fundamentally different, given the PLA's much greater emphasis on improving capabilities for its near-periphery—and therefore relatively low overall requirements and capabilities for maintenance and other logistics support abroad.[38] Research on PLA expeditionary overseas operations has identified a host of challenges that the PLA has yet to overcome in peacetime, including for maintenance and logistics.[39] Government and military coordination to send PLA forces overseas appears to remain ad hoc at some level.[40] Additionally,

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Capacity in a Taiwan Invasion," in Joel Wuthnow, Derek Grossman, Phillip C. Saunders, Andrew Scobell, and Andrew N. D. Yang, eds., *Crossing the Strait: China's Military Prepares for War with Taiwan*, National Defense University Press, 2022; J. Michael Dahm, *Chinese Ferry Tales: The PLA's Use of Civilian Shipping in Support of Over-the-Shore Logistics*, China Maritime Studies Institute, November 2021; Lonnie D. Henley, *Civilian Shipping and Maritime Militia: The Logistics Backbone of a Taiwan Invasion*, China Maritime Studies Institute, May 2022; Kevin McCauley, *Logistics Support for a Cross-Strait Invasion: The View from Beijing*, China Maritime Studies Institute, July 2022; J. Michael Dahm, *More Chinese Ferry Tales: China's Use of Civilian Shipping in Military Activities, 2021–2022*, China Maritime Studies Institute, January 2023; J. Michael Dahm, *Beyond Chinese Ferry Tales: The Rise of Deck Cargo Ships in China's Military Activities, 2023*, China Maritime Studies Institute, February 2024.

[37] For the limited discussion of maintenance support in the national defense mobilization system, see Erin Richter and Benjamin Rosen, "China's National Defense Mobilization System: Foundation for Military Logistics," in Shatzer and Cliff, 2023, p. 47.

[38] For two examples of this prioritization, the PLA's most-recent reforms in 2015–2016 both reaffirmed and strengthened the orientation of the PLA's operational forces into five regionally focused Theater Commands, which DoD notes "are organized based on the PRC's perception of peripheral threats." Each conventional PLA service likewise has a "strategic task" to participate in the "primary strategic direction," which Western analysts typically take to refer to a Taiwan contingency, as well as supporting potential contingencies involving a range of U.S. allies and partners. A 2022 RAND study found that the PLA's pursuit of overseas basing and access supports senior leaders' domestic political and economic objectives that are oriented around peacetime economic development (Cristina L. Garafola, Timothy R. Heath, Christian Curriden, Meagan L. Smith, Derek Grossman, Nathan Chandler, and Stephen Watts, *The People's Liberation Army's Search for Overseas Basing and Access: A Framework to Assess Potential Host Nations*, RAND Corporation, RR-A1496-2, 2022, https://www.rand.org/pubs/research_reports/RRA1496-2.html). On prioritization, see Office of the Secretary of Defense, 2023, p. ix; and Shou Xiaosong, [寿晓松], ed., Science of Military Strategy [战略学], Academy of Military Science Press [军事科学院], 2013, pp. 199, 209, 221.

[39] On the expeditionary PLA, see Kristen Gunness, *China's Overseas Military Diplomacy and Implications for U.S. Interests,* RAND Corporation, CT-A2571-1, 2023, https://www.rand.org/pubs/testimonies/CTA2571-1.html; Garafola et al., 2022; Isaac B. Kardon, "China's Overseas Bases, Places, and Far Seas Logistics," and other chapters in Joel Wuthnow, Arthur S. Ding, Phillip C. Saunders, Andrew Scobell, and Andrew N.D. Yang, eds., *The PLA Beyond Borders: Chinese Military Operations in Regional and Global Context*, National Defense University Press, 2021; Joel Wuthnow, Phillip C. Saunders, and Ian Burns McCaslin, "PLA Overseas Operations in 2035: Inching Toward a Global Combat Capability," *Strategic Forum*, No. 309, National Defense University Press, May 2021; Wuthnow, 2021; Kristen Gunness, "The Dawn of an Expeditionary PLA?" in Nadège Rolland, ed., *Securing the Belt and Road Initiative: China's Evolving Military Engagement Along the Silk Road*, National Bureau of Asian Research, September 2019*;* Luce and Richter, 2019; Cristina L. Garafola and Timothy R. Heath, *The Chinese Air Force's First Steps Toward Becoming an Expeditionary Air Force*, RAND Corporation, RR-2056-AF, 2017, https://www.rand.org/pubs/research_reports/RR2056.html.

[40] Garafola et al., 2022, p. 53.

the JLSF does not operate overseas, and whether it would eventually fulfill this role is not known.[41] A 2022 RAND report analyzing historical case studies of competitors expanding their overseas basing additionally noted that many past competitors benefited from compatible military standards with their hosts, such as spare parts. Although China's arms sales and transfers are growing, and it may share some Russian-derivative equipment with potential future hosts, the PLA may not be able to take advantage of significant system-level or parts compatibility to support overseas maintenance needs.[42]

Overall, the PLA's hybrid approach of compensation and improvement to address maintenance weaknesses and bolster strengths would likely also apply to a high-end contingency. Areas in which the PLA attempts to compensate for deficiencies include maintainer skill levels, lack of innovation, and poor knowledge-sharing. All three areas could see significant stress and strain during high-end combat. Likewise, evolving technological advances in military equipment could outpace the PLA's maintenance capabilities, and a compensating approach might be tested under those conditions. When new systems were fielded to one PLAA unit, for example, the maintainers lacked sufficient time to learn the maintenance of those systems before the equipment was exercised.[43] In other areas, the PLA's approaches to maintenance improvements have led to gains in efficiency, such as process reforms and military-civil fusion.[44] These improvements can lead to better operational outcomes, such as a reduced number of required maintainers, increased sortie generation, and higher levels of equipment availability for training and exercises.

One last factor to consider is geography. For operations within the first island chain, China's maintenance and logistics apparatus potentially benefits from leveraging in-garrison or other prepared infrastructure likely affected by the transition from peacetime to wartime but still fundamentally local to the fight. Hong Xuezhi, the logistics department head for the Chinese military during the Korean War, noted some comparative strengths in China's logistics system that remain relevant for a modern conflict in China's near-periphery—mainly the significant disparity in length of supply lines for U.S. and other United Nations Command forces compared with the Chinese military benefiting from close rear areas.[45]

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[41] Wuthnow, 2021; Luce and Richter, 2019, pp. 257–292.

[42] Garafola et al., 2022, p. 52.

[43] Lei Zhaoqiang [雷兆强], Wen Suyi [闻苏轶], and Li Peijin [李沛锦], "How to Face the New Challenges Brought by the New Position? This 'Ace Maintenance Worker' Gives the Answer" [如何面对新岗位带来的新挑战?这名"王牌维修工"给出答案], *PLA Daily*, April 9, 2021.

[44] There is some evidence that top-down military-civil fusion-related reforms have sought to shape maintenance practices. Also, there may be service-specific dynamics. For example, in 2009 the PLAN established its first integrated civil-military vessel equipment center, which has enhanced equipment support to vessels throughout South China. On top-down initiatives, see Fleming et al., 2023, pp. 79–81; on the PLAN, see Susan M. Puska, "Taming the Hydra: Trends in China's Military Logistics Since 2000," in Roy Kamphausen, David Lai, and Andrew Scobell, eds., *The PLA at Home and Abroad: Assessing the Operational Capabilities of China's Military*, Strategic Studies Institute, 2010.

[45] Hong Xuezhi, "The CPVF's Combat and Logistics," in Xiaobing Li, Allan R. Millett, and Bin Yu, eds., *Mao's Generals Remember Korea*, University Press of Kansas, 2001, p. 116.

For many PLA operations that reach out to the second or even third island chain, maintenance or other logistics dynamics may change because of support requirements for different types of, or potentially smaller quantities of, specialized units conducting high-intensity operations. However, most key sustainment activities will continue to take place "at home" once the bomber has landed or the transporter-erector-launcher has fired its missile. Key exceptions might be Navy surface or submarine assets, which require at-sea logistics support that is more challenging to provide far from Chinese shores during wartime.[46]

Implications and Recommendations for U.S. Policymakers

Although less quantifiable than some aspects of the U.S.-China military balance, logistics and maintenance are the lifeblood of military operations and will be a crucial factor in determining the success or failure of the PLA, as well as the U.S. armed forces and like-minded U.S. partners, in a high-end conflict. Logistics and maintenance can set conditions for operational success at a conflict's outset, but their importance is especially pronounced in a protracted war, when the ability to sustain one's remaining military assets vis-à-vis an opponent can potentially change the course of the war. In this light, the U.S. government and broader policy community's limited understanding of PLA logistics and maintenance capabilities represents a critical gap in the ability to assess PLA wartime performance. Following from recent, foundational research that has begun to fill this gap,[47] logistics and maintenance may be an area of U.S. advantage over the PLA. Congress and DoD have an opportunity to ensure that this balance remains favorable.

As illuminated by the Russian military's initial failures during its invasion of Ukraine, a military's approach to maintenance may prove insightful regarding the strengths and weaknesses of its overall logistics capability and the influence of maintenance and logistics on its broader warfighting capability.[48] Three specific themes within the PLA's approach to maintenance are worth highlighting for their broader implications. First, there are indications that PLA operators and junior-level maintainers do not have the knowledge, skills, and abilities to perform some routine maintenance functions, meaning that senior maintainers shoulder a heavier maintenance burden. This skill gap could impede operators' ability to use systems to their full capability and is of particular interest as the PLA continues to modernize its weapon systems.

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[46] Justin Boggess and Travis Dolney, "PLA Navy At-Sea Sustainment Capabilities," in Shatzer and Cliff, 2023, pp. 128–130. Boggess and Dolney note that there is considerable uncertainty over how the PLAN would conduct at-sea logistics during wartime.

[47] Shatzer and Cliff, 2023; Fleming et al., 2023; research on the JLSF cited throughout this testimony; maritime-focused research by the China Maritime Studies Institute; Wuthnow et al., eds., 2021.

[48] Marta Kepe, *Logistics and Sustainment in the Russian Armed Forces,* RAND Corporation, RR-A2523-1, 2023, https://www.rand.org/pubs/research_reports/RRA2523-1.html.

Second, maintenance shapes a military's pattern of adaptation.[49] When maintenance proficiency is low, an organization can either compensate for deficiencies through operational design, or it can attempt to improve its capabilities. Within the PLA, the system is not always responsive when addressing the needs of maintainers, as demonstrated by such deficiencies as the lack of appropriate maintenance materials and manuals that do not adequately address maintenance requirements. To overcome these deficiencies, maintainers compensate through individual efforts. However, these individual solutions do not appear to feed into systemic improvement across the organization.

Third, maintenance practices can also shed light on how a military might plan to operate and provide insight into plans or assumptions regarding the duration of operations. These plans are not known for the PLA, but the stovepiped nature of the PLA's maintenance practices indicates that cross-unit interoperability could be constrained. Stovepiping could slow the PLA's tempo in operations, particularly in sustaining high-tempo operations in a stressing contingency. However, some of these constraints could be overcome by the PLA's ability to leverage the civilian sector, which would provide more flexibility.

Given these findings, U.S. policymakers might consider the following options:

- **Strengthen data protections and security for U.S. logistics and maintenance data while encouraging allies and partners to do the same.** China is both a keen observer of other militaries' logistics and maintenance performance and a consumer of others' data, whether acquired via licit or illicit means, particularly at the platform level. Many U.S. logistics data systems reside on unsecure systems or with limited protections, making them vulnerable to exfiltration. DoD could consider implementing stronger data protection measures with the aim of slowing or denying the PLA's ability to obtain U.S. logistics data. Congress could also consider requesting risk assessments by DoD to inform improved data protection standards. The executive branch could work with allies and partners to strengthen their protections as well.
- **Engage with U.S. allies and partners to curtail military logistics exchanges or relevant information-sharing with the PLA**. While logistics-related exchanges may appear to be a low-risk engagement with the PLA compared with combined exercises involving advanced weapon systems and platforms, sharing logistics best practices may improve PLA capabilities and erode potential U.S. and allied military advantages. DoD could consider conducting risk assessments for such activities. Congress could also stipulate restrictions on U.S. arms sales or other forms of security cooperation with countries that continue to engage in logistics exchanges or exercises with the PLA.
- **Evaluate the utility of potential export controls on logistics systems.** Although much of the current dialogue surrounding export controls and data protection focuses on advanced components in key sectors and high-profile software applications, controlling access to lower-profile logistics systems could complicate the PLA's modernization efforts, especially given that the PLA already recognizes shortcomings in its logistics capabilities and is working to address them. The Department of Commerce's Bureau of

[49] James S. Powell, *Taking a Look Under the Hood: The October War and What Maintenance Approaches Reveal About Military Operations*, Institute of Land Warfare, Association of the United States Army, August 2019, p. 30.

Industry and Security could consider export controls to limit the sale of potential dual-use software or other enablers for military logistics. Congress could also consider mandating a report on dual-use military-civil fusion technology relevant for PLA logistics and maintenance capabilities, given that many military logistics subfunctions, such as supply and transportation, may benefit from commercial applications but remain understudied.

- **Fund additional research on China's military logistics capabilities.** Fundamentally, PLA logistics remains an understudied topic, with few pieces of research to date on the PLA's capabilities within various logistics subfunctions in a joint or service-specific context.
  - Congress could consider mandating studies on the PLA's capabilities relevant for each logistics subfunction, including those listed in the Joint Publication 4.0 definition of logistics, as well as subfunctions listed in the PLA's definition.[50]
  - Service-specific analyses are currently a gap, particularly for the logistics and maintenance capabilities of the PLA Navy, Rocket Force, and branches within the PLAA and PLAAF important for counterintervention, such as surface-to-air missiles.
  - New research could also explore the PLA's approach to logistics success factors beyond the maintenance-specific factors highlighted in this testimony, including the other factors listed in Table A.1 of the appendix. This approach may illuminate other attributes of the PLA's organizational culture that have implications for its ability to wage high-end conflict.
  - Research on the interaction of multiple logistics subfunctions, such as maintenance and supply or transportation and health services, would additionally help build a picture of PLA strengths and weaknesses relevant for high-end contingencies.
  - Initial analysis of weapon systems that are fielded to the PLA and exported abroad showed maintenance issues affecting customers. These issues include unavailable repair parts because of insufficient supply chains, with the parts shortage affecting system availability.[51] Although it is unclear whether the PLA faces these same challenges at home, analyzing the increasing Chinese exports of the systems that the PLA fields could provide additional insights regarding maintenance and logistics going forward.

[50] The seven core subfunctions for the U.S. armed forces are "deployment and distribution, supply, maintenance, logistics services, operational contract support, engineering, and joint health services" (Joint Chiefs of Staff, 2023, p. xi). The PLA's definition of *military logistics* (军事后勤) focuses on "activities carried out by the state and armed forces to support the needs of military struggle and military force building," specifically in the areas of "finance, quartermaster, materiel, fuel, medical, transportation, infrastructure and barracks, and others" (Academy of Military Science All-Military Military Terminology Committee [全军军事术语管理委员会，军事科学院], *Chinese People's Liberation Army Military Terminology* [中国人民解放军军语], Academy of Military Science Publishing House [军事科学出版社], 2011, p. 475). The term for "force building" is literally "construction" (建设) but in the abstract sense.

[51] Fleming et al., 2023, pp. 84–86.

Appendix. Logistics Success Factors

This appendix lists the 11 logistics success factors identified in recent RAND research on the PLA's approach to maintenance management.[52] Table A.1 lists each factor, provides a detailed description of it, and offers examples of success or failure related to the factor.

Table A.1. Factors Present in Successful Logistics Organizational Cultures

Factor in Success	Description of Factor and Results	Examples of Operational or Strategic Success or Failure
Culture of learning	• Continual analysis of logistics procedures • Investment in new technologies or processes during peacetime • Application of lessons learned	• U.S. Army's Center for Army Lessons Learned, Haiti, 1994 • Chinese People's Volunteer Force • Korean War, 1950–1953
Agility leveraging the civilian sector	• Ability to leverage civilian infrastructure • Knowledge-sharing between civilian and military organizations • Interoperability between civilian and military sectors	• The U.S. Department of Defense's (DoD's) application of the Defense Production Act for Mine-Resistant Ambush-Protected vehicles, 2000s • Vietnam War, Viet Cong and North Vietnamese Army forces' integration of civilians into a military logistics system, 1955–1975
Routinization and prioritization of maintenance functions	• Maintenance of equipment on a regular basis • Allocation of sufficient time to perform essential equipment maintenance • Documentation and practice of maintenance triage • Processes to ensure that inspections and maintenance are performed to standard	• Russian invasion of Ukraine, 2022 • Flight operations on U.S. Navy carriers, 1980s
Latitude for independent decisionmaking by logisticians at the unit level	• Reliance on logisticians to exercise independence and judgment in carrying out their duties rather than following strict rules • System of maintenance management that reflects the needs of performing organizations as opposed to the objectives of the controlling agencies	• Flight operations on U.S. Navy carriers, 1980s
Cradle-to-grave view of sustainment	• Life-cycle management (LCM) approach to acquisition that incorporates logistics from the initial design of a system • Level of collaboration between acquisition and sustainment branches	• DoD acquisition reforms, 1980s–1990s • Defense LCM in the PLA's General Armament Department (GAD), 2010s

[52] Fleming et al., 2023.

Factor in Success	Description of Factor and Results	Examples of Operational or Strategic Success or Failure
Ability to recruit and retain quality personnel	• Provision of benefits and incentives that affect morale and retention to military personnel, such as adequate housing, food, and wages • Resolution of issues related to unequal treatment of different groups • Prioritization of training and education in a given field or specialty, such as training in specific maintenance tasks	• U.S. transition to an all-volunteer force, 1970s
Integration of logistics personnel into operational units	• Colocation of logistics personnel with operational units • Use of military exercises that include both operations and support elements working together in realistic scenarios • Integration and coordination of logistics plans with strategic plans	• United States in the Pacific War, 1941–1945 • World War I, Mobile Ordnance Repair Shops, 1917–1918
Unified chain of command	• Unified command structure with a clear chain of command • Clear lines of communication • Span of control	• U.S. military information operations, 2010s
Appropriate balance between competing priorities in a constrained environment	• Appropriately balanced cost, quality, and timeliness factors related to maintenance and supply • No prioritization of cost, quality, or timeliness factors at the expense of each other	• Flight operations on U.S. Navy carriers, 1980s
Low prevalence of corruption	• Lack of corruption that diverts scarce resources and has negative effects on operational performance	• Russian invasion of Ukraine, 2022
Balanced emphasis between support and combat elements	• Sufficient support to combat soldier ratio • Protection provided to support units	• Russian invasion of Ukraine, 2022 • United States in the Pacific War, 1941–1945

SOURCE: Reproduced from Fleming et al., 2023, Table 3.1.