Chapter 10

Informatization and the Chinese People's Liberation Army Navy

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Introduction

In recent years, the modernization of the PLA Navy (PLAN) has become a very high priority for China. Senior Chinese Communist Party (CCP) leaders and high-ranking military officers have emphasized the importance of naval modernization. Most prominently, CCP General Secretary, President, and Central Military Commission (CMC) Chairman Hu Jintao in a December 2006 speech to PLAN officers underscored the need to "endeavor to build a powerful People's navy that can adapt to its historical mission during a new century and a new period."[1] Similarly, PLAN Commander Wu Shengli and PLAN Political Commissar Hu Yanlin promoted the importance of naval modernization in an article that appeared subsequently in the authoritative CCP journal *Seeking Truth* (求是). According to Wu and Hu, "Since the reform and open door policy, along with the consistent increase of overall national strength, the oceanic awareness and national defense awareness of the Chinese people have been raised and the desire to build a powerful navy, strengthen the modern national defense and realize the great revitalization of China has become stronger than at any other time."[2] Moreover, Wu and Hu contend, "To build a powerful navy is the practical need for maintaining the safety of the national sovereignty and maritime rights."[3] High-level statements such as these appear intended to underscore the importance that China's civilian and military leaders attach to the modernization of the PLAN.

This growing sense of urgency about naval modernization appears to be a function of increasing concern about maritime security issues, particularly Taiwan's status, maritime resources, and energy security, with the most rapidly developing, high-intensity capabilities focused on the "Near Seas" (the Yellow, East China, and South China Seas), and their immediate approaches. Chinese naval modernization is focused partially, but by no means exclusively, on Taiwan. Most of the platforms China is acquiring are multimission platforms, and the PLAN is investing in capabilities like large amphibious ships and aircraft carriers, which are clearly much more relevant to other missions.

Moreover, the comments of senior PLAN officers underscore the diversity of missions the PLAN must be ready to execute. For example, Wu and Hu emphasize that the PLAN must be prepared for a potential conflict over Taiwan.[4] At the same time, however, they point out that the PLAN must be prepared for a wider range of missions, including the protection of maritime resources and energy security issues.[5] This reflects Hu Jintao's concept of the Chinese military's "New Historic Missions," which was introduced at an expanded CMC conference on December 24, 2004.[6] In an attempt to transform Hu's general guidance into more specific policy, articles in state and military media have argued that to safeguard China's economic growth, the PLA must go beyond its previous mission of safeguarding national "survival interests" (生存利益) to protecting national "development interests" (发展利益).[7]

Hu has also stated specifically that the PLA must prepare for "military operations other than war" (MOOTW), such as peacekeeping, humanitarian assistance and disaster relief, and noncombatant evacuation operations (NEOs). As Hu stated in December 2008, "As we strengthen our ability to fight and win limited wars under informatized conditions, we have to pay even more attention to improving noncombat military operations capabilities."[8] The PLAN's participation in antipiracy operations in the Gulf of Aden since December 2008, its dispatch of a hospital ship to the Indian Ocean in summer 2010, and its involvement in the evacuation of Chinese citizens from Libya in February 2011 underscore its importance in fulfilling the "New Historic Missions."

Indeed, these expanding combat operations and MOOTW missions drive the PLAN's requirements, not only for the new platforms China is putting into service with the PLAN, but also for command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) capabilities to support their use in monitoring and—in a worst case scenario—targeting foreign platforms on, under, and above the sea.

Within this context, enhancing the PLAN's information technology (IT) and communications capabilities is seen as critical to the success of China's overall naval modernization program. According to one recent article on the future of the PLAN, "The informatization of the shipboard weapons and equipment is the core of maritime joint combat . . . the Chinese Navy should vigorously build the data links for maritime military actions and fundamentally change the way to carry out tasks in the future."[9] The ultimate goal is operations carried out by a "networked fleet."[10] Reaching this goal means narrowing the gap between the PLA and the world's most advanced militaries through the development, acquisition, and integration of advanced information technology, which is one of the major goals of contemporary Chinese military reforms.

Central to this effort is the process of informatization (信息化), which is often billed as crucial to the modernization of the Chinese military. This emphasis on informatization derives from the expectation that the PLA must strengthen its preparation for local wars under informatized conditions. As part of China's broader strategy of active defense, the PLA is "enhancing in an all-round way its capabilities of defensive operations under conditions of informatization" to make sure "that it is well prepared for military struggle" and capable of "winning local wars under conditions of informatization."[11] This applies with particular force to the navy. According to the authors of the above-mentioned article on the future of Chinese maritime power, "Informatized warfare is the mainstream trend in the development of future maritime wars."[12]

PLA modernization is critical to China's military competitiveness, and "informatization" is central to the PLA's modernization. An explicit goal of the 2006 Defense White Paper was to build informatized armed forces capable of winning informatized wars. In the view of the PLA, China has yet to fully exploit mechanized warfare, while it is now having to transform to the follow-on era of informatization. According to Beijing's 2006 Defense White Paper, "China pursues a three-step development strategy in modernizing its national defense and armed forces, in accordance with the state's overall plan to realize modernization. The first step is to lay a solid foundation by 2010, the second is to make major progress around 2020, and the third is to basically reach the strategic goal of building informationized armed forces and being capable of winning informationized wars by the mid-21st century."[13] At the 17th Party Congress in October 2007, Chinese President Hu Jintao declared, "To attain the strategic objective of building computerized armed forces and winning IT-based warfare, we will accelerate composite development of mechanization and computerization, carry out military training under IT-based conditions, modernize every aspect of logistics, intensify our efforts to train a new type of high-caliber military personnel in large numbers and change the mode of generating combat capabilities." The PLAN is at the center of this effort to achieve the informatization of the Chinese military. It "has published an entirely new set of revised guidance documents since the end of the 9th Five-Year Plan (1996–2000)."[14] Since the beginning of this decade, the "Two Transformations" program has sought to implement this guidance by using informatization and mechanization to transform the PLAN, along with the rest of China's military, from a posture that is personnel-intensive to one that is technology-intensive.[15]

This chapter explores PLAN informatization and its implications for command and control (C2) and joint operations. Drawing on a variety of Chinese-language publications, it attempts to address the following key questions:

■ How does the PLA define the concept of *informatization*, what does this mean for the PLAN, and how does it relate to the modernization of PLAN C2?

■ How well can the PLAN currently connect sensors, C2, and weapons to get a clear picture of the battlefield and execute combat operations?

■ What is the PLAN's ability to conduct joint operations with other services?

■ What technical improvements is China's navy likely to make over the next decade (e.g., space-based ocean surveillance, use of unmanned aerial vehicles, and better communications) and which capabilities would make the most difference for combat effectiveness?

■ Where does the PLAN currently fit in the spectrum between the U.S. and Russian C2 models?

The remainder of this chapter is organized as follows. The first section surveys how the concept of "informatization" is defined in naval terms and how it relates to the modernization of PLAN C2. The second examines the PLAN's current ability to connect sensors, C2, and weapons to get a clear picture of the battlefield and execute combat operations, as well as its ability to conduct joint operations with other services. The third section addresses the technical improvements likely to materialize over the next decade and the capabilities that would make the most difference for combat effectiveness. The fourth examines the training and education issues that are integral to PLAN informatization. The fifth section assesses the PLAN's position on the spectrum between the U.S. and Soviet models of C2. The final section summarizes the key findings and highlights some possible areas for further research on naval informatization.

PLAN "Informatization"

The PLAN is modernizing to undertake an expanded set of missions in support of China's national security interests. It is undergoing an impressive transformation from what was essentially a coastal defense force to a more offensively oriented force capable of executing a variety of regional missions. As part of this impressive modernization program, a number of new surface ships and submarines have entered service in recent years. China's new surface ships include Russian-built *Sovremenny* guided-missile destroyers (DDGs) and indigenously developed *Luzhou* and *Luyang* I and II[16] DDGs as well as *Jiangkai* I and II guided missile frigates (FFGs), in addition to *Houbei*-class wave-piercing missile catamarans. Among the PLAN's new submarines are

Kilo-class submarines acquired from Russia and the domestically developed *Shang* nuclear-powered and *Song* and *Yuan* conventional attack submarines. With the addition of these new platforms, the PLAN is improving its surface warfare, undersea warfare, and air defense capabilities. The PLAN also appears poised to become an increasingly important part of China's nuclear deterrence posture with the addition of several Type–094 nuclear-powered ballistic missile submarines (SSBNs), which will be armed with JL–2 submarine-launched ballistic missiles (SLBMs). According to China's 2006 Defense White Paper, the PLAN "aims at gradual extension of the strategic depth for offshore defensive operations and enhancing its capabilities in integrated maritime operations and nuclear counterattacks."[17]

China's leaders perceive their nation to be confronting a strategic environment in which "Military competition based on informatization is intensifying."[18] This view both highlights the growing importance of information technology in military modernization and places a heavy premium on striving for information dominance in any future conflict, especially one with a technologically advanced adversary. Some Chinese analysts write about the role of information in a style reminiscent of U.S. publications that emphasize information superiority and extol the virtues of "network-centric warfare."[19] For example, according to one recent article by three researchers affiliated with the PLAN's Dalian Ship Academy, "In the information age, information has become one of the main sources of combat power."[20] Consequently, as the authors of the 2006 version of *Science of Campaigns* emphasize, informatization permeates PLA doctrinal reform: "advancement of military 'informatization' construction and development of battle theories based on 'informatization' are currently the primary topics of discussion for national military construction and battle preparations."[21]

The term "informatization" contains many concepts that are familiar both across Chinese writings and to similar Western characterizations:

- information superiority
- reconnaissance and counter-reconnaissance
- jamming and antijamming
- networking and platform integration
- space operations
- joint operations and joint integration
- sensor-to-shooter connectivity
- electronic attack

■ autonomous operations

■ notions of speed, accuracy, security, and continuity of communications.

Although many PLA publications emphasize the importance of informatization, the term is not always defined explicitly and Chinese press coverage is sometimes vague.[22] This complicates efforts to understand exactly what PLA authors mean when they use the term, and to determine how it applies to the modernization of the PLAN.

Fortunately, some Chinese authors do provide explicit definitions of informatization in their published work. For example, in a recent article, three researchers at the Dalian Ship Academy offer the following definition of *naval informatization*:

> The informatization of naval equipment refers to using information technology as the impetus, information networks as the foundation, and command automation as the core, effectively developing information resources, carrying out information transformation of every aspect and every link of naval equipment, and continuously promoting the "information ability" and "informatization level" of naval weaponry and equipment.[23]

This definition of naval informatization stresses hardware development and equipment modernization, but PLA writers conceive of naval informatization as a larger process that involves training and education as well as upgrading C4ISR systems and related military hardware. According to one recent article, "The Chinese Navy must establish the guiding principles to build digital troops and prepare for informatized combat, which is extremely important. In the crucial period of the military reform, what plays an effective role oftentimes is not technologies, but thinking and concepts. He who first understands is clear-sighted and he who moves ahead of others is in an advantageous position."[24] Nonetheless, from the perspective of many Chinese military authors, upgrading C4ISR hardware capabilities is clearly an essential component of narrowing the gap that separates the PLA from the world's most technologically advanced militaries.

PLAN C4ISR Systems

This section provides an overview of the PLAN's current communications and ISR capabilities and offers some preliminary judgments about its ability to connect sensors and weapons. It also discusses some Chinese C4ISR and space systems developments that, while not PLAN-specific, have implications for maritime security and naval missions.

Given the Chinese military's C4ISR shortcomings in the 1980s and 1990s, the PLAN's informatization drive started from a relatively weak position. For many years, the entire PLA, including the PLAN, faced major shortcomings in its C4ISR capabilities. As Mulvenon and Bickford observed in the late 1990s, the PLA had traditionally relied upon a telecommunications infrastructure that was "inadequate" and "outdated." This weakness "severely limited the military's ability to transmit and process large amounts of information or coordinate activities between the various Military Regions, thereby reducing military effectiveness."[25] The PLA also faced challenges when it came to modernizing its ISR architecture. Although China was capable of launching photoreconnaissance satellites, Chinese satellite imagery technology was "outdated by Western standards."[26] Moreover, the PLA's situational awareness was hindered by China's lack of a real-time photoreconnaissance capability.[27] As of the late 1990s, therefore, C4ISR remained an area of substantial weakness for the PLA. As a U.S. Department of Defense (DOD) report published in 2000 pointed out, the PLA's C2 capabilities were not capable of effectively supporting joint service operations.[28]

Despite these modest beginnings, Chinese C4ISR modernization has taken off since the late 1990s, when the PLA embarked on a massive effort to modernize, upgrade, and expand its communications infrastructure. This ambitious project was bolstered by the rapid development of the civilian information technology and telecommunications industries in China. One of the key results of the communications upgrade was the construction of a national fiber-optic communications network that provided the PLA with much greater communications capacity, higher reliability, and improved communications security.[29]

Near–real-time C4ISR is facilitated increasingly by China's integrated *Qu Dian* military C4ISR system, which enables civilian and military leaders to communicate with forces in theater using secure fiber-optic cables, high frequency (HF) and very high frequency (VHF) communications and microwave systems, as well as related wireless networks and data links. According to China's 2010 Defense White Paper, "The total length of the national defense optical fiber communication network has increased by a large margin, forming a new generation information transmission network with optical fiber communication as the mainstay and satellite and short-wave communications as assistance."[30] This system is regarded by some as the equivalent of the U.S. Joint Tactical Information Distribution System (JTIDS); China has developed, and possibly deployed, a related Triservice Tactical Information Distributed Network (三军战术数据分发系统).[31]

The PLA is likewise making major strides in the development of its communications networks more generally. Indeed, the expansion of military

communications networks is a particularly noteworthy aspect of Chinese military modernization and one that has major implications for the informatization of the PLAN. The PLA reportedly has accelerated the development of its nationwide communications capabilities in recent years, devoting particular attention to diversifying the means of communication and enhancing security and antijamming capabilities.[32] According to one source, "Firstly, in the coastal military commands, a gigantic optic-cable communication network has been set up, which guarantees the optic-cable communication among the headquarters of each military command. Meanwhile, satellite communication has been applied more widely, which ensures smooth communication between the top commanding organ and the headquarters at different levels of the military commands."[33] Chinese research institutes have also "developed a VSAT [very small aperture terminal] communication system consisting of mobile vehicle-borne components" as well as new microwave and troposcatter communication systems, and China is also upgrading some of its traditional HF, VHF, and ultra high frequency (UHF) communication systems.[34]

Improving military computer networks and making them available to more and more units have been a particular priority for the PLA as it expands its communications networks, another key "informatization" development that has major implications for the PLAN. Indeed, recent reports indicate that all PLAN units at the division level and above are now connected to military computer networks, and that current plans focus on extending coverage to lower-level units.[35]

This appears to be the case throughout the PLAN. One recent article highlights the extent to which various PLAN units in the South Sea Fleet are being connected to the military's computer networks: ". . . 100% of the divisions, brigades, and regiments under the South Sea Fleet aviation corps have successfully established their LANs [local area networks], while 92% of its companies have been connected to the military network. . . . all of the study rooms of units above regiment level have been connected to the comprehensive information network of the People's Liberation Army [全军综合信息网]."[36]

In addition, the PLAN is improving the capabilities of its ocean survey vessels and reconnaissance ships, which are responsible for a number of tasks, such as surveying, gathering meteorological and hydrographic information, laying and repairing undersea cable, and collecting various types of intelligence. For example, one article on the South Sea Fleet's survey and reconnaissance ships states that they have "continually raised the level of unit informatization building and brought about an historic leap forward in informatized support capabilities including electronic reconnaissance, sea survey, and cable laying on the sea floor."[37] More specifics are offered by another article

on reconnaissance ships subordinate to the North Sea Fleet, which in recent years have "successively introduced advanced equipment such as fathometers, monitoring and scanning sonar, and gravity and magnetic surveying devices, transforming traditional manual survey operations . . . enhancing the accuracy and effectiveness of surveys, and reducing the cycle of data processing and chart creation."[38]

Finally, PLAN researchers believe that refitting older weaponry and equipment with modern information technology greatly increases its combat effectiveness. Among the benefits of this approach are that it is quick and relatively inexpensive.[39] For example, the PLAN apparently views minesweepers equipped with "torpedo" mines as a viable ASW platform that illustrates the potential for "old equipment + networks + talent" to "thoroughly convince" those who believe that "it is not possible to establish a platform for informatized exercises on old equipment."[40] On the other hand, this approach could risk a situation in which the PLAN ends up with a hodgepodge of equipment, some of which does not suit its requirements.

To improve both its nonterrestrial networks and the data available on all networks, Beijing has also intensified its efforts to improve its space-based C4ISR capabilities. Indeed, China began an ambitious manned space program, started participating in a variety of international space partnerships, and moved forward with several military space programs.[41]

Space-based ISR and communications capabilities have been at the forefront of this transformation of the PLA's C4ISR architecture. Chinese military strategists view space operations as vital components of joint campaigns in informatized local wars.[42] For the PLA, as Dean Cheng points out, space is "as vital a battlefield as any on earth."[43] According to the authors of *The Science of Campaigns*,

> Future anti–air raid campaigns will be conducted with highly informationized weapons and equipment. The information system, as a main body of an integrated C4ISR system and an important information source and information channel, plays a decisive role in confrontations in the information sphere. Information confrontational activities for seizing information superiority, such as reconnaissance and anti-reconnaissance, jamming and anti-jamming, destruction and anti-destruction, will penetrate through the entire process of operations and become important contents of anti–air raid campaigns.[44]

Consequently, according to DOD, "China has accorded building a modern ISR architecture a high priority in its comprehensive military modernization, in particular the development of advanced space-based C4ISR

and targeting capabilities."[45] China is developing space-based ISR systems such as remote-sensing satellites, advanced imagery satellites, and electronic intelligence (ELINT) and signals intelligence (SIGINT) satellites.[46] China can also purchase commercial imagery products to supplement its current reconnaissance capabilities.[47]

The PLA is leveraging the PRC's dynamic commercial information technology (IT) sector to accelerate the modernization of its C4ISR capabilities. According to a recent RAND study, China's IT sector is likely "the most organizationally innovative and economically dynamic producer of equipment for China's military."[48] Even though Chinese IT companies are oriented mainly toward domestic and international commercial IT markets, "the PLA has been able to effectively leverage certain IT products to improve the military's command, control, communications, computers, and intelligence (C4I) capabilities—a critical element of the PLA's modernization efforts."[49]

Space-based C4ISR developments are particularly crucial for naval informatization, especially given the PLAN's evolving missions. Indeed, an increase in Chinese naval capability from antiaccess/antiarea denial (A2/AD) in the Near Seas to regional blue-water operations and power projection in the Far Seas will hinge in part on improvements in aerospace capabilities, especially air/space-based platforms and C4ISR. Despite major imbalances in its development, by the end of the Cold War China had become the first developing country to achieve comprehensive aerospace capabilities. While China still suffers from some challenges, particularly in its aviation sector, it appears to be making rapid, comprehensive progress in producing advanced aerospace platforms. This in turn affords China an increasing range of military operational possibilities.

China has developed a full range of military, civilian, and dual-use satellites of various mission areas and sizes. Remote-sensing satellites include the *Fengyun*–1D and –3A weather satellites, with their visible, IR, and microwave imaging. Advanced imagery satellites include the *Yaogan* 2–11 high resolution synthetic-aperture radar (SAR) and electro-optical military satellites. The CBERS–2 and –2B near real-time electro-optical satellites, with 2.7-meter resolution, are also used for military observation. China possesses dedicated ELINT and SIGINT satellites.[50] An independent global positioning system and data relay satellites are essential components of a robust ISR system. According to Chinese media, the PLA is now using such satellites as *Beidou*–4 and *Tianlian*–1 for, respectively, positioning and data relay (transmission of inputs from sensors beyond line-of-sight from Chinese ground stations).[51] Other *Beidou* navigation satellites and space remote-sensing technologies also enhance precision strike capabilities, with the General Armament Department's (GAD's) Survey and Mapping Bureau given particular credit.[52]

The *Fenghuo*–1 communications satellite and its identically-named follow-on may likewise support military operations.[53] China's approximately 15 reconnaissance-capable satellites include electro-optical, multi- and hyper-spectral, and radar, especially synthetic-aperture radar.

Navigation and positioning has been a major area of emphasis with implications for military modernization and the informatization of the PLAN. Satellite navigation facilitates the monitoring of friendly forces and the targeting of enemy forces by offering reliable positioning signals. It supports C2 by providing basic communications functions. At present, China uses the U.S. GPS and Russia's GLONASS satellite navigation systems as well as its own indigenous *Beidou* satellite navigation system.[54] Beijing has had only limited access to receiver technology and was denied access to the military mode of Europe's nascent Galileo system, apparently intensifying existing Chinese efforts to develop *Beidou* further.[55] Unlike those of GPS, *Beidou* users receive signals from broadcasts from a ground station, not directly from the satellites.[56]

China deployed its own three-satellite *Beidou*-1 navigation constellation in 2007, but it is limited to providing service from 70 to 140 degrees east longitude and from 5 to 55 degrees north latitude and navigation coverage accurate to within ~20 meters. This enables *Beidou*–1 to support operations on China's immediate maritime Near Seas, but not farther afield. To ensure reliable independent access in the future, and to support broader operations, China is deploying a 35-satellite (5 geostationary, 30 medium earth orbit) constellation—called *Beidou*-2/Compass (北斗卫星导航定位系统)—that would provide much-improved accuracy, with regional navigation and communications coverage anticipated by 2011 and global navigation and communications coverage by 2015–2020.[57] Eight satellites have been launched thus far; five remain fully operational.

Maritime observation satellites are another area of particular interest from the perspective of naval informatization. China's first series of dedicated maritime monitoring satellites is administered by the State Oceanic Administration (SOA). China launched its first maritime observation satellite, *Haiyang*-1A, on May 15, 2002. This satellite, which monitored ocean water color and temperature, had military applications; an official publication states that 12 percent of *Haiyang*-1A's 2003 "satellite data distribution" was "military."[58] *Haiyang* (HY)–1B was launched in April 2007 to survey the Near Seas. Fully operational versions are scheduled to follow: HY–1C, –1D, and –2A in 2011, and HY–3 in 2012.[59] A total of 15 further *Haiyang* ocean monitoring satellites are planned in three sets.

Likewise relevant to maritime surveillance will be China's *Huanjing* disaster/environmental monitoring constellation, envisioned to contain 11

satellites capable of visible, IR, multi-spectral, and SAR imaging. Two initial satellites in the series, *Huanjing*–1A and –1B, provide real time multi- and hyper-spectral imaging respectively, to a resolution of 30 meters. *Huanjing*–1C and –1D are reportedly scheduled for launch in 2011.

China uses a variety of other satellites to link these sensors to shooters, and to support related network functions in real time. Its first data relay satellite, *Tianlian*–1, facilitates near-real-time communication between satellites and ground control, complementing China's more than 10 ground stations and 4 operating *Yuanwang* space event support ships. *Tianlian*–2 will reportedly be launched in June 2011.

Satellite surveying and mapping are close to real time in capability. This is being exploited by a variety of services, including the PLAN. One South Sea Fleet unit developed a reportedly combat-relevant "Stipulated Technical Procedure for Maritime Terrain Digitized Satellite Surveying and Mapping."[60]

Trends in C4ISR Research and Development

This section addresses technical improvements that are likely over the next decade and assesses their potential implications for PLAN operations.

"China has the most active land-based ballistic and cruise missile program in the world,"[61] the 2010 DOD report emphasizes. As part of this larger missile-centric approach, China has been developing the capability to target U.S. ships with ballistic missiles based on the DF–21D medium-range anti-ship ballistic missile (ASBM). Top U.S. Navy officials state that China's ASBM has reached the equivalent of initial operational capability (IOC). While the exact details remain uncertain, both U.S. officials and the director-general of Taiwan's National Security Bureau state that China has already begun to deploy the DF–21D.[62]

If supplied with accurate real-time target data, China's growing family of radar reconnaissance and electro-optical surveillance satellites, terminal radar seekers, and maneuvering warheads could enable Chinese ballistic missiles to complicate or negate U.S. ballistic missile defense efforts and seriously threaten targets such as airbases and aircraft carriers. If these Chinese systems work effectively in practice as a "system of systems," they would be extraordinarily difficult to defend against.

Chinese researchers emphasize the importance of linking platforms together into an integrated whole, suggesting that this will continue to be a major focus of defense research and development (R&D) programs. This is considered particularly important for the PLAN. According to one recent article, "A platform-centric navy cannot bring into full play the potentials of its sensors and weapons," but "effective networks formed with multiple platforms

and multiple sensors can enable the resources of military strength to grow steadily" and "resource sharing among various platforms and coordinated allocation of the resources of all operational forces can enable the currently available resources of military strength to be fully utilized."[63] According to another technical journal article, "In order to effectively fuse all C4ISR system elements and achieve a seamless connection from sensors to shooters it is necessary to solve the problems of data integration."[64] Publications such as these suggest that networking sensors and data fusion are two topics of particular interest to Chinese researchers and are likely to enjoy high priority in the next few years.

Unmanned reconnaissance systems are another area of strong emphasis in Chinese C4ISR-related research and development. Indeed, recent technical journal publications indicate that Chinese scientists and engineers are conducting research on various types of unmanned aerial vehicles (UAVs).[65] China is purchasing foreign models, transforming former piloted aircraft into unmanned combat aerial vehicles (UCAVs), and developing indigenous variants. This is an area of particular emphasis and investment for China; more than 25 UAV prototypes or models were on display at Airshow China 2010 in Zhuhai, up from 12 in 2008. Chinese researchers are also working on unmanned underwater vehicles (UUVs). For example, one recent article by PLAN researchers addresses the sonar capabilities of remotely operated vehicles (ROVs).[66] Such vehicles could have applications in ISR and a number of other maritime warfare mission areas.

Digitization of sea charts has also been emphasized.[67] The National Institute for South China Sea Studies, for instance, has produced China's first "Digital South China Sea" chart. Extensively tested, it reportedly brings the PLAN's charts to international standards and will support its voyages.[68]

PLAN Training and Education: Preparing for Informatized War at Sea

Chinese planners realize that rapid improvements in the PLAN's hardware will not be fully effective without corresponding increases in the ability of its personnel to operate it under realistic combat conditions.[69] This requires the PLAN to make corresponding improvements in training and education.[70] In keeping with recent PLA-wide guidance from the General Staff Department that stresses making exercises more realistic and challenging, the PLAN has emphasized making sure that training approximates the actual battlefield environment as much as possible. Official sources indicate that the PLAN has made a considerable amount of progress in making training more rigorous.[71]

Citing President Hu Jintao's instructions that military training "must be raised to a new level through making innovations," a recent article in *People's Navy* (人民海军), the PLAN's official newspaper, elaborates, "We should more

intensively and extensively carry out battle training, and take battle training in an authentic environment and in a complicated battlefield situation as a basic form of conducting campaign and tactical exercises so as to enhance the naval units' adaptability in sea battles under the condition of informatization."[72] Similarly, China's 2006 National Defense White Paper states: "The PLA conducts training in strict accordance with the requirements for winning local wars under conditions of informatization" and "takes vigorous steps to accelerate the transition from military training under conditions of mechanization to military training under conditions of informatization."[73] Some of these steps include training to fight in an electronic warfare (EW) environment, conducting more realistic opposing forces training, increasing the use of modeling and simulation, and training for joint operations.

Chinese sources frequently highlight the importance of conducting training under "complex electromagnetic conditions" so that Chinese forces will be prepared to conduct operations in an environment characterized by jamming and electronic attacks. For example, a January 2007 press report states: "Starting this year, units from across the entire Army have brought military training in a complex electromagnetic environment into line with the military training outline to ensure that it becomes a part of training and educational practices and making it required training, learning, and testing content during the units' training and in the education of the academies and schools."[74] In September 2007, for example, *North Sword 0709* involved 2,000 soldiers equipped with electronic devices that beamed real-time battlefield data back to headquarters.[75] The PLAN is also implementing this guidance, as highlighted by recent articles in *People's Navy*.[76]

Training to conduct operations in a complex electromagnetic environment includes a variety of topics, such as jamming, electronic attacks, reconnaissance, and electronic deception. For example, a June 2007 North Sea Fleet (NSF) exercise reportedly incorporated several of these subjects.[77] The PLAN is also conducting opposing forces training featuring "Blue Force" detachments playing the role of enemy units as part of its drive to improve training for future informatized conflicts.[78] The PLAN is also making extensive use of modeling and simulation to enhance training. As one recent article put it, "We should use computer networks, simulation, and virtual reality technology extensively to develop advanced training means and to promote simulation, base, and network training."[79] Indeed, the PLA's official newspapers are replete with articles that highlight the employment of modeling and simulation in PLAN exercises. For example, a recent *Liberation Army Daily* article highlights the PLAN's use of simulation to improve surface warfare training.[80] In addition, the PLAN is using simulations to enhance submarine force training.[81] The use of simulations reportedly allows units to increase their training efficiency.[82]

Another area of emphasis for the PLAN is joint training. This reflects the conclusion that the Chinese military will have to fight jointly in future conflicts. According to one recent article in the PLAN's official newspaper, "As profound changes take place in the form of war, future warfare will be integrated joint operations under informatized conditions. Training is the rehearsal for war, and what kind of a war we fight determines what kind of training we should conduct."[83] Numerous recently published articles highlight the PLAN's joint training activities.[84] Some of these joint exercises have focused specifically on communications capabilities.[85]

The PLAN's participation in joint exercises like these depends on military computer networks that connect all of the services. Another article in the PLAN newspaper relates the details of a March 2006 "online joint training" exercise: "Yesterday morning, a group of commanders and staff officers gathered at the operation command center of a certain group army of the Guangzhou Military Region. Through computers, they synchronized their actions with commanders of numerous navy, army, and air force units several hundreds of kilometers away. . . ."[86]

Personnel

"In the course of promoting the change of the Navy's military training system from a condition of mechanization to a condition of informatization," a major PLAN directive emphasizes, "a critically important factor . . . is the quality of our personnel."[87] In order to make "training more technology-intensive and innovative,"[88] therefore, the PLAN is making substantial efforts to better manage and educate existing personnel and recruit new ones with improved skills. This requires the PLAN "to adopt a set of standards and mechanisms for selecting, promoting, training, using, appraising, awarding, and punishing staff personnel in the light of the informatization requirements. . . ."[89] Across the PLA, China's 2010 Defense White Paper maintains,

> strategic planning, leadership and management of informatization have been strengthened, and relevant laws, regulations, standards, policies and systems further improved. A range of measures, such as assembly training and long-distance education, have been taken to disseminate knowledge on information and skills in applying it. Notable achievements have been made in the training of commanding officers for joint operations, management personnel for informatization, personnel specialized in information technology, and personnel for the operation and maintenance of new equipment. The complement of new-mode and high-caliber military personnel who can meet the needs of informatization have been steadily enlarged.[90]

Nevertheless, there is reason to believe that this remains a difficult challenge.

Major efforts are underway to ensure that PLAN personnel are able to operate their increasingly sophisticated equipment effectively. To address discrepancies between the technical specialties of its personnel and the new demands to which they are subjected operationally, a South Sea Fleet Reconnaissance Ship Group "arranged for concerned specialists to go to scientific research organizations for study and development." Each year, the group "earmarks nearly 100,000 Yuan for 'major rewards' to personnel for outstanding accomplishments in scientific research and military training. It also allocated 200,000 Yuan to set up an 'on-the-job personnel development fund' to pay tuition and travel expenses for officers and soldiers engaged in self-study and examinations."[91] To facilitate training involving increasingly complex missiles, torpedoes, and sea mines, a South Sea Fleet base brought skilled civilians from their factories of origin to help "guide and assist."[92] The PLAN strives to improve informatization training even for crews of its older platforms, such as East Sea Fleet *Jianghu*-class frigate *Wuxi* (Hull 512).[93] A new Ship Captain Training Center at Lushun Naval Base, which trains captains of minesweepers and other smaller vessels, is emphasizing training in "informatization, networking [网路化], and integration…."[94]

As for recruitment, the PLAN, as "one of the high-tech-intensive military services . . . urgently needs a large number of high-quality non-commissioned officers with modern science and technology backgrounds and with the ability to skillfully operate modern weapons and armaments."[95] The PLA's Strategic Project for Talented People, implemented by the Central Military Commission in 2003, seeks to prepare future PLA officers and the forces under their command for informatized war.[96] According to a Taiwanese report, since 1999 this program has "given scholarships of 5,000 Yuan per year [\$625 at 2007 exchange rates] to outstanding students in information engineering related programs at Qinghua and Beijing Universities." Following graduation, the students reportedly serve at an "All-Army Network Technology Research Center" (全军网络技术研究中心). During winter break in 2000, apparently, more than 40 scholarship recipients practiced at the Research Center and over 300 "network assassins" currently work there.[97]

Education

As part of a project for establishing key military educational institutions during the 11th Five-Year Plan period, the PLAN "continues to focus efforts on building a number of institutions and research centers for disciplines and specialties that are important in building an informationized military and winning informationized wars."[98] Transformation of teaching materials has reportedly

become the "top priority of all priorities" for many of these institutions. In this regard, the PLAN Command Academy has "actively made explorations and fruitful experiments, continuously updated the contents of the teaching materials, improved the teaching material system, and enhanced the level of teaching material development."[99] In addition to these high-level initiatives, a variety of measures are afoot to ensure that more PLAN personnel are provided with opportunities for further education through everything from special classes to libraries and local area networks with educational materials.

Remaining Challenges

Despite the aforementioned improvements, according to Rear Admiral Yang Yi, "The Chinese military has still not completely achieved mechanization, and we are even farther from establishing an informatized force."[100] According to a major PLAN commentary,

> At present, the simulation devices used by naval units in their military training on the whole cannot satisfy the actual military training needs and still lag behind the development of armament. The insufficiency of simulation training devices has become a major "bottleneck" that restrains efforts to build fighting capacity in naval units. In practical training, it is hard for us to simulate a strong "blue force," but things may be completely different on the network platforms. The attacks there seem to be more authentic.[101]

The use of local area networks in naval education, for instance, has been impeded by lack of familiarity with the demands of informatization, challenges of network management and maintenance, concerns regarding information security, and the desire of some higher-ranking officers to monopolize access to information.[102] According to Ren Xiao, associate dean of the Institute of International Studies at Fudan University, "although rapid progress is being made in various aspects of the PLA building, because of the comparatively weak foundation and low starting point for modernization and the incomplete condition of mechanization, the process of informatization in the PLA remains at an initial stage, and the modernization level still lags substantially behind that of the world's military powers."[103] Articles in *People's Navy* also acknowledge that the ability of PLAN personnel to implement reforms effectively remains a major constraint on informatization efforts.[104] It is important to recognize, however, that *People's Navy* often serves a didactic function to call attention to areas that need improvement. This in no way constitutes a self-assessment by the PLAN that implies despair at improving the situation. Indeed, there have been great improvements in recent years, albeit from a relatively low baseline by Western standards.

Implications for Joint Operations and C2

This section analyzes the implications of PLAN informatization. The first part of the section addresses the implications for the PLAN's ability to conduct joint operations. The second focuses on the implications for the C2 system.

Naval Informatization and Joint Operations

Numerous recent PLA publications emphasize the importance of joint campaigns and joint operations.[105] In *The Science of Campaigns*, for example, the authors describe joint campaigns as "the primary form of future warfare."[106] PLAN publications also consistently emphasize the growing importance of joint operations, which many authors connect to the challenges of informatized operations in a complex battlefield environment. According to one article on the modernization of Chinese naval power, "under informatized conditions the structure of the equipment for the ships has been changed and the electronic systems have become a main component for the weapons and equipment. … the battlefield environment has changed, and operation assurance is facing the challenge of the complex electro-magnetic environment. . . . integrated joint operations have become the main operational pattern."[107]

Chinese military authors define joint campaigns as campaigns that involve the participation of two or more services, and in which all participating forces operate under the direction of a joint campaign command. According to *The Science of Military Strategy*, for instance, "The strategic coordination refers to the coordinated and concerted actions taken according to the tasks, space and time by different strategic groups and different services and arms carrying out strategic tasks so as to realize the overall strategic aim." Strategic coordination of this type is the responsibility of the strategic command authorities.[108] The writings on joint campaigns imply the equivalence of all of the participating services. This is potentially controversial in a military traditionally dominated by the ground forces. In Dean Cheng's words, this emphasis on the equality of the services in joint campaigns marks a "fundamental and major shift in PLA culture."[109]

Joint operations and informatization are expected to play a prominent role in a variety of campaigns in which the PLAN might be called to participate. Chapter 12 of *The Science of Campaigns*, "Joint Blockade Campaign," for instance, emphasizes the need to achieve objectives rapidly in a complex battle environment by jointly implementing an air, maritime, and information blockade.[110] The last entails "actively destroy[ing] the enemy's important ground information installations, disrupt[ing] the enemy's satellite and radio channels, cut[ting] off the enemy's submarine cables and cable channels . . . [and] smashing the enemy's information warfare capability."[111] In an antiair raid campaign, it is also thought necessary to "apply all kinds of information attack operational weapons and

equipment to jam, suppress, damage, and destroy the enemy air raid information system."[112] In "Offensive Campaigns Against Coral Island Reefs,"

> It is essential to synthesize the use of the various means of reconnaissance, and establish a perfected intelligence and reconnaissance architecture [情报侦察体系] in order to provide real-time intelligence [实时情报] for campaign operational activities. Furthermore, it is essential to: synthesize the use of multiple signals connectivity measures; establish a single organic vessel-, aircraft-, island- and shore signals network body; hold in reserve signals troops as well as a specified quantity of spare signals materials parts; and safeguard the speed, accuracy, secrecy and continuity of campaign communications.[113]

Joint campaigns require joint campaign command structures, which are responsible for coordinating service activities in pursuit of the overall campaign objectives. According to Dean Cheng, the chief roles of the joint campaign command are "resolving issues of timing, phasing, and various other aspects of coordination."[114] According to the *Science of Military Strategy*, the command and communications systems of troops under the same command or participating in coordinated operations must be interoperable.[115] Technical interoperability of C4ISR assets is a necessary, but not sufficient, condition for the development of joint operational capabilities.

The PLA is clearly striving to develop the capability to plan and conduct joint campaigns, but Chinese authors suggest that it is still in the preliminary stages of "jointness." Dean Cheng highlights a 2002 *Liberation Army Daily* article in which the author characterizes the achievement of a true joint operations capability as a three-stage process. In the first stage, considered preliminary joint training, there are three unbroken eggs in a bowl. In the second stage, which is characterized as limited joint training, the three eggs are broken. It is only in the third stage, however, that the eggs are mixed together and all-around joint training is achieved. The article implies that the PLA is still relatively early in this process, though it aspires to move forward so that it will ultimately be able to conduct the more sophisticated types of joint training and operations.[116] Nonetheless, it is important to highlight that Chinese writings on joint campaigns focus on achieving jointness at the operational level, rather than jointness at the tactical level as practiced by U.S. forces. Furthermore, as ONI noted in its 2009 report on Chinese naval modernization, "Emphasis on jointness has been noted in exercises, professional education, and logistical planning, yet significant challenges still exist. Progress continues to be hampered by a decades-old domination of the Chinese military by the army, which remains at many levels."[117]

The PLA still faces several potential problems, many of them bureaucratic and institutional. Perhaps the most important of these is a highly

centralized and hierarchical command structure and organizational culture that is averse to delegating decisionmaking authority to lower levels, much less junior officers and NCOs. Another potential roadblock is institutional resistance and bureaucratic opposition resulting from the tendency of joint campaigns to emphasize the importance of the PLAN, PLA Air Force (PLAAF), and Second Artillery and to downplay the traditional dominance of the army. The Chinese military has recognized that organizational reforms and changes in command structure are required to support the conduct of joint operations. Achieving these changes will require overcoming institutional resistance. Developing a manual (*gangyao*[118]) for joint operations, an accomplishment almost 10 years in the making, was just the beginning of what will probably be a long and difficult process of reorganization and institutional change.

Still another challenge is the PLA's almost total lack of real experience conducting joint operations (the only historical example being the relatively small-scale Yijiangshan campaign in 1955; the rest of the PLA's warfighting experiences were at most combined arms campaigns).[119] As the 2006 DOD report on Chinese military power points out, "Although the PLA has devoted considerable effort to developing joint capabilities, it faces a persistent lack of interservice cooperation and a lack of actual experience in joint operations."[120] Finally, the PLA faces the challenges of undertaking so many major changes simultaneously.[121] In short, the PLA will likely encounter a variety of challenges as it moves forward with the development of joint operations capabilities.[122] Nevertheless, the PLA has already made considerable progress and is clearly determined to further enhance its ability to conduct joint operations.

Recent publications suggest that at least some in the PLA believe China will eventually need to reach a level of integration comparable to the level of "jointness" in the U.S. military. According to one article by a student at the PLA's National Defense University, "All of the ground, air, naval, space, electromagnetic and other forces must be blended together and this system must be organized by tasks, not by services or space. The combat forces of the various services and branches must be mixed together to a high degree."[123] Such a level of integration would require an interoperable communications system that links the ground forces, PLAAF, PLAN, Second Artillery,[124] and a "continuous command decision-making process" [连续的指挥决策 过程], rather than a "coordinated joint operations command process based on running around in circles" [循环往复的协同性联合作战指挥过程].[125]

Naval Informatization and the C2 System

In addition to informatization's effect on the PLAN's ability to conduct joint operations with the other services, the introduction and integration of advanced information technology is also likely to influence the PLAN's approach

to command and control (C2). The PLA has a tradition of highly centralized command. This tradition derives from a variety of sources, including the political system, institutional culture, and organizational structure.

Chinese scholars argue that the PLA's general staff organizational structure is conducive to centralized C2. According to Peng Guangqian and Yao Youzhi, two major generals with significant ability to shape PLA strategy as advisers to China's powerful Central Military Commission (CMC) and Politburo Standing Committee, "The form of general staff is beneficial to the centralized command and control of the troops."[126] Moreover, for the PLA, unity of command historically has meant centralization of command. Mao emphasized centralizing the decisionmaking responsibility in the hands of a small number of senior leaders or even one person.[127] This tradition appears to have considerable staying power. According to Peng and Yao, for example, "All the decision-making power and command authority on issues concerning the overall war situation should be centralized to the strategic commander and the strategic commanding authorities."[128] Moreover, they write, "No services and arms or units shall be allowed to change the operational objectives and operational plans specified by the strategic commander and the strategic commanding authorities without authorization."[129]

Given the PLA's long tradition of centralized command, it seems entirely possible that China will choose to use its improved C4ISR capabilities to make centralized command function more efficiently and effectively. Chinese authors have certainly recognized the potential of enhanced communications capabilities to enable higher-echelon decisionmakers to function more effectively. For example, Peng and Yao argue that advances in information and communications technology have "significantly enhanced the efficiency of strategic command."[130]

High-bandwidth secure communications, for instance, allow strategic leaders to transmit plans and other operational documents electronically in real-time and hold videoconferences with their subordinates instead of traveling to the front for face-to-face meetings. According to Peng and Yao: "Under high-tech conditions and with the aid of the strategic command automation system, the form of assigning strategic tasks orally, realized only face to face in the past, can now be actualized between different places, and assigning strategic tasks in the past by written operations documents can now be completed through computer network in real time."[131] Specifically, they add, "Practices [have] proved that the very strict system of reports and requests for instructions was a very effective method of the PLA to conduct strategic supervision and inspection."[132] "Under modern conditions," therefore, "special attention should be paid to making use of the high-tech strategic command automation system to conduct the supervision and inspection."[133]

Supervision and inspection are not supposed to degenerate into meddling for its own sake, however. The purpose of supervision and inspection activities is to make sure that the actions of the PLA's combat units accord with the commander's strategic intent. "It can be said that conducting strict and scientific supervision is one of the good traditions of the PLA in its strategic command. And this good tradition is still of great significance to the strategic command under high-tech conditions."[134]

There are also strong incentives to consider decentralizing authority, at least to some extent. Indeed, notwithstanding the strong emphasis on the role of the strategic commander and the centralized command system, PLA writers suggest that strategic decisionmakers should not attempt to micromanage activities at the tactical and operational levels. According to Peng and Yao, "The strategic commander has command and control authority over all military troops up from the strategic operational groups down to the units and elements. However, due to the high level of strategic command, it is neither necessary nor possible for the strategic commander to closely command and control all the details of all the armed forces' operations."[135]

Having more information at higher echelons is not necessarily better; huge amounts of data may simply overwhelm strategic commanders. As Peng and Yao write: "Under the high-tech conditions, the glut and overload of strategic information have increased to a large extent the difficulties of strategic judgment . . . it's not an easy job to retrieve and pick out valuable strategic information when the total sum of strategic information has greatly increased." Furthermore,

> the high-tech means of reconnaissance, intelligence and communication can blow away to a certain extent the traditional "fog of war," but at the same time they can change the manifestation of uncertainty in war, thus adding a new "fog of war." Therefore, under the high-tech conditions, making sound strategic judgment demands dealing effectively with the information overflow, and processing and utilizing the information in a scientific way.[136]

Centralized command does not mean that strategic commanders should micromanage operations or that lower-level commanders should never take the initiative in response to a rapidly evolving situation on the battlefield. As Peng and Yao put it:

> Emphasizing the centralized unity of command does not necessarily mean that the strategic commander and the commanding authorities can interfere in and even run the whole show of his subordinates' command. In the course of conducting the strategic command, the strategic

commander and his commanding authorities should permit and encourage, under the prerequisite of not infringing the overall strategic intention, the junior commanders to give full play to their subjective initiative and creatively fulfill their operations tasks.[137]

Moreover, "If flexibility is pursued without due consideration for the overall situation or each goes his own way on the pretext of flexibility, the cooperation and coordination of the overall strategic situation shall be affected, and the smooth realization of the whole strategic plan shall be affected and even undermined. Therefore, to conduct highly efficient strategic command, high unity of the initiative, the flexibility and the planning must be persisted in."[138]

Wartime emergencies may result in extreme centralization of command, or devolution of authority to commanders at lower levels, depending on the circumstances.

Certainly, major doctrinal writings stress the importance of the strategic commander being able to handle all foreseeable contingencies:

> After the commencement of war, the strategic commander regulates the operations of his subordinates through his strategic determination and strategic plan. In the course of war, many unpredictable things often come about with the changes of the battlefield situation, and the strategic commander must make a correct assessment of the situation, make timely adjustments to the strategic plan, address different situations flexibly and hold firm the helm of command to lead the war to victory.[139]

Also, "Under emergencies, the junior commander should be given the authority to make prompt decisions and act according to circumstances."[140]

But Chinese texts also indicate that decisionmakers at the General Staff Department (GSD) or CMC level may directly exercise command over lower-echelon units under emergency circumstances. According to Peng and Yao, in wartime emergencies, "the supreme headquarters can bypass the immediate leadership to exercise its command."[141]

More broadly, PLA writers appear to be engaging in a debate about the advantages and disadvantages of centralized and decentralized command systems. Some PLA authors argue that conducting complex joint firepower strikes requires centralized command. They contend that there must be centralized and unified planning, organization, control, and coordination to conduct high-efficiency integrated firepower strikes. They point out that participating forces belong to different services and branches, so command relationships are complex and carrying out operational tasks will require temporary partnerships, which means that organization will be difficult. Consequently, there must be centralized control of all of the services' and

branches' firepower strike forces to assure the timeliness, continuity, and coordination of firepower strike operations.[142]

Other PLA writers appear to favor a C2 system that gives greater autonomy to junior leaders on a more routine basis, not just under emergency conditions that impede communications with higher-level commanders.

Chinese analysts recognize that there are inherent trade-offs between centralized and decentralized command systems.[143] Indeed, PLA officers are engaging in debates about command relationships and organizational culture. Some parts of this debate have taken place indirectly through the PLA's analysis of U.S. military operations. For example, the PLA's official history of the Gulf War, produced by the PLA's Academy of Military Science (AMS), credits "flexible command" with enhancing the combat effectiveness of coalition forces.[144] According to the Military History Research Department of the AMS, which edited the volume, "In the Gulf War ground campaign, in order to bring into play the initiative and creativity of lower-ranking commanders the U.S. military widely adopted a style of command that placed responsibility in their hands."[145] Higher-level planners indicated the tasks that had to be completed, but substantial autonomy and responsibility were delegated to lower-level commanders to determine how best to complete the assigned tasks. The editors' evaluation of this style of command is clearly highly favorable. They assess that the "task-oriented style of command" was one of the main reasons that U.S. forces won the war so quickly. They also note with approval that "the flexibility of this type of command was reflected in the ability of commanders to rapidly reach new judgments and change their original decisions in response to changes in the battlefield situation."[146]

In contrast to the flexible approach of U.S. and coalition forces, Iraq's command arrangements were outdated and further diminished its chances of winning the conflict. On the Iraqi side, "command authority was excessively centralized, limiting the initiative of lower-level commanders."[147] The overcentralization of authority also meant that when Iraqi forces in the field lost contact with higher-level commanders, they were unable to respond to changing situations with any flexibility. Although the authors of the volume do not apply this analysis explicitly to command in the Chinese military, their assessment seems to convey some implicit criticism of the PLA's own traditional, highly-centralized style of command, and to suggest that more autonomy should be devolved to commanders at lower levels.

The informatization of the PLAN, especially advances in ISR and communications capabilities, may offer China the opportunity to employ a more flexible and responsive C2 system that relies on "directive control" and "mission type orders" to meet the challenges of joint operations in high-tech

regional wars. The terms "directive control" and "mission type orders" derive from the German concept of *Auftragstaktik*, which calls for general guidance rather than highly centralized oversight of operations. This decentralized approach is considered a central element of C2 for modern joint operations.[148] It is associated with individual initiative and independent decisionmaking at relatively low levels. Senior commanders tell junior commanders what objectives to accomplish, but allow their subordinates to determine how best to accomplish the mission. According to Keithly and Ferris, "Skillful commanders, guided by doctrine, should be able to develop and exercise suitable tactical moves in an operation on their own initiative, achieving mission objectives in accordance with theater operational and strategic goals. Directive control allows commanders to adapt to changing circumstances, exercise flexibility, demonstrate initiative, anticipate events, and thereby gain tactical and operational advantage."[149] Although adopting such an approach would appear to offer significant operational advantages to the Chinese military and to complement the PLA's evolving doctrine, a number of obstacles would potentially stand in the way of such a dramatic transformation. The most important of these obstacles are the PLA's tradition of highly centralized C2 and an organizational culture that does not appear to encourage junior officers to take the initiative. If these hurdles could be overcome, successful implementation of a more flexible C2 system would require providing training and education aimed at developing junior leaders capable of taking the initiative and seizing fleeting opportunities on the battlefield.

To be sure, modern military commanders have not always used advances in technology to support the delegation of authority to lower echelons. On the contrary, in many cases, they have sought to use technology to improve the efficiency and effectiveness of centralized C2. As Keithly and Ferris point out, "technology can be a two-edged sword, especially when developments lend themselves to ever-greater centralization of execution, and in extreme cases to battlefield micromanagement."[150] It is entirely plausible that the PLA will pursue this well trodden path instead of exploiting technological advances to implement a "directive control" or "mission type orders" system, especially given its institutional predispositions. Indeed, it remains to be seen how the PLA will adapt its command style to changes in doctrine and improvements in information and communications technology. Enhanced IT and C4ISR systems capabilities could permit the PLA to give greater decisionmaking authority to lower-level commanders. At the same time, however, the modernization of the communications infrastructure could just as easily reinforce strong organizational tendencies to favor highly centralized C2 arrangements, as seems to have happened in some recent U.S. military operations.

These are challenges that the entire PLA must confront, but there are also several service-specific issues that PLAN commanders will need to resolve in the coming years. First, C2 of PLAN assets is somewhat complicated due to the organizational structure of the PLA. The commanders of the PLAN's three fleets answer both to PLAN Headquarters and to regional military commanders. As Peng and Yao point out:

> The command departments of the military area commands shall be directly responsible for the command of the joint services and combined arms operations within their respective military areas in wartime. The PLA has adopted a dual command system for the Navy and Air Force troops. When the Navy or Air Force troops carry out operational tasks alone or as the main force, the supreme headquarters administers its command through the command departments of the Navy or Air Force; when the Navy or Air Force carry out operational tasks in cooperation with other services, they are under the command of the command department of the corresponding military area command.[151]

Second, the deployment of SSBNs will present the supreme command and the PLAN with special challenges. The supreme headquarters exercises direct C2 over China's strategic missile forces through the Second Artillery Corps.[152] Presumably, the supreme headquarters would also exercise direct C2 over deployed SSBNs through the GSD or PLAN Headquarters.

Centralization is essential for SSBN C2, particularly in the highly centralized PLA. Insights into C2 are extremely difficult to obtain, but recent research relevant to China's submarine force offers preliminary suggestions. According to John Wilson Lewis and Xue Litai, China's SSBN force, like all other nuclear units, is overseen by the Strategic Forces Bureau. This is intended to ensure that "Only the [Central Military Commission] Chairman . . . has the authority to launch any nuclear weapons after getting the concurrence of the Politburo Standing Committee and the [Central Military Commission]."[153]

The PLAN has been working to achieve secure, reliable SSBN communications for more than two decades.[154] However, it remains unclear to what extent centralized SSBN command, control, and communication (C3) is possible for China across the range of nuclear scenarios. "At present China's communications infrastructure is vulnerable to a first strike," Garth Hekler, Ed Francis, and James Mulvenon contend.[155] This points to another critical problem for the PLAN: ensuring the ability to communicate with SSBNs in an environment in which its C2 system has been degraded.[156]

Conclusion

Enhancing China's naval capabilities is a key component of China's military transformation, as reflected by several recent leadership statements on the importance of naval modernization and the development of several new classes of surface ships and submarines in recent years. Moreover, informatization is clearly a central aspect of PLAN modernization, and naval C4ISR modernization will have important implications in areas such as joint operations and command and control. Chinese C4ISR modernization has become a top priority, and PLAN informatization appears to have made some impressive progress in recent years.[157] "In line with [the PLA's] strategic objective of building informationized armed forces and winning informationized wars," China's 2010 Defense White Paper maintains,

> Significant progress has been made in building information systems for reconnaissance and intelligence, command and control, and battlefield environment awareness. Information systems have been widely applied in logistics and equipment support. A preliminary level has been achieved in interoperability among command and control systems, combat forces, and support systems, making transmission of orders, intelligence distribution, command and guidance more efficient and rapid.[158]

Indeed, there appears to be tangible evidence of Chinese efforts to achieve all of the abstract concepts reflected in Chinese writings:

- The PLAN appears to be pursuing a full range of sensors across the radio frequency (RF) and acoustic spectrums.

- New PLAN weapons reflect efforts to increase speed (and thus decrease enemy reaction time), reduce signature and thus observability (again, decreasing enemy reaction time), and increase the sophistication of seekers.

- The PLAN is pursuing new communications capabilities across the RF spectrum.

- In C2, the PLAN is seeking increased automation and data links.

- The PLAN is fielding a broad range of new space systems for navigation, sensing, and communications, as well as antisatellite capabilities.

- The PLAN is seeking sophisticated capabilities for computer network attack and exploitation.

- The PLAN is pursuing kinetic information warfare and signal jamming capabilities.

For nearly every operational concept, one can see tangible evidence of systems development, and perhaps even more so than China's military competitors in the area of information denial. Clearly, the PLAN is serious about the hardware aspects of naval informatization. At the same time, however, at least three broader and no less important questions remain unanswered.

How Unique Are Chinese Concepts of Informatization?

The first unanswered question is whether there is anything in the Chinese concept of informatization that is radically different from Western characterizations of the role of information and information and communications technology in modern warfare. It is not evident from the Chinese sources that there is anything truly unique about how Chinese strategists view the importance of information and information superiority. Some of the Chinese writings are undoubtedly attempts to assimilate and repackage ideas that are very familiar to readers of U.S. and Western writings on "network centric warfare," information dominance, and related concepts. It is possible that these similarities are an artifact of a translation process that seeks to fit uniquely Chinese concepts into more familiar U.S. and Western terminology. But it seems more likely that these are more or less universal conceptions of the role of information in modern warfare that are quite consistent with U.S. and Western thinking. Open source writings offer good insight into Chinese thinking with respect to information in warfare, but Chinese thinking is still evolving and Chinese theorists seem to be in roughly the same position as U.S. proponents of network centric warfare with respect to connecting abstract concepts to operational practice. Indeed, the actual connection between abstract theory and practice remains unclear and the question of how long it will take to go from theory to practice remains unanswered. Nevertheless, if the PLAN conception is very different from that of the U.S. Navy, the latter might be surprised by how close the PLAN is to making the conceptual transition.[159] Consequently, it will be important to watch the trends in both PLAN writings and practice to see how these developments play out in both the short and long term. Of perhaps most critical concern would be any evidence of radically different, asymmetric approaches to informatization and the attainment and exploitation of information dominance that could offer China military capabilities a relative level of power that is now unforeseen.

How Informatized Does the PLAN Really Need to Be?

The second of these broader questions centers on how close the Chinese are to achieving the so-called "informatized force." The PRC's 2006 Defense White Paper established a goal of being able to fight and win informatized wars by the mid-21st century. This reflects a perceived relative and persistent gap

between the Chinese armed forces and the world's most advanced militaries that Chinese writers often suggest will take decades to overcome. But it also raises the issue of distinguishing between the "ideal" capability the Chinese military seeks to establish in the long term and that which might simply prove "good enough" in the relatively near term.

For the most part, Chinese analysts tend to overestimate U.S. and Western capabilities and portray themselves as backward by comparison. Certainly many Western observers continue to denigrate PLA capabilities and note that even some of the Chinese military's recent achievements are relatively simplistic by U.S. standards. These limitations certainly merit examination: perhaps China's greatest C4ISR challenge is "bureaucratic data fusion," as different organizations control different elements of sensor architecture yet lack joint operational experience, control of some space assets changes from peacetime to wartime, and a robust interservice struggle is underway for overall control, the outcome of which remains unclear.

But one should ask how often U.S. forces actually implement such a complex "system of systems" in practice themselves. A relatively simple system of deconfliction by time or geographic area with disparate platforms might actually be "good enough" to allow the PLA to achieve its objectives under most circumstances.

The most common criticism of Chinese capabilities is the apparent lack of a sophisticated sensor-to-shooter data fusion capability for utilizing long-range, precision-strike weapons. This may be a valid critique, but the need for a complex C4ISR system should not be overstated. This is the case for three reasons. First, much of the need for sophisticated target data fusion can be mitigated by building smarter missile seekers that perform target discrimination that is good enough for a given missile inventory. The United States still maintains a man-in-the-loop to prevent collateral damage and fratricide. The Chinese might have fewer qualms about such occurrences and thus leave much more of the targeting "decision" to the missile itself. Second, the Chinese certainly put a premium on missile speed to rapidly exploit often-fleeting data on mobile targets and reduce the need for target tracking. For instance, a typical short-range ballistic missile flight time to maximum range is on the order of 6–7 minutes, that of a medium-range ballistic missile 10–11 minutes. Third, numbers matter. The notion of "one weapon, one target" may not be applicable to the Chinese military. At some point, the cost of discriminating targets from nontargets exceeds the cost of destroying all possible targets. A low concern for collateral damage and fratricide makes classification by destruction an attractive option. China is fielding land attack and antiship missiles in numbers that reach well into the thousands.

In short, the PLAN might have a very different metric for integrated C4ISR than that of the U.S. Navy. The U.S. concept emphasizes having "one weapon, one target" on the battlefield and minimizing collateral damage. The PLAN could mitigate many of the sensor and fusion problems with a large arsenal and classifying "by destruction," particularly if collateral damage is not much of a concern. The Chinese notion of C4SIR requirements might differ from that of the U.S. Navy, and the PLAN might achieve an employable capability with surprising rapidity, especially if it pursues one that is relatively crude by U.S. standards, but that is nonetheless "good enough" to meet operational objectives.[160]

How Will the PLAN Resolve Two Critical Informatization Debates?

Perhaps most interesting in the Chinese writings examined are the ongoing debates arising from increased informatization. These will be very insightful to watch as the PLA struggles with some of the same basic issues that are being debated in the U.S. and Western militaries. Two major debates merit elaboration here.

The first concerns the offense-defense balance in information warfare, that is, the issue of information assurance versus information denial. The conceptual goal is obviously full information assurance for one's own forces and complete information denial to the enemy's forces. More likely this is some type of balance depending upon capabilities and geography. One could posit that information assurance tends to favor short-range operations close to home (where one can rely on land lines and high power line-of-sight communications), i.e., in the Near Seas; while information denial might predominate at long range away from home, i.e., in the Far Seas (where one becomes reliant on satellite communications and long-range RF signals that might be jammed or geolocated). It will be interesting to see how this debate progresses in Chinese writings, especially as strides are made in perhaps creating a regional blue-water navy.

A related question that remains unanswered is whether the PLAN will develop unrealistic expectations about the potential of informatization. In the United States and other countries, some observers have gone so far as to suggest that the widespread employment of advanced information technology will dramatically reduce or perhaps even eliminate much of the confusion and uncertainty of the battlefield. Recent military operations have shown the value of advanced information and communications technology, but have also demonstrated some of its vulnerabilities and limitations. Advances in informatization will dramatically improve the Chinese military's situational awareness and communications capabilities, but these changes will not eliminate the problems of friction and the fog of war for the PLA any more than they have for any other modern military. As Keithly and Ferris warn, "A grave

contemporary mistake is to regard technological advances in communications as a means finally to overcome the fog and friction of war."[161] It remains to be seen whether the PLA will heed this warning.

In this vein, a key possibility that Chinese planners must consider is that the PLAN's continuing development of modern C4ISR capabilities will not only enhance its ability to operate effectively, but also increase its vulnerability to C2 warfare. As the PLAN becomes more reliant on high-tech C4ISR systems, it will need to be prepared to contend with electronic, computer network, and kinetic attacks designed to disrupt or deny its ability to use these new capabilities. Indeed, the PLAN—along with the rest of the Chinese military—will likely need to devote just as much attention to protecting its own C4ISR capabilities as it will to degrading or destroying those of its potential adversaries. Here PLAN writings do not yet seem to offer a definitive conclusion with respect to the offense-defense balance. The Chinese appear to be pursuing both efforts with equal vigor, both practically and theoretically. One could conclude that for short-range C2, where nodes can be connected by land lines, connectivity will generally trump efforts to deny it, but for long range C2, where nodes must be connected by RF signals, interruption will generally trump efforts to maintain connectivity. PLAN writings do not yet offer a definitive assessment of this problem, but it would seem to be quite important for future Chinese naval operations, including the prospects of PLAN power projection beyond areas in which China can rely on "using the land to control the sea" (以陆制海).[162]

The second debate concerns the appropriate balance between centralization and decentralization. The conceptual goal for most militaries is centralized planning and decentralized execution—that is, empowering the lowest levels with information so that they can leverage superior tactical training and initiative. Certainly the practical experience in the West does not always match this conceptual goal. Indeed, many times the reality is that "commanders who can control, do control." This is certainly an issue that has been raised in Chinese writings—with the so-called "10,000 mile screwdriver" as evident to them as it is to us. The issue of decentralized operations will likely be a more difficult issue for the PLA, which is not known for valuing and cultivating battlefield initiative in the high-technology operations called for in modern war. In particular, Chinese writings seem to reflect the opposite view, that informatization should offer the provision of decentralization in emergencies. Indeed, one could conclude that some of their key efforts at informatization are intended to increase rather than decrease centralized control.

Nonetheless, PLAN "connectivity" theories and efforts do appear to have provoked a debate between advocates of centralization and proponents of decentralization. The historical experiences of other navies

suggest that centralization tends to win out if connectivity can be maintained (e.g., commanders "will command what they can command"). If connectivity is denied, however, then forces have tended to fall back on decentralized execution, with tactical training generally carrying the day. It is possible that China will seek to mitigate relative tactical training deficiencies by "taking the man out of the loop" at the tactical level. Depending upon the offense-defense balance, the PLAN might become very good at short-range operations, but face serious problems at long range where RF sensor-to-shooter links might be effectively denied.

On a more concrete level, it remains to be seen whether the PLAN will use its enhanced C4ISR capabilities to push information down to lower levels and empower junior commanders to make decisions, or instead attempt to leverage new ISR capabilities and growing communications capacity to further strengthen centralized C2 at higher echelons, which would probably be more consistent with the Chinese military's present approach to C2. Although hardware modernization garners much of the attention from outside observers, there is a strong case to be made for devoting more attention to some of the less readily quantifiable factors such as "software" reforms and the organizational culture of the PLAN, which will likely prove to be equally important determinants of the extent to which naval informatization will translate into greater combat effectiveness and an improved ability to conduct joint operations.

The overall implication could be that China is on a path to conduct highly effective centralized operations close to China itself. This may be useful in an access denial role, but might also be an effective limitation on China's future power projection in which information assurance decreases with distance. Clearly, the evolution of the theory and practice of naval informatization will merit careful observation.

Notes

[1] For more on Hu's speech, see David Lague, "China Airs Ambitions to Beef Up Naval Power," *International Herald Tribune*, December 28, 2006, available at <http://www.iht.com/articles/2006/12/28/news/china.php>.

[2] Wu Shengli, Commander of the Navy, and Hu Yanlin, Political Commissar of the Navy; edited by Wang Chuanzhi [吴胜利, 胡彦林], "Building a Powerful People's Navy That Meets the Requirements of the Historical Mission for Our Army [锻造适应我军历史使命要求的强大人民海军], *Seeking Truth* [求是], no. 14 (July 16, 2007), available at <http://www.qsjournal.com.cn/qs/20070716/GB/qs^459^0^10.htm>.

[3] Ibid.

[4] Ibid. According to Wu and Hu, "The Taiwan issue involves our national security and development—the full unification of our nation. It is also the key interest of the Chinese nation and one of the three important historical missions for our Party. To ensure the unification of our nation is the holy mission of our army. A powerful navy is a key force that can shock the 'Taiwan independence' separatists, and defend the unification of our nation."

[5] Ibid. As Wu and Hu elaborate, "In order to protect normal fishing, oceanic resource development, oceanic investigation and scientific tests, to maintain the safety of the oceanic transportation and the strategic passageway for energy and resources, to ensure the jurisdiction of our nation to neighboring areas, continental shelf, and exclusive economic zones, and to safeguard our national maritime rights effectively, we must build a powerful navy."

[6] The policy defined four missions of the PLA: first, to serve as an "important source of strength" for the Chinese Communist Party (CCP) to "consolidate its ruling position"; second, to "provide a solid security guarantee for sustaining the important period of strategic opportunity for national development"; third, to "provide a strong strategic support for safeguarding national interests"; and fourth, to "play an important role in maintaining world peace and promoting common development." The last two missions truly reflect new emphases for the PLA, and the fourth is unprecedented. See "Earnestly Step Up Ability Building within CCP Organizations of Armed Forces," *Liberation Army Daily* [解放军报], December 13, 2004, available at <www.chinamil.com.cn>.

[7] Maj. Gen. Tian Bingren [田秉仁], "The Scientific Development of the Historical Mission of Our Army in the New Phase of the New Century" [新世纪阶段我军历史使命的科学拓展], *China Military Science* [中国军事科学], October 2007, 21–27.

[8] Shen Jinlong [沈金龙], "Naval Non-combat Military Operations—Challenges Faced and Countermeasures" [海军非战争军事行动—面临的挑战及对策], *People's Navy* [人民海军], December 1, 2008, 4.

[9] Liu Jiangping and Zhui Yue, "How to Reform the Navy in Order to Execute China's Maritime Strategy in the 21st Century: Management of the Sea in the 21st Century. Whither the Chinese Navy?" *Modern Navy* [*Dangdai Haijun*] (June 2007), 6–9.

[10] Ibid.

[11] See "China's National Defense in 2006," Information Office of the State Council, People's Republic of China, December 29, 2006, available at <http://www.fas.org/nuke/guide/china/doctrine/wp2006.html>.

[12] Liu and Zhui, 6–9.

[13] "China's National Defense in 2006."

[14] Office of Naval Intelligence, *Handbook on China's Navy 2007*, 24, 27.

[15] Ibid.

[16] An article that seems to refer to the *Luyang* II describes this "new generation of 'flagship' on the sea" as "a model for informatization of the navy." See Jiang Yi, Zhao Dong, and Wu Chao [姜毅, 赵东, 吴超], "Constructing a 'Flagship'—On-the-Spot Report on Construction of New Type of Guided Missile Destroyer Supervised by One of the Naval Equipment Technical Department's Representative Offices in Shanghai" [铸就 '旗舰' 啸海疆—海装驻上海某军事代表室监造某新型导弹驱逐舰纪实], *People's Navy* [人民海军], November 1, 2006, 1–2.

[17] "China's National Defense in 2006."

[18] Ibid.

[19] Chinese military researchers have clearly devoted considerable attention to U.S. writings on "network centric warfare" and applied some of these concepts to their own work. See, for example, Wang Lu and Zhang Xiaokang, "Analysis of C4ISR System in NCW and Analysis of Its Effectiveness" [网络中心战C4ISR系统研究及效能应用分析], *Command Control & Simulation* [指挥控制与仿真] 28, no. 2 (April 2006), 22–25; and Zhao Liang and Luo Xueshan, "Research on Collaboration and Its Quantifiable Model in Network Centric Warfare" [网络中心战中的协作及其量化模型研究], *Information Command Control System & Simulation Technology* [情报指挥控制系统与仿真技术] 27, no. 6 (December 2005), 35–39.

[20] Ji Chengxin, Li Xiangyang, and Wan Yongfeng, "Some Ideas of Naval Service Equipment Information Modification" [对海军现役装备信息化改装的几点思考], *Journal of the Academy of Equipment Command and Technology* [装备指挥技术学院学报] 17, no. 1 (February 2006), 10. The authors are affiliated with the Scientific Research Department at the PLAN Dalian Ship Academy (海军大连舰艇学院) in Dalian, China.

[21] Zhanyixue [*The Science of Campaigns*], 2006, Introduction, 10.

[22] Zhang Wenxin [张文新], "PLAN Draws Up 'Road Map' for Informatization Development" [海军设计信息化建设路线图], *People's Navy* [人民海军], May 10, 2006, 1. Military press coverage of an April 26, 2006 PLAN "Forum on the Informatization Development of the Navy," for instance, has not offered the contents of what were undoubtedly instructive speeches by PLAN Chief of Staff Sun Jianguo, Jiang

Zhijun, director of the Expert Consultation Committee on the Informatization of the Navy and of the PLAN Armament Research Institute, and other experts, as well as the forum's compendium of 107 selected articles on the subject.

[23] Ji , Li, and Wan, 10.

[24] Liu Jiangping and Zhui Yue, "Management of the Sea in the 21ˢᵗ Century: Whither the Chinese Navy?" *Modern Navy* [*Dangdai Haijun*], (June 2007), 6–9.

[25] See James Mulvenon and Thomas J. Bickford, "The PLA and the Telecommunications Industry in China," in James C. Mulvenon and Richard H. Yang, eds., *The PLA in the Information Age* (Santa Monica, CA: RAND, 1999), 245–257.

[26] Office of the Secretary of Defense [hereafter, DOD], *Annual Report on the Military Power of the People's Republic of China 2000*, 12.

[27] Ibid., 12–14.

[28] Ibid., 21. The report declared that the PLA's ability to "effectively command and control its forces—particularly in a joint service environment—is practically non-existent."

[29] Ibid.

[30] "China's National Defense in 2010," Information Office of the State Council, People's Republic of China, March 31, 2011, available at <http://news.xinhuanet.com/english2010/china/2011-03/31/c_13806851_8.htm>.

[31] Kevin Pollpeter, "Towards an Integrative C4ISR System: Informationalization and Joint Operations in the People's Liberation Army," in Roy Kamphausen and David Lai, eds., *The PLA at Home and Abroad—Assessing the Operational Capabilities of China's Military* (Carlisle, PA: U.S. Army War College and National Bureau of Asian Research, 2010), 204.

[32] See "China Reinforces Construction of National C3I System," *Kanwa Defense Review*, April 1, 2005, 18–19.

[33] Ibid.

[34] Ibid.

[35] Wang Feng and Yang Yuwen [王锋, 杨玉文], "The Navy's Comprehensive Military Information Network Is Officially Established, Indicating a Significant New Step Forward in the Navy's Network Building Effort" [海军军事综合信息网正式开通, 标示着海军网络建设迈上新台阶], *People's Navy* [人民海军], August 28, 2006, 1.

[36] Kou Yongqiang and Chen Jing [寇永强, 陈静], "Lofty Mountains and Islands Connected by Electronic Networks: 92 Percent of South Sea Fleet's Companies Are Now Connected to Military Network" [高山海岛e网通: 南航部队92%的连队接线军网], *People's Navy* [人民海军], November 29, 2006, 1.

[37] Lu Daoquan, Liang Qingcai, and Li Gencheng [吕道全, 梁庆才, 李根成], "Enhancing Information Support Capability at Sea—A Certain South Sea Fleet Vessel Dadui Is Devoted to Building 'Digitized Battlefields'" [提升海上信息支援能力--南海舰队某舰船大队倾心建造 数字战场], *People's Navy* [人民海军], September 1, 2005, 1. According to the article, "In a limited maritime war under high-technology conditions, information support is of the utmost importance. Maritime training operations such as ships setting sail, submarines remaining concealed, missile launches, and torpedo attacks all require sea survey forces providing accurate information."

[38] Wang Tingjun and Zhang Gang, "Reconnaissance Ship Group Provides Precise Battlefield Information for Warships" [某侦测船大队为战舰提供精确战场信息], *People's Navy* [人民海军], December 8, 2005, 1**.**

[39] Ji, Li, and Wan.

[40] Sun Tao, Qiao Yanfei, and Wu Chao [孙涛, 乔燕飞, 吴超], "Set the Sail Right and You Can Travel for a Thousand Leagues—A Certain Minesweeper Unit's Experience in Carrying Out Informatization Construction/A String of Puzzles: How Did the Minesweeper Capture So Many First Places?/Unraveling the Puzzles: They Had the Help of Informatization/Behind the Puzzles: Informatization Makes Its Landing On Old Equipment" [帆正自可行千里--某扫雷舰大队推进信息化建设的一段经历/ 谜提一串: 扫雷舰咋拿了那么多第一?/谜底揭开: 原来他们有信息化帮忙/ 谜的背后: 信息化老装备上'着陆'], *People's Navy* [人民海军], November 1, 2003, 2.

[41] Ibid., 12–14.

[42] Zhang Yuliang, "Chapter 14—Anti Air Raid Campaign," *The Science of Campaigns* (Beijing: National Defense University Press, 2006), 9.

[43] Dean Cheng, "*Zhanyixue* and Joint Campaigns," 114; Zhang Yuliang, 10–11.

[44] Zhang, "Chapter 14: Anti-Air Raid Campaign," *The Science of Campaigns*, 10.

[45] DOD (2006), 31.

[46] Richard P. Lawless, "Statement Before the Senate Foreign Relations Committee, Subcommittee on East Asian and Pacific Affairs," April 23, 2004.

[47] DOD (2006), 33.

[48] Evan S. Medeiros, Roger Cliff, Keith Crane, and James Mulvenon, *A New Direction for China's Defense Industry* (Santa Monica, CA: RAND, 2005) , 205–251.

[49] Ibid.

[50] Lawless.

[51] Chen Quanyu and Chen Huijun [陈全育, 陈会君], *China Space News* [中国航天报], December 4, 2008, available at <http://www.wforum.com/gbindex.html>.

[52] Liu Jihong and Li Peigong [刘继红, 李沛功], "PLA Employs Beidou and Space Remote Sensing Technology to Raise Precision Strike Capability" [解放军利用北斗及航天遥感技术提升精确打击能力], *Liberation Army Daily* [解放军报], May 9, 2010, available at <http://i.ifeng.com/mil/china/news?aid=3898051>.

[53] "FengHuo 1 (ChinaSat 22/A) Tactical Communications Satellite," *China Defense Today*, available at <http://www.sinodefence.com/space/spacecraft/fenghuo1.asp>; "China: Military Programs," available at <http://cns.miis.edu/research/space/china/mil.htm>.

[54] *Military and Security Developments Involving the People's Republic of China 2010* [hereafter, DOD (2010)], Annual Report to Congress (Washington, DC: Office of the Secretary of Defense, August 16, 2010), 36.

[55] Peter B. de Selding, "European Officials Poised to Remove Chinese Payloads from Galileo Sats," March 12, 2010, available at <http://www.spacenews.com/policy/100312-officials-poised-remove-chinese-payloads-galileo.html>.

[56] "Strategic Weapon System, China," *Jane's Sentinel Security Assessment—China and Northeast Asia*, January 17, 2011, available at <www.janes.com>.

[57] DOD (2010), 36.

[58] Sun Zhihui, ed., *China Ocean Yearbook 2004* (Beijing: Ocean Press, 2005), 569.

[59] For all launch schedule predictions, see "Chinese Launch Record," available at <http://www.sworld.com.au/steven/space/china-rec.txt; www.forum.nasaspaceflight.com>.

[60] Wu Xiaofeng and Deng Ping, "Stipulated Technical Procedure for Maritime Terrain Digitalized Satellite Surveying and Mapping Passes Experts' Evaluation" [《海上数字化地形卫星测绘技术规程》通过专家评审], *People's Navy* [人民海军], June 6, 2009, 1.

[61] DOD (2010), 1.

[62] For details, see Andrew S. Erickson, "China's Anti-Ship Ballistic Missile (ASBM) Reaches Equivalent of 'Initial Operational Capability' (IOC)—Where It's Going and What It Means," *China Analysis from Original Sources*, June 10, 2011, available at <http://www.andrewerickson.com/2011/06/china%e2%80%99s-anti-ship-ballistic-missile-asbm-reaches-equivalent-of-%e2%80%9cinitial-operational-capability%e2%80%9d-ioc%e2%80%94where-it%e2%80%99s-going-and-what-it-means/>.

[63] Wang Hangyu, Wang Huihua, Hu Fengping, Chi Jian, and Zhou Dexin, "The Exploration of the Key-Technique in Sensors Networking" [传感器组网的关键技术], *Fire Control and Command Control* [火力与指挥控制] 30, no. 4 (August 2005), 118–121.

[64] See, for example, Li Qiang, Zhao Xin-guo, and Li Peng, "Research on Data Integration of C4ISR System" [C4ISR系统数据集成研究], *Command Control & Simulation* [指挥控制与仿真] 28, no. 4 (August 2006), 29–32.

[65] See, for example, Liu Gang, Wang Minle, and Ye Guangqing, "Evaluation Model of UAV Combat Effectiveness" [无人侦察机作战效能评估模型], *Fire Control and Command Control* [火力与指挥控制] 31, no. 1 (January 2006), 45–51. The authors of this article are affiliated with the Second Artillery Engineering Institute in Xian.

⁶⁶ See, for example, Guo Weimin and Ma Aimin, "Visualized Simulation of Image Sonar on ROV" [灭雷具图像声纳可视化仿真方法], *Fire Control and Command Control* [火力与指挥控制] 31, no. 2 (February 2006), 66–68.

⁶⁷ See, for instance, Wang Tingjun and Zhang Gang, "Reconnaissance Ship Group Provides Precise Battlefield Information for Warships" [为战舰提供精确战场信息], *People's Navy* [人民海军], December 8, 2005, 1, extra edition.

⁶⁸ Wang Hai and Zhang Xiaoqi, "Digital Sea Chart Ushers in New Era of Navigation," *Liberation Army Daily* [*Jiefangjun Bao*], January 23, 2007.

⁶⁹ Editorial, "Make Great Effort to Promote a Transformation of the Navy's Military Training in the Direction of Informatization" [大力推进海军军事训练向信息化方向转变], *People's Navy* [人民海军], July 21, 2006, 1; PLAN Political Department Director Fan Yinhua, "The Scientific Development Concept Is the Guiding Ideology for the Significant Development of Socialist Modernization Construction," *Qiushi*, no. 6 (March 16, 2006), available at <http://www.qsjournal.com.cn/qs/20060316/GB/qs^427^0^5.htm>.

⁷⁰ Xu Sheng, "CMC Vice Chairman Xu Caihou Addressed Second National Defense Work Conference of Qinghua University, Called for Conscientiously Carrying Out Principle of Military-Civilian Integration, Providing Support in Terms of Qualified Personnel, Science, Technology; PLA General Political Department Director Li Jinai Also Attended Conference," *Jiefangjun Bao*, July 9, 2006, 1; Sun Dongyan and Wang Dongming, "Four General Departments under the PLA Issue 'Opinion' Standardizing Acceptance and Training of Local University Student Cadres," *Xinhua*, February 19, 2006.

⁷¹ Wu and Hu.

⁷² "Make Changes to the Training Mechanisms, Contents, and Methods—Second on Promoting the Innovation and Development of Military Training in the Navy in the New Stage of the New Century," *People's Navy* [人民海军], July 28, 2006, 1, OSC# CPP20060906318003.

⁷³ See "China's National Defense in 2006," Information Office of the State Council, People's Republic of China, December 29, 2006, available at <http://www.fas.org/nuke/guide/china/doctrine/wp2006.html>.

⁷⁴ Xu Zhuangzhi and Guo Jiabao, "People's Liberation Army Military Training Undergoes Historic Transformation—Focus on Informatization," *People's Daily* [*Renmin Ribao*], March 2, 2007, 15.

⁷⁵ Peter Harmsen, "China's Military Tests Sophisticated Real-Time Data System," Agence France Presse, September 19, 2007.

⁷⁶ Mi Jinguo and Jiang Xiangjie [米晋国, 姜祥杰], "Soul-Stirring Training Carried Out by PLA Naval Forces in Complex Electromagnetic Environments: A North Sea Fleet Destroyer Flotilla, Combat Ready and Set in Battle Formation, Seeks Out and Annihilates Powerful Enemy Forces in Complex Electromagnetic Environments" [海军部队复杂电磁环境下训练惊心动魄: 北海舰队某驱逐艇支队--雾里张弓列阵, 磁场寻歼敌], *People's Navy* [人民海军], July 3, 2007, 1. The article pledges that the newspaper "will devote more efforts to covering news in this respect as a means to push forward the in-depth development of training carried out by our naval forces in complex electromagnetic environments."

⁷⁷ Ibid., 1.

⁷⁸ Xiao Bai, "Blue Force Detachments: 'Whetstones' on the Battleground," CCTV-7, June 20, 2007.

⁷⁹ Commentator, "Make Changes to the Training Mechanisms, Contents, and Methods—Second on Promoting the Innovation and Development of Military Training in the Navy in the New Stage of the New Century" [从体制内容方法上求变革--二谈大力推进新世纪新阶段海军军事训练创新发展], *People's Navy* [人民海军], July 28, 2006, 1.

⁸⁰ Qin Ruoyun, "Meticulously Cultivate High-quality Commanding Talent," *Jiefangjun Bao*, May 1, 2007, 1.

⁸¹ Liu Jian [刘剑], "Submarine Academy Emphasizes Teaching and Training Under Complex and Emergency Conditions: Classroom Moves to the Training Ground; Instructors Switch with Warriors" [突出复杂和应急条件下的教学训练: 课堂训练场靠拢, 教员向战斗员转换], *People's Navy* [人民海军], December 15, 2006, 1. According to the article, "Lined up in front of computers were more than ten submarine captains and department heads fighting a battle of wits and courage, displaying their ability to coordinate all the battle stations on a submarine. No sound of gunfire was to be heard, yet the situation was no less tense than a unit's real-war exercise. Lines were linked up into a command net, constituting an extraordinary classroom battlefield. This setup is an important measure by which this academy emphasizes teaching and training under complex and emergency conditions and fosters the development of the corps of submarine unit commanders."

⁸² Du Guangrui [杜广瑞], "Informatized Command Node Rises Between Sea and Sky: South Sea Fleet Aviation Regiment Actively Explores Patterns of 'Air-Air Command' Training and Operations" [海天间崛起信息化 '指挥枢纽': 南航某飞行团积极探索 '空空指挥' 训练作战模式], *People's Navy* [人民海军], December 12, 2006, 1.

⁸³ Zhang Jian and Yuan Zhenjun [张剑, 袁珍军], "Data Platform Links to Three-Dimensional Battleground—Scenes of Long-Range Strike Field Exercises of a Destroyer Detachment of the PLA East Sea Fleet" [数据平台, 连通立体战场--东海舰队某驱逐舰支队远程奔袭对抗演练见闻], *People's Navy* [人民海军], August 4, 2006, 1.

⁸⁴ Cha Chunming, Li Fuxiang, and Chen Ji [查春明, 李福祥, 陈吉], "Our Special Reporter's Exclusive: From Scene Where PLA Navy Conducts Informatized Joint Drill" [本刊特约记者独家报道--人民海军信息化联合演练现场], *People's Navy* [人民海军], September 1, 2006, 14–19.

⁸⁵ Li Fuxiang and Wu Dengfeng [李福祥, 吴篓峰], "Navy Organizes Multi-service Arm Maritime Combat Communications Exercise" [海军组织多兵种海上作战通信演练], *People's Navy* [人民海军], August 16, 2006, 1.

⁸⁶ Peng Zecheng and Zhang Kejin, "A Certain Training Cooperation Zone of the Guangzhou Theater [zhan qu] Conducts Synchronized Training at Different Locations Using Computer Network to Train the Three Armed Forces," *Liberation Army Daily* [*Jiefangjun Bao*], March 2, 2006, 2.

⁸⁷ Commentator, "Strive to Enhance the Comprehensive Quality of Officers and Sailors—Fifth on Making Great Effort to Promote the Innovation and Development of the Navy's Military Training in the New Stage of the New Century" [着力提高官兵综合素质--五谈大力推进新世纪新阶段海军军事训练创新发展], *People's Navy* [人民海军], August 4, 2006, 1.

⁸⁸ See "China's National Defense in 2006," Information Office of the State Council, People's Republic of China, December 29, 2006, available at <http://www.fas.org/nuke/guide/china/doctrine/wp2006.html>.

⁸⁹ Commentator, "Building Well-functioning, Highly Efficient Command Organs" [建设务实高效的司令机关], *People's Navy* [人民海军], February 7, 2006, 1.

⁹⁰"China's National Defense in 2010."

⁹¹ Lu Daoquan, Rao Yanwen, and Li Gencheng [吕道全, 饶燕文, 李根成], "Using Battlefield Requirements to Drive Scientific and Technological Innovation: South Sea Fleet Reconnaissance Ship Flotilla Achieves Sustainable Development of Combat Power" [以战场需要牵引科技创新: 南海舰队某侦察船大队战斗力建设实现可持续发展], *People's Navy* [人民海军], October 13, 2006, 1.

⁹² Qian Xiaohu and Zhou Yawen, "A South Sea Fleet Base's 'Senior Blue Collar' Personnel Become 'Whetstones' for Sailor Training," *Liberation Army Daily* [*Jiefangjun Bao*], January 6, 2007.

⁹³ Chen Zhouhai and Yang Xiangchun [陈洲海, 杨向春], "Training Continues While Vessels Go Through Repair—Frigate 'Wuxi' Receives Outstanding Marks During the First Sea Training After Refit" [出厂后首次出海训练全优—'无锡'舰停航不停训], *People's Navy* [人民海军], June 12, 2006, 1.

⁹⁴ Chen Wanjun and Zhang Wenxi, "The Chinese Navy Established the First Ship Captain Training Center at Lushun Naval Base," *Xinhua*, October 24, 2006.

⁹⁵ Commentator, "Make Accomplishments in Promoting Informatization-Oriented Force Transformation of the Navy" [在推进海军建设向信息化转型中有所作为], *People's Navy* [人民海军], August 14, 2006, 1.

⁹⁶ Office of Naval Intelligence (ONI), *Handbook on China's Navy 2007*, 68.

⁹⁷ Lin Tsung-ta, "Information Warfare and the 'Development by Leaps and Bounds' Strategy of the PLA's Modernization," *Ch'uan-C'iu Fang-Wei Tsa-Chih* (May 2005), 90–93.

⁹⁸ See "China's National Defense in 2006," Information Office of the State Council, People's Republic of China, December 29, 2006, available at <http://www.fas.org/nuke/guide/china/doctrine/wp2006.html>.

⁹⁹ Qin Ruoyun [秦若云], "PLA Navy Command Academy Drives Teaching Material Reforms into the 'Fast Lane' by Adding Informatization Contents to 188 Sets of Teaching Materials, Some Are Selected to Be Priority Teaching Materials by the State and All PLA" [指挥学院教材改革驶入'快车道': 188部教材融入信息化作战内容, 多部入选国家军队重点教材], *People's Navy* [民海军], June 7, 2006, 3.

¹⁰⁰ Tao Shelan, "PLA Navy Admiral: China Is Pursuing a Defensive Strategy, But That Really Does Not Mean It Will Not Develop Offensive Military Capabilities," *China News Service* [*Zhongguo Xinwen She*], January 9, 2007.

[101] Commentator, "Effectively Implement the Training-first Support System—Sixth Talk on Promoting the Innovation and Development of the Navy's Military Training in the New Stage of the New Century" [切实落实训练优先保障制度--六谈大力推进新世纪阶段海军军事训练创新发展], *People's Navy* [人民海军], August 7, 2006, 1.

[102] Zhang Jian et al. [张剑], "Why Was There Not Much 'Traffic' on the Broad 'Road'?"—Education Platforms Need Standardized Management—Part Three of the Investigation and Consideration of the Conditions of Ideological and Political Education in Naval Units under the Condition of Informatization" ['路宽' 为何 '车马' 稀?--教育平台需要规范化管理: 对信息化条件下海军部队思想政治教育情况的调查与思考之三], *People's Navy* [人民海军], May 18, 2007, 1–2.

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[105] Recent Chinese-language publications on joint operations include the following: Ceng Sunan, ed., *Research on Integrated Joint Operations* [一体化联合作战专题研究] (Beijing: Military Science Press, 2004); Jiang Fangran, ed., *Joint Operations Headquarters Work* [联合作战司令部工作] (Beijing: Military Science Press, 2004); Zhou Dewang, *Joint Operations Command Structure Research* [联合作战指挥机构研究] (Beijing: National Defense University Press, 2002); Gao Yubiao, *Joint Campaign Teaching Materials* [联合战役学教程] (Beijing: Military Science Press, 2001); Zhang Peigao, *Joint Campaign Command Teaching Materials* [联合战役指挥教程] (Beijing: Military Science Press, 2001); An Weiping, ed., *New Theory of Joint Warfare* [联合作战新论] (Beijing: National Defense University Press, 2000); Chen Anran, *Political Work in Joint Operations* [联合作战政治工作] (Beijing: National Defense University Press, 1999); and Wang Zhiyuan, ed., *Joint Information Warfare* [联合信息作战] (Beijing: Military Arts and Literature Press, 1999).

[106] Dean Cheng, "*Zhanyixue* and Joint Campaigns," in James Mulvenon and David Finkelstein, eds., *China's Revolution in Doctrinal Affairs: Emerging Trends in the Operational Art of the Chinese People's Liberation Army* (Alexandria, VA: Center for Naval Analyses Corp., 2006), 101.

[107] Huang Haipeng, Zhang Li, and Gu Linghua, "On the Informatized Battlefield, What Battle Ships Desire and What They Practice," *Liberation Army Daily* [*Jiefangjun Bao*], June 15, 2007, 3.

[108] Peng and Yao, 262.

[109] Ibid., 102.

[110] *The Science of Campaigns* [*Zhanyixue*], 2006, 297–301; Zhang Yulang, chief ed., et al., "Chapter XII—The Joint Blockade Campaign," *The Science of Campaigns* [战役学] (Beijing: National Defense University Press, 2006), 10.

[111] *The Science of Campaigns* [*Zhanyixue*], 2006, 300; Zhang Yulang, chief ed., et al., "Chapter XII—The Joint Blockade Campaign," *The Science of Campaigns* [战役学] (Beijing: National Defense University Press, 2006), 11.

[112] Zhang Yuliang, chief ed., et al., "Chapter XIV—Anti-Air Raid Campaign," *The Science of Campaigns* [战役学] (Beijing: National Defense University Press, 2006).

[113] Zhang Yuliang, chief ed., et al., "Chapter XXIV—Offensive Campaigns Against Coral Island Reefs" [对珊瑚岛礁进攻战役]," in ibid.

[114] Ibid., 107.

[115] Peng Guangqian and Yao Youzhi, ed., *The Science of Military Strategy* (Beijing: Military Science Publishing House, 2005), 265.

[116] Ibid., 115.

[117] See ONI, *The People's Liberation Army Navy: A Modern Navy with Chinese Characteristics*, Suitland, MD, April 2009, 34.

[118] Also translated as "outline," "compendium," or "doctrine."

[119] *Joint campaigns* involve the participation of forces from more than one service, while *combined arms campaigns* involve the participation of multiple branches from a single service. For full definitions of

these terms, see *Joint Publication 1-02, Department of Defense Dictionary of Military and Associated Terms*, Washington, DC: U.S. Department of Defense, April 12, 2001 (as amended through September 17, 2006), available at <http://www.dtic.mil/doctrine/jel/doddict/index.html>.

[120] DOD (2006), 16.

[121] Cheng, "*Zhanyixue* and Joint Campaigns," 115–117.

[122] In joint blockade campaigns [联合封锁战役], for instance, ". . . there is widespread use of highly-technical weapons; there is a complex electromagnetic environment; offensive operations are intertwined with defensive operations; and there are rapid changes in the battlefield situation. All this results in an expansion of the difficulty in commanding and coordinating the campaign, thus requiring that [those who provide] campaign guidance be adept at judging the timing and sizing up the situation, adapting themselves to changing situations, and making resolute decisions." Zhang Yulang, et al., "Chapter XII—The Joint Blockade Campaign," 3.

[123] Zhang Shuhui [张书晖], "Revelation to Weapon Equipment Construction Based on Integrative Joint Firepower Strike" [一体化联合火力打击对武器装备建设的启示], *Journal of the Institute of Command and Technology* [装备指挥技术学院学报], 2007, 2. Zhang is a graduate student at the National Defense University, where he is conducting research on joint campaigns.

[124] Zhang Yuliang et al., "Chapter XIV—Anti-Air Raid Campaign."

[125] Zhang Shuhui, 2.

[126] Peng and Yao, 253.

[127] Ibid., 267–268.

[128] Ibid., 268.

[129] Ibid.

[130] Ibid., 257.

[131] Ibid., 262.

[132] Ibid., 265.

[133] Ibid., 264.

[134] Ibid., 265.

[135] Ibid., 255.

[136] Ibid., 268–269.

[137] Ibid., 258–259.

[138] Ibid., 272.

[139] Ibid., 252.

[140] Ibid., 258–259.

[141] Ibid., 256.

[142] Zhang Shuhui, 2.

[143] Zhang Yan, Feng Shuxing, and Lu Hongbing, "Research on the Time Effectiveness of Aerospace Command Modes in Future Operations" [浅探未来作战中航天指挥方式的时效性], *Journal of the Academy of Equipment Command & Technology* [装备指挥技术学院学报] 18, no. 2 (April 2007), 55–59. This article compares centralized, decentralized, and skip echelon command systems.

[144] Academy of Military Science, Military History Research Department, *Haiwan zhanzheng quanshi* [The Complete History of the Gulf War] (Beijing: Liberation Army Press [Jiefangjun chubanshe], 2001), 413.

[145] Ibid.

[146] Ibid., 414.

[147] Ibid., 417.

[148] See David M. Keithly and Stephen P. Ferris, "*Auftragstaktik*, or Directive Control, in Joint and Combined Operations," *Parameters* (Autumn 1999), 118–133.

[149] Ibid.

[150] Ibid.

[151] Peng and Yao, 255.

[152] Ibid., 255–256. According to Peng and Yao, "The operations of PLA strategic missile force come under direct command and control of the supreme headquarters, and the command department of the Second Artillery Corps is responsible for the specific command work."

[153] John Wilson Lewis and Xue Litai, *Imagined Enemies: China Prepares for Uncertain* War (Stanford, CA: Stanford University Press, 2006), 120.

[154] For a Chinese evaluation of foreign submarine communications systems, see Wang Xiaofei, ed. [王小非], *Network Warfare at Sea* [海上网络战] (Beijing: National Defense Industry Press, 2006), 379–382.

[155] Garth Hekler, Ed Francis, and James Mulvenon, "C3 in the Chinese Submarine Fleet," in Andrew Erickson, Lyle Goldstein, William Murray, and Andrew Wilson, eds., *China's Future Nuclear Submarine Force* (Annapolis, MD: Naval Institute Press, 2007), 198.

[156] The authors wish to thank William Murray for raising this point.

[157] See, for example, Wu and Hu, "Building a Powerful People's Navy That Meets the Requirements of the Historical Mission for Our Army." According to Wu and Hu, "along with accelerating the development of informatized equipment, the Navy has been using information technology to integrate and upgrade its existing equipment, and to strive to realize the long-range and precision capabilities of the main combat weapons as well as inter-communication, inter-connection and inter-operation capabilities of various combat platforms, which has greatly increased the level of the informatization of weapons and armaments."

[158] "China's National Defense in 2010."

[159] The authors are indebted to Jim Fitzsimonds for the insights contained in this paragraph.

[160] The authors are indebted to Jim Fitzsimonds for the ideas contained in this and the previous paragraph.

[161] See Keithly and Ferris, 118–133.

[162] The authors are indebted to Jim Fitzsimonds for the insights contained in this paragraph.