11. SYSTEMS INTEGRATION IN CHINA'S PEOPLE'S LIBERATION ARMY

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In many circles, the People's Liberation Army (PLA) is best known for its obsolescence, shortcomings, failures, and ineptitude. However, among others, especially some circles in the West, the PLA's strengths and successes are highly touted. There is a measure of truth in the exaggerated convictions of both these categories of observers of PLA prowess, or the absence thereof. It is not enough to suggest, as some might, that the PLA does well in areas of low technology and poorly in high-technology areas, although there is certainly a kernel of truth in that oversimplified explanation. The PLA has, of course, excelled in some areas where at least a modicum of modern technology is involved. Success for the PLA, however, has been extremely elusive in areas where integration of systems and technologies is required. This is not to suggest that the whole story of PLA technological successes and failures can be linked to systems integration. The story is far more complex than that. Nevertheless, an examination of the issue based on systems integration capabilities is a useful and instructive one to pursue. This is undertaken in three parts: (1) an introductory look at two prominent examples of PLA modernization programs from the perspective of systems integration, (2) a definition of systems integration and the various levels into which military systems integration may be divided, and (3) an examination of PLA aspirations for systems integration, the status of the effort including problem areas, and conclusions about what the future might hold.

I. TWO METHODS OF COPING WITH SYSTEMS INTEGRATION IN THE PLA

What the PLA Cannot Do Well: The Strategic Rocket Force Story

The PLA has been unable to undertake modernization of all, or even most, of its numerous and diverse forces and units, either simultaneously or seriatim. It simply lacks the wherewithal to do so. This inability to carry out sweeping or steady modernization stems from inadequacies in its research and development facilities,

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sparse funds for equipment acquisition, limited ability to acquire and assimilate technology, and lack of availability of educated personnel, training methods and devices, and more. One preferred solution or work-around has been to modernize selected PLA forces and units. Some of these selective modernization efforts have been referred to as "pockets of excellence." The pockets vary greatly in magnitude and scope. One of the largest and deepest of the pockets (double-entendre intended) is the Strategic Rocket Force (SRF) or Second Artillery, as it is best known in the PLA.

The example of the SRF is particularly interesting because it is a conspicuous pocket of excellence—arguably the most conspicuous—and an area where systems integration is minimal. In fact, it can be said that the Chinese designed their Strategic Rocket Force in such a way that the force has great utility without reliance on the integration of systems beyond the level of the individual missiles. Unlike the American intercontinental ballistic missile (ICBM) force with its complex structure of warning systems, decisionmaking arrangements, command and control networks, coordination of a triad of platforms, etc., China's system for its nuclear missiles is extremely simple and unintegrated. The PLA's SRF is not linked to systems in space for detection of an enemy's incoming missiles. The execution of a prompt, complex, coordinated nuclear strike is not contemplated by China. Instead a rather leisurely retaliation is envisioned, using a handful of missiles, possibly days or weeks after surviving an attack. The situation is similar for the short-range ballistic missiles (SRBMs) of the SRF, for example the Dongfeng-15s (CSS-6 in American terminology or M-9s, as they are more widely known) used against Taiwan in 1995 and 1996. This is not to suggest that the Dongfeng-15s and China's other ballistic missiles are not complex systems, requiring many properly operating components to achieve success. Nonetheless, these SRBMs and their TELs (transporter-erector-launchers) can reach a launch point and be fired at a target location without reliance on an integrated system. The point is that China's most conspicuous military technological success story has a conspicuous characteristic: essential absence of requirements for complex, external systems integration. This suggests that the Chinese have recognized their weakness in systems integration and avoided this burgeoning but complex technological discipline. The structure of the SRF, with respect to both its nuclear and conventional arsenals, takes into account China's lack of skills in systems integration.

The PLA's shortcomings in systems integration are no secret, either inside the PLA or among foreign observers. Dr. Paul Godwin of the U.S. National War College has referred to articles, essays, and seminars (taken from the *Liberation Army Daily*, military professional journals, and seminars sponsored by an organ of COSTIND—the Chinese Commission on Science, Technology, and Industry for National Defense) on this subject over roughly five years of this decade. He noted that these essays and seminars reflect that the PLA is unable to aspire to early integration of advanced technologies into their operational systems—and recognizes that inability.[2] The SRF example seems to take this conclusion one step further. The PLA, out of necessity, can be quite good at making do, at achieving imaginative and

[2]Paul H. B. Godwin, "Military Technology and Doctrine in Chinese Military Planning," p. 43.

effective work-arounds. However, in doing so, the PLA knowingly comes up well short of world-class capability, in large measure because of inherent inability to undertake, much less achieve, the sort of systems integration that has become a hallmark of truly modern armed forces, especially nuclear forces.[3]

What the PLA Can Do: The Tale of Three Ships

It would, of course, be absurd to suggest that the PLA has neither attempted nor achieved any significant form of system integration. Nevertheless, examples are not easy to discover. The logical explanation for the lack of visibility is neither that none exist nor that secrecy has obscured the existing examples, but it is true that the PLA generally makes a conscious effort to hide examples of system integration. There is a full realization by the PLA that disclosure of its efforts and achievements in this area reveals important secrets about its capability—secrets that go far beyond simpler revelations of the identity of all or most of the weapon systems and other obvious equipment on a combatant ship. For example, it is one thing to reveal (essentially unavoidably) that a ship has an air search radar, a fire-control radar, a surface-to-air missile battery, and antiaircraft guns. On the other hand, how those components can operate together, and if that operation is effective, is a much higher magnitude secret. This secrecy is reinforced by the xenophobic Chinese view of control of military information. (It should be remembered as well that PLA secretiveness stems not only from a desire to hide systems capabilities but also from an effort to keep the curious from learning just how embarrassingly rudimentary some PLA systems are compared to those of modern armed forces.)

The PLA Navy, consequently, has been considerably less than forthcoming with respect to the degree of integration of weapon systems that exists on its three most advanced missile-equipped warships: the *Jiangwei*-class frigates, the later versions of the *Luda*-class destroyer (including the single *Luda* III), and the most recently commissioned ships, the *Luhu*-class destroyers. Even after separate visits to the three ships by the author and colleagues over a period of several years and the review of available reference materials, we cannot be confident of what is precisely the case concerning systems integration. However, the correlation of these direct observations on board the ships with reported information on sales and installations leads to considerable confidence in the conclusion that all three classes of ship have combat direction systems installed and operating systems to integrate the sensors and weapons of these ships, at least within the ship.

The fact that relatively new surface combatant ships have combat direction systems may not seem a remarkable conclusion, but the class of frigate built just before the Jiangwei program began, the *Jianghu*, does not seem to have had such a system. The author asked during a 1991 tour of a *Jianghu*-class frigate to visit the space where

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[3]The Chinese nuclear missile arsenal serves well under this somewhat strange arrangement: no warning system, no alert status, warheads stored apart from missiles, a minimal force, etc. Its shortcomings, including those brought about by China's lack of skills in systems integration, are acceptable—possibly even desirable—because the utility of that arsenal is directly dependent on its not being used. Arguably, China has not sought an integrated system, or suffered from the lack thereof, because it does not seek to achieve an integrated nuclear capability that fosters reliance on a ready ability to retaliate. Another way of putting this is that China has made a virtue of necessity.

such equipment was located and was told that no such space existed. (Such answers were not unusual at that time and were not always factual, so this could not be considered as conclusive information.) A query by the author in the early 1990s to a Thai Navy officer concerning the *Jianghus* built by China for his navy resulted in essential corroboration that the ship lacked a facility comparable to the combat information center, as that officer understood the concept. Norman Friedman obtained similar information concerning a *Jianghu*-class frigate delivered in 1990 to Thailand.[4] These three examples of "negative information" are not conclusive evidence that *Jianghu* do not, or did not, have some sort of combat information center, but they strongly suggest that remarkable possibility.

Possibly the most that can be concluded from this limited information concerning installation practices and timing is that at some point, not later than early in the 1990s, China began as a matter of course to incorporate what, by that time, was called a *combat direction system* in its warships. (Other inconclusive evidence suggests that this practice may have begun earlier in the *Luda*-class destroyers.) In any event, the system doubtlessly now being installed in Chinese combatants, significantly, is not of Chinese design. It was developed by Thomson-CSF of France. The prototype was assembled in the mid-1970s and is now called TAVITAC (*Traitement Automatique et Visulation TACtique*). According to *Jane's Naval Weapon Systems*, two of the early systems were sold to China.[5] The Chinese version of the system is called ECIC-1, the existence of which reflects an apparent ability at least to replicate a system for integrating tactical information, displaying the data, and permitting the designation of weapons systems to targets. (Incidentally, China's audacity and ingenuity in unauthorized reverse-engineering may be indicated by the fact that, according to *Jane's*, China is not licensed by Thomson-CSF to produce the system.)

Jane's describes the early TAVITAC (through the early 1980s) as a mainframe system for tactical data handling. The upgraded version, TAVITAC 2000, is said to have a "star" architecture but as still relying on a basic mainframe design structure, short of the superior technology and versatility of the fully distributed architecture of the TAVITAC NT which Thomson has sold to Kuwait. The PLA Navy's newest guided missile destroyers are equipped with either the ECIC-1 or the TAVITAC 2000. This system compiles a picture of the tactical situation using inputs from radars and other sensors both on the ship and from remote sources (another ship, for example). To connect with off-board sensors, it uses a data link, which the U.S. Naval Institute reference book *Combat Fleets of the World* terms Link-W[6]—said to be similar to the Link 11 of Western navies. Several hundred targets can be tracked. The system designates these targets to weapon systems and purportedly provides some measure of assistance in reaching judgments concerning the tactical situation, i.e., assessing

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[4]Norman Friedman, "Chinese Military Capacity: Industrial and Operational Weaknesses," in Arnett, pp. 69–70.

[5]E. R. Hooton, *Jane's Naval Weapon Systems*, Surrey, U.K.: Jane's Information Group Ltd., 1998.

[6]A. D. Baker III, *Combat Fleets of the World 1998–99*, Annapolis, Maryland: Naval Institute Press, 1998, p. 120.

urgency related to developing situations and assigning priorities to engaging targets with various systems (missiles and guns).

The system typically uses five or six vertical or horizontal consoles consisting of keyboards and large displays. The following description compiled from *Jane's Naval Weapons Systems*[7] may offer the technically inclined some idea of the relative sophistication of the system:

> The TAVITAC 2000 system uses the Thomson-CSF MLX-32 computer which is built around the Motorola 68030 and 68040 32-bit microprocessors. Each TAVITAC 2000 system has two mutually redundant computers with six Mbytes of memory, one acting as master and the other as a hot standby, and capable of 3 Mips. The system uses Ada software language, the UNIX System V operating system, and features a duplicated VME bus 10 Mbytes Ethernet-standard local area network. A rugged disk storage offers a database management capability for map displays, ship resources, and management.

Another interesting, if less technical, indication of the level of sophistication of the combat direction system installation in the *Luhu* is that France has installed the TAVITAC 2000 in its impressive, stealthy new *Lafayette*-class frigates. Based on information from several sources,[8] it appears that this combat data system, incongruously, is also present on the version of the *Lafayette* frigates recently delivered to Taiwan. (As with the PLA Navy, the ROC Navy is not inclined to allow visitors on these new frigates, especially in the combat direction center.)

What We Learn from the SRF and Ship Sagas

The story of the PLA's Strategic Rocket Force and the tale of the PLA's three most modern warships are instructive with respect to the state of systems integration in the PLA. The Chinese know both that systems integration is important in the building of modern armed forces and that the PLA is very weak and inexperienced in this field. This recognition has led them, in the case of the SRF, to avoid their weakness, even if it means having a nuclear deterrent "with Chinese characteristics," implying in this case a need to work around severe limitations. In the case of the destroyers and frigates, recognition of the weakness in systems integration technologies forced China to go elsewhere, to France in this case. It was not feasible to design a workable guided missile destroyer's combat direction system if it had to be done with Chinese characteristics. At a minimum, a modicum of advanced system integration technology was necessary to have a moderately combat-capable warship. It is noteworthy that the evidence derived from these cases and the impression one derives from a broader look at the systems integration picture for the PLA leads to the conclusion that China has gone no further with respect to systems integration than to identify the problem and PLA shortcomings. No significant aptitude has been displayed for successfully attacking the problem indigenously.

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[7] Hooton.

[8] Friedman, p. 69; A. D. Baker III, *Combat Fleets of the World 1995*, Annapolis, Maryland: Naval Institute Press, p. 730; Hooton, *Jane's Naval Weapon Systems*, table at end of TAVITAC section.

Several aspects of the issue remain quite murky, however. The importation of systems like TAVITAC and even the Chinese copying and production of that system do not necessarily imply that the systems work well on board the PLA Navy ships. For example, the diverse radar and sonar systems and other sensors, some obtained from various countries and others produced in China, undoubtedly present formidable challenges in data interfaces, input coordination, and systems compatibility. Computer hardware and software differences among the various systems and the translation and comprehension of manuals and computer programs offer further challenges. It is hard to imagine that the PLA Navy has succeeded in putting all this together and formed a seamless combat direction system.

II. DEFINING SYSTEMS INTEGRATION AND ITS LEVELS OF APPLICATION

Comprehending the Concept

Like the currently popular terms *asymmetry* and *RMA* (*revolution in military affairs*), *systems integration* has become something of a buzzword in defense affairs circles. Further, the term is used or misused widely, often to reinforce whatever point the writer or speaker wants to make, with little concern for consistency or accuracy. Consequently, prior to delving more deeply into the matter of systems integration in the PLA, it is useful to examine informed efforts to define and understand this term. The term is relatively new in its current ubiquitous military usage, especially in the PLA. Few, if any, defense specialists have spent more time and effort on defining the term systems integration and focusing its application than those in the U.S. Department of Defense who are dedicated to the acquisition of systems, development of technologies, and the formulation of the U.S. policies related thereto. The introduction to a definitive document produced by that office, the U.S. Department of Defense publication entitled *Militarily Critical Technologies List* (*MCTL*),[9] states:

> *Systems integration* enables the harmonious and productive working of disparate components and the interfaces that connect them. Each weapon system requires the use of specific hardware and software and the integration of new technologies or advances in existing technology subsets to increase overall system performance, improve manufacturing or reduce costs.
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> *Systems integration* is an ongoing process. Good integration includes traceable assurances that the components and functions will fit together and operate in concert. In the past, weapons systems designers have successfully improved both the hardware and software in an interactive process, and then integrated both to effect simultaneous improvements. Excessive integration adds cost and time without yielding a significant improvement in the product or system. Too little integration results in products or systems that do not function as advertised.

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[9]Office of the [U.S.] Under Secretary of Defense for Acquisition & Technology, *Militarily Critical Technologies List*, Washington: National Technical Information Service, Springfield, VA 22161, June 1996, p. 2.

> *Technology integration* can be treated as a subset of systems integration. High technology weapons systems are fundamentally driven by availability and integration of technologies . . . . *The tools and techniques for preparing, mixing and matching the various components are also critical technologies because they are key to achieving the desired qualities* [final emphasis added].

This careful, if lengthy, description of systems integration and explanation of its importance outlines the purpose and nature of the process of achieving it, points to the pitfalls, and, possibly most important for this examination of the subject, states that the very methods employed in the integration are *critical technologies in themselves*. As has long been recognized, China, and especially the PLA, suffers from technological disadvantages in areas such as electronics, computers, and software. That is difficult enough, but, more tellingly, China, it seems, has yet to begin to grapple seriously with the next very complex step: mastering the critical technologies of systems integration, referred to in the extract from the MCTL.

Paul Dibb, formerly Director of the Australian Joint Intelligence Organisation and Deputy Secretary of the Australian Department of Defense, wrote recently: "Not only is implementation or planning for systems integration almost totally deficient in the [Asia-Pacific] region, there is also a very limited capacity to modify and adapt current combat systems that are vital to operational effectiveness." Noting that systems-integration technology has eluded even Japan, Dibb asserts that the failures "are even more pronounced in China and India."[10]

The Scope of Systems Integration: Five Levels Applicable to the PLA

For China's military leaders, contemplating the largely unexplored sweep of systems integration as it applies to China's armed forces, from the broadest context down to individual units or troops in combat is, undoubtedly, a daunting task—as it is for the outsider trying to grasp the scope of this problem for China. There is, of course, no fixed set of categories or levels for the application of systems integration. However, the following attempt to divide the sweeping problem into five comprehensible levels of applicability may be useful as a device to try to understand both the scope of the problem and its many facets.[11]

Military systems integration at the regional or global level. The highest plane of the systems-integration challenge that faces China could be termed the *big picture* level. This level of the integration problem is perhaps illustrated well by examining the saga of the U.S. aircraft carrier battle groups deployed to the region in March 1996 as a response to the second round of SRF M-9 missile "tests" and leading up to the first popular election of a president in Taiwan. Put starkly, the Central Military Commission (CMC) in Beijing had to depend on American announcements from Washington and Honolulu and reports from CNN to learn that the carrier battle groups had been deployed and where they might be operating. Then the PLA had no

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[10]Paul Dibb, "The Revolution in Military Affairs and Asian Security," *Survival*, Vol. 39, No. 4, Winter 1997–98, pp. 102–103.

[11]The following scheme of five levels of system integration is an artificial device conceived by the author to facilitate treatment of a complex subject and should not in any way be viewed as reflecting concepts employed by the PLA or the U.S. Department of Defense.

means to verify the presence of the battle groups or to determine their positions. Unknown were even the general locations, much less the latitude and longitude or course and speed of individual ships. It is likely that to this day no one in China knows when the second carrier battle group arrived, where it operated, how its ships and aircraft were disposed, and precisely when it departed the area. From the U.S. perspective, this was a very comfortable situation. Its forces, because they could not be located by China without U.S. complicity or "cooperation," were operating essentially in a form of sanctuary. Further, there was the luxury, if desired, to announce or leak something about the location and disposition of forces and have that serve almost as well as if it were wholly factual. This example illustrates well China's predicament should it wish to react to such events more than a few score miles off its coast, lacking an integrated system that can present a dynamic tactical picture over the area of concern.

The character of this problem of location and identification possibly can be even better appreciated by a quick look at China's existing capabilities to determine the tactical situation in the ocean areas off China and Taiwan. A PLA Navy maritime reconnaissance aircraft, on an extended mission, might, after arriving on station, search an area of 20,000–30,000 square miles using radar and electronic intercept equipment—assuming that the U.S. ships (or other naval units of interest) were not evading detection. Yet the area that might warrant searching (where the carriers could be in positions to close the target area and launch strikes or conduct other missions, for example) is 400,000–600,000 square miles—ten times the optimistic search area of a single aircraft mission. Moreover, the searching aircraft, typically using radar, can be denied the ability to detect the ships of interest by being turned away by intercepting aircraft and through various electronic and spoofing means.

China looks to a future when the PLA can operate its ships and aircraft several hundred miles from its coastlines and, in doing so, protect its maritime interests. This blue-water endeavor may take rudimentary form, ensuring that ocean commerce is not disrupted, or it may attempt something more sophisticated, such as an effort to achieve sea denial or control. Whatever form China chooses, the admittedly rather rudimentary example provided here illustrates that the PLA cannot begin to determine the tactical situation it faces in its surrounding ocean areas, absent an integrated surveillance system. That system should be able to detect threats or other contacts of interest (and discriminate between them) day and night and in all weather, and even under circumstances where the targets are attempting, through sophisticated or simple means, to avoid detection. This system would then have to be integrated with means to identify and evaluate the detected contacts, eliminate false contacts, and correlate the many detections in such a way as to compile target tracks and to be able to forecast future positions—assuming some action with respect to the targets was contemplated. This is but one example of a level of systems integration that would require interfaces and correlation on a grand scale among sensors and other systems widely separated in distance, design, and character.

This level of the "big picture" system integration problem also would apply to aspirations by China to compile a picture of satellites in space that might threaten

China or that China might hope to threaten. Furthermore, as alluded to at the outset, China is severely constrained, whether by design or necessity, in its nuclear deterrent policy by its lack of capability to obtain warning of a nuclear missile attack. All of these examples of the highest level of system integration are almost certainly out of China's reach for the foreseeable future. Beijing may continue to conclude that it will simply have to tolerate this shortcoming in big-picture system integration. Whichever direction China chooses with respect to this very complex technological problem and, especially the systems-integration aspects thereof, will be a critical determinant of the character of China as a major military actor in East Asia. As physicist and security expert Norman Friedman put it after extensive research, "While China's recent history features a number of socio-political set-backs that have crippled the military technology base, the rest of the world has been racing forward at a remarkable rate. As a result China is not only far behind the state of the art in electronics and command and control; Chinese planners may be unable even to conceive of appropriate solutions to the problem of closing the gap."[12]

Integration among platforms in a warfare area. The next level of systems integration involves meshing various platforms and components within a specific warfare area. These areas might include, for example, antisubmarine warfare (ASW) or air defense.

An effective ASW capability optimally would include:

— **aircraft** (fixed-wing and helicopters) dropping sonobuoys and monitoring the radio signals from those buoys for submarine-generated noise or for echoes from explosive charges dropped in conjunction with the buoys, or, in the case of helicopters, using passive and active dipping sonars. Aircraft able to proceed at high speed to investigate suspected contacts generated by other means and deliver attacks with homing torpedoes;

— **surface ships** (probably destroyers and frigates) employing hull-mounted sonars and trailing variable-depth sonar equipment. Ships able to coordinate at least local area antisubmarine operations and to deliver attacks with homing torpedoes;

— **submarines** (preferably quiet nuclear-powered vessels which have faster submerged speeds for unlimited periods) able to occupy the same acoustic water layers as the target submarine and with the ability to communicate contact information to the local ASW coordinator and, critically, to antisubmarine aircraft that are able to close contacts rapidly and deliver attacks, as described above;

— **sea-bottom acoustic arrays** (sets of hydrophones on the ocean floor) positioned in strategic areas of concern and linked to monitoring stations ashore with the capability to detect, identify, and track targets that could then be prosecuted by aircraft or possibly by ships or submarines in some circumstances.

Air defense systems are more intuitively obvious to most readers, but they might include as a minimum:

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[12] Friedman, p. 67.

— **land-based, sea-based, and/or airborne radars** that can provide requisite coverage against low-flying aircraft, are resistant to jamming or other electronic deception, can be defended against anti-radiation missiles, and can detect, identify, track, and facilitate intercept and engagement of targets;

— **interceptor aircraft** with appropriate speed, altitude capability (service ceiling), maneuverability, and equipped with engagement radars or other sensors and air-to-air missiles sufficiently capable against the intruding aircraft so that they may be fired effectively before the intercepting aircraft can be evaded or neutralized; and

— **land-based or sea-based surface-to-air missiles**, some of which can engage targets at considerable distances and others capable of short-range engagements.

It must be said forthrightly that the PLA Navy and PLA Air Force have not achieved significant proficiency in any of the component technology areas described for ASW or air defense systems. Moreover, they certainly have not made substantial progress in any form of ASW or air defense system integration, save rudimentary direct communications (e.g., voice radio) between ASW aircraft and surface ships or interceptor aircraft and controlling radar sites as they carry out rather old-fashioned ground-controlled intercepts, for example. At the warfare-areas level of systems integration, there has been essentially none of the "harmonious and productive working of disparate components and the interfaces connecting them," as described in the U.S. Department of Defense MCTL.

China's prospects for changing the situation at this level of systems integration were addressed by Erik Baark in his recent examination of science and technology policy and technological innovation in Asia. He wrote, "When the interaction of military and civil sectors in China . . . is evaluated in terms of technological capabilities, it appears that there are still some serious bottlenecks, in particular the lack of innovation networks which, in practice, could serve to link . . . R&D to manufacturing. The networks which formally exist . . . suffer from a fragmentation which leaves little in terms of critical mass for the development of integrated weapon systems."[13]

Integration of various components to constitute a weapons platform. The next level in the hierarchy of systems integration is that of combining components to constitute a combat aircraft, a combatant ship, a battle tank, or similar platform—not the individual weapon systems on the platform but the overall platform that mounts the various sensors and weapons. Considerable skill and experience are required to combine successfully a fuselage, hull, or vehicle body; a propulsion unit; the electrical and other auxiliary systems required; and the suite of sensors and weapon systems, generally including very sophisticated electronic components and computers and all the linkages needed. The problem is multiplied many times over if the various assemblies are from several countries with varying origins and conforming to different technical standards. (Further, Chinese military aircraft, ship,

[13]Erik Baark, "Military Technology and Absorptive Capacity in China and India: Implications for Modernization," in Arnett (ed.), p. 109.

and vehicle manufacturers have not generally been able to produce identical versions of units of the same model, even when in serial production. Consequently, in many cases, "black boxes" cannot readily be exchanged from spare-parts bins or among units to troubleshoot, effect repairs, or carry out preventive maintenance, for example.)

The general nature of the problem can be appreciated by considering the PLA Air Force's (PLAAF's) proposed future fighter aircraft, something intended roughly to approximate a modernized F-16. Paul Dibb, using this developmental F-10 as an example, refers to these as *hybrid systems*, "combining platforms, radars, avionics, and missiles from different suppliers." He goes on to write that "China's next-generation fighter, the troubled J-10 [often referred to as the F-10 in the West], has a Chinese airframe, Israeli avionics, and Russian engines."[14]

The *Luhu*-class destroyer serves possibly as an even more dramatic example. The first ship of that class, *Harbin*, while under construction at the Jiangnan Shipyard in Shanghai, was described reliably (by Chinese sources) as featuring 189 of China's "achievements in the development of naval equipment," incorporating *more than 40 advanced foreign technologies*, and fitted with over 50,000 sets of equipment. The ship was described as having "equipment developed or produced by 19 provinces [of China], 11 ministries, commissions and corporations, and 100 manufacturers, research institutes, and entities." The anti-air missile launcher and its Mach 2.4 missiles (an actual *Crotale* launcher on the first ship and a Chinese version of that system on the second, further complicating things) were developed in France by Thomson and Matra Missiles. An air search radar (TSR3004) and the combat data system (the TAVITAC, described previously) were also developed by Thomson, but the long-range air search radar is Chinese. The A244S homing torpedoes are of Italian origin.[15] The C-801 anti-ship cruise missiles were designed and manufactured in China. The origins of many other advanced components large and small (e.g., electronic countermeasures equipment), and notably including the sonar systems, are unknown to the author.

If these statistics and lists, many of which were cited publicly by PLA Navy representatives with the intent to impress the Chinese public and foreigners as well, were not stunning enough, it should be noted that only two ships of this class were built. There was little if any time and opportunity to profit from lessons learned in this extremely complex area of systems integration. Certainly much of the effort that went into achieving some level of compatibility and devising interfaces for all these disparate components can be applied in varying degrees to the upcoming new class of destroyers, (*Luhai*, previously known as the *Dalian-C*) but those new ships, the first of which is already on the way, will incorporate new technologies that China has been able to develop and acquire.[16]

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[14]Dibb, p. 99.

[15]Tseng Hai-tao, "Commander Jiang Wants to Accelerate Naval Construction, China's Newest Warship Emerges," *Kuang chiao ching*, August 16, 1996, in FBIS-CHI-96-209, October 29, 1996, pp. 2, 5; information on the identity and origin of the long-range air search radar is from Baker, p. 120.

[16]Conversations between the author and knowledgeable PLA Navy officers in 1997.

This illustrates yet another aspect of the problem. The PLA has great difficulty forecasting what systems and technologies can be obtained, when they will become available, and which of those available it wishes to use. There are several reasons: (1) China's own research and development effort is spotty and inadequate, (2) many countries restrict what they sell to the PLA (and are prone to change their minds), (3) foreign equipment is expensive and suppliers often demand payment in hard currency, (4) China is reluctant to repeat the experience of becoming overly dependent on foreign suppliers (as it was on the Soviet Union in the 1950s and on several Western countries in the 1980s before Tiananmen interrupted that episode of technology transfer), and (5) the PLA has difficulty assimilating and incorporating new technologies. Once more, the *Luhu* class and its follow-on are illustrative. Looking at the critical matter of ship propulsion, the new follow-on destroyer, although similar to the *Luhu*, has a wider hull (broader beam) to accommodate a different, somewhat larger and bulkier marine gas-turbine engine. That is because post-Tiananmen sanctions imposed by the U.S. have precluded acquisition of additional GE LM 2500 engines like those in *Harbin* and her sister ship.[17] The follow-on ships will have Ukrainian G525000 gas turbines, said to be selected using "a combination of technical and political factors."[18]

Dr. Paul Godwin, an experienced and recognized specialist on the PLA at the U.S. National War College, summed up a part of China's plight at this level of systems integration as follows: "The simple fact that all the PLA's advanced weapon platforms depend on imported technologies for their power plants, weapons, and electronics is a clear indicator that China's research centers have yet to produce weapon platforms based on indigenous technology that match those the advanced industrial states were manufacturing by the 1970s. For such a military technology and industrial base, advancing into the technologies required for the 21st century is a daunting task. This task is made even more intimidating by China's continuing quest for military self-sufficiency."[19]

Furthermore, the path to integrating these technologies is almost never direct and efficient. The sagas involved in obtaining the avionics and engines for the J-10 chronicle more than a decade of frustration, dashed expectations, disappointments, engineering changes, schedule and cost overruns, and failures. All these have done far more than delay the progress of this seemingly plagued fighter aircraft program. They have also severely taxed Chinese aeronautical designers and engineers in an area that is already their near nemesis: the challenge of integration into a single tactical airframe of all these diverse systems from international sources. A similar situation exists with respect to the *Luhu* and many other areas where China has undertaken the daunting task of combining components from diverse suppliers in an effort to deploy a system far more advanced than that which China is able to design and build indigenously.

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[17] *Ibid.*

[18] Tseng, p. 3.

[19] Godwin, "Military Technology and Doctrine in Chinese Military Planning," p. 59.

Unless one cynically attributes it all to a quality of stubborn persistence in those who guide these PLA programs, it must be concluded, from the frequent and repeated resort to these methods, that no better method appears feasible to them. There is no question that the encumbrances of this erratic and uncertain method are not trivial. They are a critical factor in limiting China's successes in producing ships, aircraft, and other platforms that even approach or approximate the level of modern weapon systems. The *Luhu*-class destroyer is a ship that Western navies and the Japanese Maritime Self-Defense Force would have been proud to put to sea 20 or more years ago. The J-10, if it gets past the prototype stage, will likely hold its own against the F-16, an aircraft that first flew in the U.S. Air Force about a quarter of a century ago. But the designers and builders of tactical aircraft and combatant warships for the PLA are stymied by the problems of integrating systems to constitute a modern fighting platform.

Integrating components from diverse sources that form a weapon system. This level of systems integration involves the use of components to comprise a specific functional weapon system—an individual weapon system on a platform, not the overall platform (ship or aircraft). The classic case of this level of integration is the combining of a detection system (a radar, for example) with a system to aim the weapon (a fire-control system, for example) and one or more devices that deliver lethal fire on a target (missiles and the associated launcher and/or guns and the projectiles they fire). The air and missile defense system of the *Luhu*-class destroyer is a good example. The components of that system were described above.

As mentioned, the long-range air-search radar is of Chinese origin (although it probably is derived from earlier radars developed in other countries). The *Luhu* has no means of engaging air and missile targets at the ranges (up to a hundred miles or more) that this *Sea Eagle* radar could gain contact. It would be desirable to have an automatic interface between the Chinese radar and the French systems that can provide a tactical display, track the targets, and assign missile batteries or guns to the target (TAVITAC 2000). The Chinese have probably at least attempted to install such a linkage, but, for the PLA, trying and succeeding to the degree that combat reliability is attained may be two quite different things.

The Luhu's missiles and launcher are French (the *Crotale* system or the Chinese version thereof, as mentioned previously), probably facilitating the interface between the combat direction system and the anti-air missile system, both designed by Thomson. However, the long-range 100mm and short-range 37mm guns are Chinese, as are the Type 347G (*Rice Lamp*) fire-control systems[20] for the guns. (The unmanned, wholly automatic 100mm gun, with a firing rate of 30 rounds per minute per barrel,[21] closely resembles an Italian main-battery gun. The 37mm guns are rapid-fire weapons—760 rounds per barrel per minute,[22] although the weapon resembles another Italian gun, the PLA Navy has expressed great pride in its

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[20]A. D. Baker III, *Combat Fleets of the World 1997-98*, p. 120.

[21]Conversation between the author and a PLA Navy captain on board the *Luhu*-class destroyer *Harbin* (but not normally assigned to the ship) while on a port visit to San Diego.

[22]Baker, p. 115.

development.) The establishment of an extremely reliable and effective interface between the combat direction system and the rapid-fire 37mm guns, two systems of widely differing origins, is especially crucial. These guns and their fire control system, something like the *Phalanx* close-in weapon system (the Gatling-gun-like CIWS) developed and used extensively in the U.S. Navy,[23] are the last resort to down anti-ship cruise missiles that leak through other air defenses. Failure of this complex sequence of target designation, precise fire control, and then faultless fire of a fusillade of projectiles from the guns would be devastating, likely resulting in heavy damage or the disabling of the ship. So, the PLA faces the need to resolve this extraordinarily difficult integration problem in a situation where there is no second chance or backup for that crucial system in combat.

Other crucial examples of systems integration problems at the level of a specific weapon system include melding the radar in the Russian Su-27 interceptor aircraft and the Chinese air-to-air missiles (AAM). The PLAAF would seek the capability to employ its PL-series missiles in addition to the Russian missiles purchased as part of the Su-27 sales arrangements. PLAAF leaders must ponder the likelihood that Russian-made missiles might be subject to easy defeat by Russian pilots, if there were once more frictions over the northern border—or that the Russian designers might have revealed missile-countering secrets to Americans or others. In the obverse of this example, the PLAAF may wish to make its Russian-made heat-seeking and radar-guided AAMs compatible with the J-10 or other Chinese-built fighter aircraft. To illustrate how far the PLAAF may have to go to be able to achieve these complex meldings, one need only recall the observations by some knowledgeable observers that the PLAAF apparently has not yet achieved a consistent capability with the Su-27s, acquired early in this decade, to employ air-to-air missiles in all-weather conditions and beyond visual range. The PLAAF does not have a good record or reputation for success in endeavors such as this, or even in much less complex tactical integration.

However, despite problems and gaps, there has been some progress in this level of systems integration by the PLA, even if spotty, as amply illustrated by the presence of the TAVITAC systems in the three latest PLA Navy warships. This example of limited success brings to the fore other critical questions: Will the PLA expend the effort and consistently provide the resources needed to keep these (largely foreign) systems operative? Will the advanced skills required for operation and maintenance be taught on a continuing basis? Will preventive maintenance and repairs of casualties be undertaken promptly and correctly or will these things be ignored, as has so often been the case in the PLA? Is there a full understanding by PLA operators and technicians of the detailed workings of the systems and the complexities of the

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[23]The U.S. CIWS, incidentally, has been sold to Taiwan for use on frigates. The fact that this system is available as last-resort protection for Taiwan's frigates makes it all the more imperative that the PLA Navy strive to feel confident in its own systems. In any sort of confrontation at sea that may come about between the PLA Navy and ROC Navy, the relative effectiveness of the anti-ship cruise missiles of the two sides is almost certain to be the crucial factor. These two systems are likely to be major determinants in the matter of defense against cruise missiles.

systems integration? Most Western observers believe that the answers range from no to maybe, at best, for questions such as these.

The existing systems integration efforts at this level are important for reasons beyond the successes with individual weapon systems. These efforts are likely to reveal the pace and trend of PLA systems integration—whether it will be slow or rapid, and whether it will tend toward failure and epidemic frustration or success and contagious enthusiasm.

Integration of high-tech systems with obsolescent and low-tech equipment. The final of the five levels of systems integration is of special applicability to China, and a situation where success of the integration may not be nearly so dependent on crucial interfaces, automaticity, and the like. For decades to come, the PLA will continue to have a very large inventory of old equipment and a much smaller inventory of advanced systems. The effort to employ selected high technology as a force-multiplier or enhancer for obsolescent equipment will surely receive a great deal of attention and may even become a very important and widespread aspect of PLA systems integration, even if the PLA (prudently) accelerates retirement of obsolete equipment. Lieutenant Colonel Lonnie Henley wrote in April 1996 that China is likely to pursue "the integration of high-tech conventional forces with guerrilla, militia, and paramilitary forces. There is already considerable discussion of this approach, generally under the rubric of 'people's war under high-tech conditions'."[24]

PLA leaders and writers on military affairs have indeed suggested this concept in an even broader sense than that described by Henley, albeit somewhat obliquely. They look to certain advanced or innovative means as a way to leap-frog over their technological backwardness and to find chinks in the digital armament that the U.S. and other modern armed forces tout as the way battles of the future will be fought. A PLA major general wrote:

> We must use a practical combination of information warfare and Marxist and Maoist military thought to guide information warfare and issues in military construction [building of the force] . . . . [T]he military [PLA] must emphasize the study of ways to use inferior equipment to achieve victory over enemies with superior equipment.[25]

> We must use all types, forms, and methods of force, and especially make use of nonlinear warfare and many types of information warfare methods which combine native and Western elements to use our strengths.[26]

A PLA senior colonel offered:

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[24]Lonnie Henley, "China's Capacity for Achieving a Revolution in Military Affairs," an unpublished paper prepared for the Annual Strategy Conference at the U.S. Army War College concerning the status of China in the 21st century held 23–25 April 1996. Lieutenant Colonel Henley, U.S. Army, has considerable experience related to the PLA.

[25]Wang Pufeng, "The Challenge of Information Warfare," in Michael Pillsbury (ed.), *Chinese Views of Future Warfare*, p. 319. Major General Wang is a former Director of the Strategy Department, Academy of Military Science, Beijing. His paper was excerpted from *Zhongguo junshi kexue*, Spring 1995.

[26]*Ibid.*, p. 325.

> The basic way to defeat a powerful opponent with a weak force in a high-tech war is to bring the overall function of [the weaker force's] operational system into full play . . . and, through the integration of the above two aspects, attain the goal of turning the inferior into the superior and finally defeat the enemy.[27]

Another major general provided this perspective:

> Large quantities of high-tech weapons on battlefields pose serious challenges to traditional methods of operation . . . On the other hand, traditional methods will be reinvigorated and adapted to new operational conditions. With technical development of precision all-weather targeting, stealth weapons, precision guidance, and night fighting, traditional warfare can also be enhanced.[28]

Open to debate is how seriously these concepts should be taken. Is there substance behind the words? Are these largely just examples of PLA writers who feel the need to tackle concepts they have read about in Western military journals and apply them to the PLA? Henley's experienced analysis of various writings on this issue includes the thought that there is a "bit of a 'me too' tone" to it all. Certainly that is an aspect of this concept that should not be ignored. Peripheral (unmodernized) PLA units naturally want to believe that they are, or can become, part of an effective fighting force, and their leaders desperately need something hopeful to tell their troops to keep morale from collapsing under the realization that their ill-equipped units would be little more than cannon fodder on the modern battlefield—or its naval or air warfare equivalent. As things stand now, we simply do not have solid evidence that the PLA is, as a matter of doctrine, pursuing this method to enhance the effectiveness of less-capable forces. Available evidence (other than the type of rhetoric cited above) points in the opposite direction, that the PLA is concentrating new systems and the integration (however rudimentary) of those systems in its "pockets of excellence": the elite rapid-reaction, or "fist" (*quantou*) units, as well as the naval and air equivalents thereof.

Michael Pillsbury has shed light on another shadow lurking in this concept, at least as it is described in Chinese military writings. In commenting on an article concerning the potential enhancement of Chinese airpower along these lines, Pillsbury wrote, "This peculiar misperception seems to mean that obsolete 30-year-old fighter aircraft (the majority of China's air force) can be made effective by adding a few AWACS aircraft and electronic jamming aircraft, which China is in the process of acquiring." (It is not possible to determine with confidence whether the writings on which Pillsbury comments are in fact an example of a PLA misperception. They may instead be wishful thinking, or an attempt to mislead potential adversaries—possibly Taiwan more than the U.S.—to believe that the PLAAF will soon be much more potent.) The point here is that there is a tendency among developing armed forces, to which the PLA is not immune, to believe, all too optimistically, that the

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[27]Shen Kuiguan, "Dialectics of Defeating the Superior with the Inferior," in Pillsbury (ed.), *Chinese Views of Future Warfare*, p. 217. In 1997, Senior Colonel Shen was a professor at the [PLA] Air Force Command Institute in Beijing. His paper originally appeared in *Zhongguo junshi kexue*, Winter 1994.

[28]Wu Guoqing, "Future Trends of Modern Operations," in Pillsbury (ed.), *Chinese Views of Future Warfare*, p. 349. In 1997, Major General Wu was Director, Department of Operations and Tactics, Academy of Military Science, Beijing. His paper was originally published in *Zhongguo junshi kexue*, Summer 1994.

addition of this or that advanced system will catapult it into modernity. Although the record is full of examples where that sort of effort has failed, hope springs eternal.

Of course, there will be specific situations where the integration of advanced systems with far less sophisticated equipment will produce enhancements, or where some very capable modern systems can provide cover and protection for older, more numerous, less capable platforms. There will be situations where obsolete and modern equipment will be present during the same engagement, with benefit accruing in some instances and confusion the likely result in others. However, it is much more likely in most cases that systems integrated in such a manner, whether by design, necessity, or inadvertence, will be no stronger than their weakest links.

Indeed, in many cases the attempt may prove counterproductive because valuable high-technology systems will be adulterated, wasted, or even sorely jeopardized. Various levels of technology can, of course, be integrated, but assurance of an outcome that is likely to succeed under combat conditions is quite another question. The success of such an integration effort is much more probable with components that are balanced and compatible. This level of systems integration, the concept of combining advanced systems to give new life to the PLA's "military museum," would seem to hold very limited promise for the PLA. Given the plight of the PLA, these dim prospects for success are unlikely to discourage isolated attempts to bring about miracles. However, widespread efforts along these lines are highly improbable.

III. DREAMS, REALITY, AND PROSPECTS

PLA Aspirations for Systems Integration: Hopes and Dreams

The concept of systems integration and its complexity are, no doubt, understood and appreciated by many of the more perceptive and better-educated officers of the PLA. Their insights are being passed along to many others through articles in *Jiefangjun bao* (*Liberation Army Daily*) and various Chinese military journals. A 1996 article is illustrative.[29] The writer describes the trend toward integration of military intelligence, tactical decision-making, and attack against opposing forces, recognizing the contradiction between the modern demand in combat for near-real-time actions and manual operations. (His reference to crude manual operations is, of course, one of the devices used by such writers to point out the situation in the PLA without having to do so directly.) He observes that such unautomated systems that exist independently, even if operated manually at the upper limit of human capability, cannot satisfy the requirements of modern warfare. Quoting from the article: "The resolution of these contradictions is certain to be the setting up, with computers as the nucleus, of an integrated system of intelligence, decision-making, and attack; forming an organic whole of automated information processing, computer-automated judgments or auxiliary decision-making and automated weapon operation; reducing information links; and having machines replace manual

[29]Wei P'ing, "Trend Toward Integration of Intelligence, Decision-making, Attack," *Hsien-tai chun-shih*, No. 229, February 11, 1996, pp. 49–51.

operations." There is further explanation in some detail of the characteristics of intelligence reconnaissance technology, the development of the science of decision-making, and the features of modern precision weapons. The author asserts that the Aegis system on U.S. and Japanese warships is representative of one type of integrated system and the German Cheetah motorized antiaircraft artillery system typifies another. The author concludes that such systems lower the requirements for weapons and equipment and offer better prospects for "big victories."

Many Chinese writings on subjects similar to this one are largely regurgitation of articles in U.S. or other Western military journals—a point often made by Westerners examining the state of PLA progress in this area. The use of the Aegis and Cheetah examples surely raises that specter in this case. Whether that is the case here is interesting to speculate about, but does not detract from the issue at hand. The point here is that the PLA, and certainly the PLA elite, is fully acquainted with the jargon and concepts of systems integration, at least at the level of detail of such newspaper and journal articles. There can be no remaining question as to whether the PLA recognizes that victory in future conflicts against modern forces will be virtually unachievable unless it can attain a goodly measure of the system integration goals to which it aspires.

The PLA Navy (PLAN) has not lagged behind in *conceptualizing* integrated systems within individual ships, between ships, and even more broadly. The expression frequently employed by PLA Navy writers is *digitized naval warfare*. They define this term to include digitized communications and information systems, computer data processing systems and terminals, and links to combat platforms. The vision is of a digitized chain of command and control to sharply increase the combat performance potential of all naval warfare platforms and weapons. As a 1996 article by two PLA Navy officers in the journal *China Military Science* stated:

> Single-ship and unit offensive-defensive capability, single-unit coordination capability, and inter-unit joint operations capability are all growing sharply [meaning in modern naval operations, not necessarily in the PLA]. And as to coordinated naval operations, with submarine, aircraft, and surface ship communication systems being linked up, mutual information transmission problems being solved, and the current joint operational difficulties and problems within and among units being overcome, all combat platforms can be effectively linked into one operating entity, to strike enemies with maximum combined force [again, hardly a description of today's PLAN] . . . . Such comprehensive operating systems can link the whole establishment together. So we can predict that the naval C^3I system grounded in satellite and computer technology will become the priority of soft systems development in the tide of the new military revolution, as well as being linked up and made compatible with air force and army C^3I systems.[30]

PLA writers often reveal more in their writings than the literal meaning of the words. They apparently are constrained in candidly addressing the shortcomings of the PLA

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[30]Shen Zhongchang, Zhang Haiying, Zhou Xinsheng and Shi Yukun, "The Impact of the New Military Revolution on Naval Warfare and the Naval Establishment," *Zhongguo junshi kexue*, No. 1, February 20, 1996, pp. 57–60. Senior Captain Shen is Director of the Science and Technology Department, Naval Military Academic Studies Institute; Lieutenant Commander Zhang and Lieutenant Zhou are affiliated with the Institute. Mr. Shi edited the article.

Navy. One method of getting around these constraints and raising the issue of PLAN inadequacies is to write about what is happening to navies generally as they modernize. That technique has been employed liberally in the article cited above. Put another way, the developments described in this article will be recognized by PLA Navy officers, the principal readers of this journal, as capabilities that the PLA does not have or concepts that the PLA is just beginning to come to terms with. Consequently, the authors do not have to state directly that their navy is lacking in the types of equipment described and the integration thereof. When they write about the conduct of future naval warfare, their purpose is clear: They are sending the message that the PLAN is behind and needs to catch up. The final sentence of the excerpt is illustrative; it should not be seen primarily as a prediction of the future of naval warfare but should be interpreted as a call to action. Stripping away the artifices of PLA writing, its meaning might be as follows: *The PLA Navy must turn its attention to the acquisition and integration of C^3I based on satellite and computer technology. This should be a priority in PLAN soft systems development and should be compatible with air force and army C^3I systems.*

The following excerpt from the same article uses this technique once more and pointedly employs a description of U.S. Navy practices to suggest what he considers the proper direction for the PLAN:

> All soft systems [sic] have become a key indicator of ship combat performance. So in the modern warship development process, all soft systems, particularly communications equipment, target detection equipment, and electronic warfare systems, are growing not only ever more numerous but also increasingly complex, becoming the key components of weapon systems. The U.S. Navy, when designing and building navy vessels, gives priority consideration to electronic equipment, equipping many of its ships with electronic jamming units to increase their defensive capability. Tactical intelligence data systems are comprehensive operating systems that the U.S. Navy has developed to a high degree of perfection on most of its surface ships. They not only can direct all weapon operations of a ship but also can use data links with other ships in the fleet to coordinate and command the weapon control systems of friendly ships and planes.[31]

Indeed, we can trace these types of rhetorical devices to the highest levels of the PLA. The Director of the Commission on Science, Technology, and Industry for National Defense (before COSTIND's reorganization in 1998), Cao Guangchuan, wrote in 1997 of the Central Military Commission's stress on scientific and technological development for national defense:

> [I]t is necessary to effect the change from aiming to win limited wars fought under ordinary conditions to winning limited wars fought under conditions of modern technologies, especially high technologies. Second, in terms of army building, it is necessary to effect the change from quantitative expansion to qualitative improvement, from building labor-intensive forces to building technology-intensive forces . . . . We must persist in putting scientific research before actual development, keeping track of the development of high technologies in the world, mainly relying on

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[31] *Ibid.*

> our own efforts, and attach importance to the digestion and assimilation of imported technologies and on innovation.[32]

It seems safe to assume that Cao's words reflect real CMC and COSTIND priorities and the state of technology in the PLA, and that they were not words written to influence or mislead a Western audience. This conclusion seems all the more plausible because many other officers and officials have written along similar lines in various journals and other publications, including some to which foreigners do not normally have access. Several conclusions might be drawn from his revealing words, but the fact that he and others, in 1997, were offering such elementary advice and guidance on such things as the sequencing of research and development may be the most interesting features. The tone of his pronouncements makes it clear that the PLA is still at a very early stage in assimilating advanced technologies, much less integrating these technologies into sophisticated systems. This is, of course, no surprise to those who follow and analyze the PLA's modernization efforts. However, it does provide confirmation and a richer context for understanding where the PLA stands today with respect to systems integration and how far it has to go. Reliance on foreign technology is evident, as is the conflicting (and understandable) desire for self-reliance. The final sentence makes clear not just the need to acquire "imported technologies" but also, by attaching importance to digesting that technology, the writer reveals (not surprisingly) that this matter of usefully assimilating such imports (and integrating them into combat systems) is an abiding concern.

The views are also shared by representatives of the defense industries that are charged with producing the systems. The President of China Ordnance Corporation wrote in 1997 in the *People's Liberation Army Daily* about integration efforts:

> Over the next few years, the ordnance industry will persist in integrating the development of new equipment with the revamping of existing equipment and in integrating development of our own efforts with the import of advanced technologies.[33]

In the same group of 1997 articles in the *People's Liberation Army Daily* as the two pieces cited above, the Supervisor of War Military Projects under the Ministry of Electronics Industry wrote:

> The year 1997 is a crucial year in the Ninth Five-Year Plan for the development of military electronics. The tasks are very arduous . . . In this year we will continue to conscientiously implement the spirit of the instructions of the Party Central Committee and the Central Military Commission by . . . strengthening basic research and anticipatory research, *improving the ability of systems integration . . . and striving to achieve a giant leap in the development of military electronics . . . We have come to soberly realize that making a success of this key project will involve many difficulties*

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[32]Cao Gangchuan, "Enhance Sense of Strategy, Elevate Level of Science and Technology for National Defense," *Jiefangjun bao*, February 24, 1997.

[33]Zhang Junjiu, "Take Military Production as the Foundation, Make New Breakthroughs in Ordnance Industry," *Jiefangjun bao*, February 24, 1997.

> *because this gigantic system is unprecedented in terms of scale and matters involved* [emphasis added].[34]

These two officials, as they wrote these apparently obligatory articles for a PLA newspaper feature entitled "Accelerate Development in Scientific and Technological Industries for National Defense, Meet Challenge of World Military Development," were forced by the lack of previous PLA achievements in this area to look solely to the promise of future progress. They did not have the option of, instead, describing previous signal successes. One suspects that, were these officials or their successors to be called upon in 1998 to write similar articles, similar words of hope for future progress would still fit best. Beyond the judgment that substantial progress is, in many regards, a hope rather than a fact, there are the inescapable conclusions drawn from these words that tasks of this nature, certainly including systems integration, are truly formidable obstacles for the PLA. The writers' description of the scope of the task is, indeed, not couched in optimistic terms but rather in a way that appears more to offer an excuse for why success will not be achieved in the foreseeable future.

Where the PLA Stands on Systems Integration and Technological Innovation: A Reality Check

Although China, and especially the PLA, would prefer to be self-reliant in both the acquisition of technology and systems integration, the inadequacy of China's research and development infrastructure has presented a major obstacle to realization of that goal, despite efforts to reform the scientific and technological sectors. China has tried to foster this process by treating technological know-how as a commodity and having its exchange and diffusion controlled by market forces. The unhappy result, however, has been essentially a failure (based on several complex factors) to create a demand for domestic technology by industry. Among the reasons for the failure was the lack of useful technological flow from Chinese domestic sources. The counterproductive result has been heavy demand for foreign technology and excessive reliance on that source.[35]

Chinese research and development successes are rare. As described at the beginning of this paper, China has achieved success in its nuclear weapons program and in the development of ballistic missiles with both nuclear and conventional warheads. This success, it must be said, has gone well beyond simple expansion of the technologies obtained from the Soviets in nuclear warhead technology and missilery. However, in virtually all other areas, China's achievements in the employment of advanced military technologies and systems integration have been sharply limited by the absence of indigenous technology and by the inability to acquire and incorporate

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[34]Wang Jingcheng, "Concentrate a Superior Force to Fulfill Key Tasks of Scientific Research," *Jiefangjun bao*, February 24, 1997.

[35]Erik Baark, "Military Technology and Absorptive Capacity in China and India," pp. 94–97.

advanced technologies from other countries,[36] primarily European nations and Russia. Dual-use technologies and spin-offs therefrom have produced surprisingly little benefit to the Chinese military technology base,[37] especially in light of the mixing in recent years of military and commercial industry through defense conversion efforts and other methods to strive for efficiencies and profits.

There is little reasonable prospect for short-term rectification of these problems with respect to the low technology base for Chinese military industry. As one careful observer put it, "China's ability to develop military technology indigenously is limited by the poor organization of the military industry, which can be improved only by revamping its organization—a step which may be possible only in the context of political reform."[38] Others are even less optimistic concerning Chinese attainment of advanced technological and systems integration skill, feeling that somehow there are cultural or societal barriers that have produced the current situation and that will perpetuate it indefinitely. Obviously, such assertions are essentially impossible to prove or disprove. Some observers point to examples of success among other similar societies, but those who believe that China has irreconcilable problems remain unconvinced and have probably persuaded some Chinese that China is far better off simply to make do as best it can with foreign systems, particularly in those areas where systems integration and other esoteric skills are most prominent.

The scope of the problem, if not the possible underlying factors, seems fully appreciated by the PLA leadership. CMC Chairman Jiang Zemin issued directions (apparently in early 1997) that the armed forces must undertake a sweeping program to improve the knowledge of cadres at all levels with respect to science and high technology. To implement the direction, the General Staff Headquarters distributed a document entitled "Three-Year Plan for Cadres of the Whole Army to Study High-Tech Knowledge."[39] The official Xinhua News Agency reported an announcement by the General Political Department of the PLA about six weeks later that the army would increase the recruiting of college graduates. The change in officer procurement practices was described as "one of the important measures . . . to implement the strategy of relying on science and technology to build up the army and to accelerate the modernization process."[40] These initiatives suggest the depth of the frustration that the PLA is experiencing in dealing with the technological revolution in warfare.

Many Westerners question the efficacy of policy pronouncements such as those described above. They argue that Chinese leaders fail to recognize that truly innovative science and technology are highly unlikely to thrive in today's China—in

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[36]Eric Arnett, "Beyond Threat Perception: Assessing Military Capacity and Reducing the Risk of War in Southern Asia," in Arnett (ed.), p. 9.

[37]*Ibid*.

[38]*Ibid*., p. 13.

[39]Gu Boliang, "General Staff Headquarters Distributes Three-Year Plan for the Whole-Army Cadres to Study High-Tech Knowledge," *Jiefangjun bao*, February 6, 1997, p. 1.

[40]Xiao Pu, *Xinhua Domestic Service*, March 19, 1997, in FBIS-CHI-97-082, March 23, 1997.

other words, that these policies are empty rhetoric. In any case, it is clear from Chinese statements made at very senior levels that the Chinese technology base, especially that applicable to military systems, and the ability to integrate such technology into the systems of modern warfare are woefully lacking. These inescapable conclusions are prompted by the words of Chinese officials who, somewhat inadvertently, reveal the depth of the problem by the very sweep of the solutions they propose.

American specialists have arrived at similar conclusions. The *Militarily Critical Technologies List* (*MTCR*) published by the U.S. Department of Defense (referred to earlier in this paper) contains assessments of foreign capabilities in various technology areas. These assessments represent the consensus of a technical working group composed of members from U.S. industry, government, and academia, including selected members of the U.S. intelligence community.[41] In the field of electronics technology, China is evaluated by this group as possessing only limited or "some" capability (the two grades at the low end of the *MCTR* assessment scale) in each of six areas of evaluation. (For example, China is credited with limited capability in the technology associated with electronic components and with some capability in microelectronics.) The *MCTR* evaluation states: "China has been slowly developing capabilities during the past five to ten years and will probably accelerate the rate of development during the next five to ten years in an attempt to catch up militarily and commercially with others."[42] In the subsection on microelectronics, including integrated circuit design and the electronic packaging technologies required to achieve the needed high speed, high power, and ability to function in severe environments for basic building-block microcircuits, China is said to trail Russia and to be generally on a par with the East European countries.[43]

In the area of information systems technology, China is assessed in the *MTCR* to have only limited or some capability in ten sub-areas and no capability in the modeling and simulation sub-area. The sub-areas in which China is comparatively deficient include high-performance computing, intelligent systems, networks and switching, signal processing, software, and transmission systems.[44] In the area of information warfare technology, a field with which the PLA is infatuated, the U.S. specialists' evaluation is particularly damning. China is assessed as having a limited capability in the sub-area of electronic attack and no capability in the other three militarily critical sub-areas of IW.[45] The picture is only slightly better with respect to space systems technology.[46] Perhaps the most revealing aspect of these evaluations is that in all the areas that are directly pertinent to integration of military systems to produce effective combat systems, China consistently receives assessments in the

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[41]Office of the [U.S.] Under Secretary of Defense for Acquisition & Technology, pp. iv., 2-3.

[42]*Ibid*., p. 5-2.

[43]*Ibid*., p. 5-12.

[44]*Ibid*., p. 8-2.

[45]*Ibid*., p. 9-2.

[46]*Ibid*., p. 17-2.

lowest categories of capability, failing to receive a ranking in the top two categories of capability in even one of the many sub-areas.

An experienced analyst of PLA modernization summed up China's position this way: "The Chinese lag even further behind [than in other military areas] in circuit design, system integration, networking, operating systems, and development of software applications . . . [T]he American armed forces are moving rapidly along a path that China is not prepared to follow . . . It is not just a matter of available technology, or even of creativity in the application of technology. The greatest impediment to China achieving an information-based revolution is its authoritarian political system."[47] This analyst points out that in Chinese publications there is "virtually no discussion of intelligence processing and fusion systems such as the U.S. All-Source Analysis System (ASAS), or of dedicated communications links for intelligence dissemination . . . This requires high-capacity, robust communications links, standardization of data formats and transmission protocols, interoperability of intelligence communications among different systems and services, powerful information processing systems at the lowest command levels, and a commitment to the free flow of intelligence information to tactical commanders . . . [A]vailable sources do not indicate any effort by the Chinese to implement such an elaborate and open intelligence environment. So the overall prognosis is that the PLA may achieve the kind of capabilities demonstrated by U.S. forces in the Gulf War [almost a decade ago], though it is likely to take at least ten and probably twenty years for it to do so." Dr. Paul Godwin of the U.S. National Defense University seconded this when he wrote: "The PLA also lacks both the logistical support systems and command, control, communications, and intelligence (C^3I) infrastructure necessary to sustain combined-arms operations."[48]

The American consensus as described above is corroborated by a Russian analyst, Viacheslav A. Frolov. Given the intimate connections with China with respect to technology transfer, the Russian perspective is particularly worthwhile. Frolov wrote in 1998:

> The vulnerability of the PLA's C^3I system is its obsolete command and communications links and lack of any measures for anti-electronic warfare. For the former, the strategic C^3I system has effective coverage of the PLA ground forces only up to divisional level. The system is heavily reliant on radio and security telephones. Only recently have satellite communication channels been created at the Group Army level, and computerized links at the divisional level. The tactical C^3I is carried mainly by semiconductor [UHF] radios, providing only limited communication capability, usually within a range of 2.5 to 10 kilometers. Space-based communications systems and global positioning systems are seen as a crucial step to enhance the PLA's C^3I system. Currently China's six communication satellites have allocated very limited channels to the PLA. To rectify this situation, a proposal has been tabled to create a network of defense satellite communications.[49]

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[47] Henley, p. 11.

[48] Paul H.B. Godwin, "Military Technology and Doctrine in Chinese Military Planning," p. 60.

[49] Viacheslav A. Frolov, "China's Armed Forces Prepare for High-Tech Warfare," *Defense & Foreign Affairs Strategic Policy*, January 1998, p. 7. Frolov appears particularly well suited to offer this evaluation. He is

Systems integration is, of course, not restricted to computers and weapon systems. As Paul Godwin mentioned (cited just above), the PLA has severe shortcomings with respect to logistical support systems. Paul Dibb notes that the integration of complex information systems in real time depends critically on a new approach to maintenance and the support in a combat environment of systems capable of remaining operational full time and in all weather conditions. He goes on to remark that very few Asian countries seem to acknowledge the vital nature of integrated logistic support (ILS).[50] As with other areas of technology assimilation and systems integration, there is acknowledgment (but little more) in PLA writings of sweeping new requirements for integrated logistic support. A mid-1996 article in the *Liberation Army Daily* states:

> On a digitized battlefield, a combat unit, combat support unit, combat duty support unit, and other combat systems have become an integrated whole with functions like battlefield intelligence, command, control, telecommunications, attack, damage and casualty evaluation, and so on, and this has promoted logistical support integration. On the one hand, an integrated logistical support system is capable of breaking through boundaries between logistical support systems of different services; comprehensively optimizing the disposal and utilization of logistical resources; raising logistical resources utilization efficiency; and preventing duplicate disposal and waste of logistical resources, thus comprehensively enhancing logistic support capability and efficiency and making logistical support conform with integrated combat operations.[51]

As has been seen in many other such writings, the author is obviously describing something the PLA does not have. The article seems to advocate PLA adoption of a sophisticated integrated logistic system. There are, however, several reasons to question whether the PLA will or should undertake such sweeping logistical reform at this early stage of force modernization. Not only is the task daunting and enormously expensive (as well as costly in other resources), but there is also the question of whether such a system, modeled along Western lines, is truly appropriate to the PLA's likely missions and circumstances. Not to be ignored is the realistic consideration of whether such a system in the PLA, even if instituted, would simply collapse of its own weight in a short time—an example of too much, too soon.

Certainly logistic enhancements are needed in the PLA. The question is whether the grander ILS schemes envisioned by Chinese writers, who are largely paraphrasing the logistics literature of the U.S. and other Western armed forces, are appropriate to the circumstances. The PLA, according to most outside observers, might first come to grips with the less grandiose (yet still complex and critical) concepts of logistic support, preventive maintenance, timely and efficient repair and rework, etc. This does not apply solely to support of indigenously produced equipment. The PLA does not provide adequate logistic support and maintenance of imported military equipment and systems, generally opting not to procure sufficient and appropriate

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described as a Sinologist by background and as Project Manager at MAPO Military Industrial Group, the manufacturer of MiG fighter aircraft, in Moscow.

[50]Paul Dibb, p. 94.

[51]Gong Fei, "Digitization and Logistical Reform," *Jiefangjun bao*, August 27, 1996, in FBIS-CHI-96-209, August 27, 1996.

training, spare parts, and maintenance systems for the weapon systems and other military equipment it purchases abroad. One reason for giving these areas short shrift is, of course, to save money. However, neglect in these areas seems also to reflect a deeply ingrained lack of recognition that these are key elements of a combat capability.

Put succinctly, the real question is whether there will be good reason, adequate will, and sufficient resources within the PLA to sustain such an integrated logistic system. The likely answer is that the system, if it evolves, will be riddled with "Chinese characteristics," raising the further question of whether, with such encumbrances, it can function at all. As with other aspects of the systems integration problem, it is far from a foregone conclusion that recognition of the problem followed by (probably token) efforts to effect a solution will lead to effective results. There is the strong prospect that attempts at developing an integrated logistic system at this stage of PLA modernization may become costly excursions into a nether world.

There are other serious underlying problems, arguably more fundamental than those described above. Chinese research and development is immature, isolated, fragmented and unfocused, all of which have stymied the gathering of needed momentum for the development of advanced military technologies and integrated weapon systems.[52] With respect to computer technology, China has until recent years emphasized hardware rather than software development, and currently domestic Chinese collaboration in software development remains deficient because of both technical and economic barriers. Contacts between developers and users, especially military users, are lacking. The capability to produce the complex and flexible programs needed for military applications is limited. Software development is proceeding apace elsewhere in the world, often leaving China behind, even with the recent attention there to software development.[53] Among the many reasons is the problem of adapting programs to the Chinese language, using Chinese-language processing, or training operators to use applications written for native speakers of other languages. This is further complicated by individual systems using different languages that must be integrated into a functional combat system. The language problems are significant and not restricted to the software area.

The author and others with whom he has spoken have seen on Chinese ships and in Chinese naval and military training facilities and simulators that manuals and equipment are frequently in English or another language other than Chinese. Chinese officers have remarked about misunderstandings, badly translated manuals and operating instructions, and decried the amount of training time that must be spent in learning or improving English comprehension to be able to maintain and operate these systems.

Other areas present formidable problems for China as well as for other countries. For example, the provision to sophisticated and delicate equipment of electrical

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[52]Erik Baark, "Military Technology and Absorptive Capacity in China and India," p. 109.

[53]*Ibid*., p. 103; also, extensive treatment of software problems in China is provided in Erik Baark, "China's Software Industry," *Information Technology for Development*, Vol. 5, No. 2, June 1990, pp. 117–136.

power of the needed stability, voltage, frequency, and phase is not a simple problem even for advanced militaries. It is certainly not one that the PLA can ignore. Of course, when one is considering combat applications there must be redundancy in many areas, including that of stable electrical power. The PLA has given little attention to redundancy and to other provisions so that its ships and other platforms could continue to fight after sustaining combat casualties or even "normal" malfunctions. The simple, if not sole, reason for this deficiency is that the PLA has not mastered keeping the first-line systems operating, much less worrying about redundancy, back-ups, work-arounds, and coping with combat damage or other casualties.

PROSPECTS FOR THE PLA: SOME CONCLUSIONS

Is the PLA gaining or losing in the race? Many observers of the PLA and analysts of PLA modernization assert that the PLA is anywhere from ten years to two generations behind modern armed forces in technological acquisition, assimilation, and systems integration. One should not be surprised at this variation in estimates. It is not reasonable to insist on any sort of precision or even accuracy in making generalizations of this sort. But there is no doubt that the PLA is not in the same league with truly modern armed forces, that it has a long way to go and is not getting there very quickly. An important question not often asked is whether the PLA is gaining or losing in this competition. Certainly there are elite PLA units that are making progress; some of these units may even achieve minor successes in systems integration. However, modern armed forces, especially those of the U.S. (which for various reasons the PLA uses as a standard for its progress), are developing at a rate that most of the world, including the Chinese, little appreciate.

Advanced technologies viewed as vulnerabilities. Some PLA writers hold out the prospect that the advent of armed forces dependent on the most advanced computer technologies and the complexities of systems integration will produce vulnerabilities for the more modern militaries and, concomitantly, opportunities for the PLA to exploit this inordinate dependence on exotic technology. The far more likely situation, albeit hardly assured, is that China will be unable or unwilling to devote the attention and resources required to develop the advanced technologies and systems integration capabilities needed for such exploitation and that this will continue to be a profound shortcoming of the PLA for the foreseeable future.

In a broader context, China is not likely to catch up with the U.S. or advanced countries in the region, like Japan and Australia. Taiwan is a different issue. The jury is out on whether Taiwan can, with U.S. assistance, achieve advances and systems integration in key areas, even if not across the board. On the other hand, with respect to the other countries of the region, China will be able to hold its own because the other countries are experiencing similar problems with technology and systems integration, although in some cases for other reasons.

For all the reasons described above, the increasing importance of extremely advanced technologies and the sweeping scope of systems integration are likely to produce an environment in which China, as the years pass, will be even more

disadvantaged than at present. Put colorfully, the PLA may rely on its dream of leapfrogging through technology exploitation and yet awaken ten years into the next century to find itself still somewhere between ten years and two generations behind. To make its dream a reality, China would have to change much more than most consider feasible and would have to embrace concepts of change far more sweeping than Chinese leaders seem willing to risk.

The PLA will certainly attain some limited success in systems integration. Some of those areas may be significant, even troublesome, in the delicate balance of forces with Taiwan in certain warfare areas and the ability to cause consternation for U.S. forces in other areas. However, overall, the odds are very high that systems integration will prove, for the foreseeable future, to be yet another area where the PLA will suffer from the problems with which China as a whole has not been able to come to closure. The PLA is not likely to be able to take advantage of this or other sea changes in technology to overcome its shortcomings compared to truly modern armed forces. It will likely slip further behind in that regard. However, China's armed forces will likely apply a mix of indigenous and imported technologies to achieve a greater comparative advantage with respect to most other regional armed forces, with the notable exceptions of Russia, Japan, and Taiwan, including the crucial area of systems integration.