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CHALLENGING U.S. SPACE SUPERIORITY:

CHINA'S SPACE "SURPRISE"

FINAL REPORT

BY

(b)(6)
Research Fellow

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(b)(4)

1015 15th Street, N.W. • Sixth Floor • Washington, DC 20005 • 202-974-2400 • Fax: 202-974-2410
www.hudson.org

EXECUTIVE SUMMARY

When China blinded a U.S. satellite in late 2006, the deputy head of Russia's Federal Space Agency was forced to feign nonchalance at the PLA's space-bound juggernaut. "We don't think China will outpace us in space *research*," Yuriy Nosenko declared. "We'll most probably move along in step with each other, as partners. And China will compete with us in space *exploration*."

Then—caught like a deer in China's ASAT headlights—other world powers scrambled to voice surprise at its January 2007 kinetic kill of an aging weather satellite. But by 2002, the People's Liberation Army (PLA) had already warned, "The prelude of the race to win 21st-century space dominance has begun."

According to Chinese military scientists, the PLA revamped its RDT&E program in the late 1990s. The Chinese decided to cancel weapons projects that had been active for 10 years or longer and to direct these funds to developing so-called "new-concept weapons": laser, beam, electromagnetic, microwave, infrasonic, climatic, genetic, biotechnological, and nanotechnological. The results demonstrate that—besides solving the problem of modernizing its conventional forces—China now has three military priorities: space, nuclear weapons, and "new-concept" weapons. Chinese aerospace scientists argue that "as we produce one generation, research and develop one generation, and pre-search one generation, we must move on to explore one generation." Indeed the "leaps-and-bounds" theory has become the linchpin of Chinese military development for 21st-century warfare.

During the Cold War, the Soviets used the arms control process to gain time to overcome a perceived lag in emerging military technologies. And, like all good Marxist-Maoists, Chinese political leaders rarely say what they mean. But their PLA helmsmen do. Viewed as a military museum at the time of Desert Storm in 1991, the PLA has engineered a quantum leap into the "space club," even imposing its own terms in the process. So the recent blinding and pulverizing of satellites can hardly be cryptic to anyone who reads their open exhortations to their own cadres.

"Whoever loses space loses the future," they say and really mean. Among other "new-concept" weapons openly earmarked for space dominance, laser technology appears to be the PLA's current "holy of holies." Citing Nikita Khrushchev's warning about *nuclear* weapons, one PLA writer warns that a *new* "Sword of Damocles" now dangles over the planet.

For more than a decade, Chinese military strategists and aerospace scientists have been openly designing an architecture for achieving space dominance. This report provides the central military-theoretical, technological, operational, and organizational elements of the PLA's evolving blueprint from 1996 to the present. It also traces the Soviet/Russian roots of that blueprint.

The author argues that China's "leapfrog" development in the RMA—not to mention the totalitarian nature of its defense industry—will seriously threaten U.S. space superiority in the near term. The United States should cease to be complacent about the sanctity of its orbital assets.

KEY RESEARCH FINDINGS

SPACE TECHNOLOGIES

"The weaponization of space," say the Chinese, "is an inevitable developmental trend." And the "commanding height" of strategic competition in the 21st century "will not be on Earth, but in space."

In early 2006, Chinese military strategists announced that "space weapons systems composed of hypersonic weapons will be the crack space troops with uniform tri-service land, sea, and air coordination and a widely increased scope of joint operations capability." They will be united in informational completeness, and the enemy—thus exposed to space weapons attack—will be forced to protect friendly land, sea, and air forces against such attack. Hypersonic weapons will become ***"the dominant combat ordnance"*** in future high-tech battlefields, and aerospace integration will be the primary mode of operations in future high-tech warfare.

In addition, hypersonic aerospace aircraft represent ***"one of the key weapons to be employed for controlling space and vying for 21st-century space dominance."*** Whatever complications may arise in their technological development, ***"these types of weapons will be the nucleus of military competition in the early period of the 21st century."***

SPACE WARFARE

Published by the Chinese Academy of Military Sciences, a recent book entitled *Strategy* defines the components of "military space strategy" as 1) the policies and principles for building military space forces; 2) the fundamental principles for employing military space forces; 3) the significance and role of space dominance; and 4) the characteristics, forms, and tactics of space war.

Since 1996, Chinese military scientists have defined space warfare as combat operations whose major goal is to seize and maintain space dominance, whose major combat arena is outer space, and whose major combat strength is military space forces. The features of space warfare are said to include dogfights between the space-based combat systems of both belligerents; intercepts of strategic ballistic missiles by space-based combat platforms; strikes by space weapons on Earth targets and Earth-based counterspace or space defense operations; and strikes from the land, sea, and air on enemy space launch platforms and command-and-control organs.

SPACE INFORMATION WARFARE

Both China and Russia have long contended that the "space-information continuum" constitutes the nucleus of the current RMA. The "Space Epoch" thus requires a colossal revision of military-strategic thought. ***"As informationized war advances," say the Chinese, "space will truly become the new theater of war and thereby establish a new milestone in mankind's history of warfare."***

Echoing their Russian counterparts, Chinese military scientists assert that information warfare (IW) missions are accomplished most effectively by using space-based assets. The Chinese delineate at least three reasons for the critical importance of space warfare to IW missions. First, space is the "commanding height" for future IW. Second, seizure of space control constitutes "the first combat operation in future IW." With the continuing development of space weaponry and equipment, belligerents will conduct such new modes of space warfare as 1) space information warfare, 2) space electronic warfare, 3) space antisatellite warfare, 4) space antimissile warfare, and 5) space-to-Earth warfare.

ANTISATELLITE (ASAT) WARFARE

Chinese military scientists assert that ASAT warfare is the most effective way to achieve space dominance. The principal forms are 1) use aircraft, warplanes, and rockets to launch ASAT missiles to destroy enemy satellites; 2) install "space landmines" on the orbits of enemy satellites for destruction once they hit the landmines; and 3) use positioning weapons such as lasers, clusters of particles, and microwaves to attack enemy satellites.

Destroying space targets by means of directional energies has the advantage that their powers can be adjusted, the weapons can be reused over and over again, their speed is high, and they can attack targets in a vast space. Modern ASAT weapons can also destroy enemy satellites by employing nonlethal destructive measures, such as spraying chemicals on them.

According to Chinese military and aerospace scientists, satellites will be the main space system for seizing space dominance in the 21st century. Attacking the enemy's satellites and protecting one's own satellites are the primary tasks of space warfare. To seize an advantage in space, and to protect national security, the competition for ASAT weapons and satellite defense will become more and more intense. The global trends of advanced satellite technology should be correctly followed, and ASAT weapons should be enthusiastically developed.

ANTIMISSILE WARFARE

Chinese military strategists stress that the creation of ballistic missile defense systems and corresponding "penetrating measures" again prove the "shield-spear" dialectic, each of which will always generate the other and advance competitively. For today, the Chinese propose the following "penetrating measures": 1) multiple warhead attack, 2) decoy penetration, 3) interruption and concealed penetrations, 4) enclosing balls (huge metallic membrane balloons), 5) trajectory change penetrations, 6) mobile launch, and 7) preemptive strike: "attack and destroy a certain part" of the NMD system.

Conducting a preemptive strike includes: 1) use "suicide satellites" (an orbital type of cruise satellite) or laser weapons to destroy the early-warning satellite system and space-based infrared systems of the NMD system to paralyze them, and 2) launch preemptive attacks against each component of the NMD system. According to the Chinese, Russian scientists state that it is possible to use a mid-air nuclear explosion to destroy the "command, control, and communication management center" of the NMD system to both paralyze and attack its essential defensive capabilities.

INTEGRATED AIR-AND-SPACE OPERATIONS

"This revolution," say the Chinese, "is first of all a revolution in concepts." Like their Russian counterparts, Chinese military strategists have long been articulating a body of operational concepts for conducting integrated "air-and-space operations" (ASO).

Owing to the technological breakthroughs in systems such as the space shuttle, aerospace aircraft, space weapons, and "new-concept" weapons, integrated ASO are becoming a new operational form of informationized warfare. For example, the space shuttle will become a completely new space weapon that combines aviation and spaceflight strikes, transportation, and information operations. This kind of milestone weapon, say Chinese scientists, will create the conditions for multidimensional, stereoscopic operations conducted from space to Earth, from Earth to space, and from space to space—thereby transforming integrated ASO from theoretical to actual.

The principles behind integrated ASO consist in "attacking systems" and "attacking the whole." Implementing a whole system-to-system confrontation is completely consistent with the Chinese concept of "whole operations" in informationized warfare (i.e., "integrated network-electronic warfare"). As space weapons continue to be developed, the speed at which targets can be acquired and attacked from outer space will undergo an Einsteinian change. Targets can be obliterated in an instant from distances of up to 10,000 kilometers, which makes the course of operations measurable in minutes or seconds. ***The concept of time in operations will thus move from the "time of combat vehicles" and "time of missiles" to the "time of the speed of light."***

Chinese military strategists predict that the emergence of integrated ASO will inevitably trigger a sea change in military strategy. The expanding space battlefield will compel new theories such as space threat warfare, space mobility warfare, space blockade warfare, space attack warfare, and space defense warfare. As "new-concept" weapons continue to be developed, the expanding space arsenal will generate such operations as laser attacks, microwave attacks, meteorological attacks, genetic attacks, virus attacks, and nonlethal attacks.

The first wave of war will develop from "firepower attack" and "electromagnetic attack" to "satellite paralysis." ***Space will become, say the Chinese, "the first true battlefield."***

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When China blinded a U.S. satellite in late 2006, the deputy head of Russia's Federal Space Agency was forced to feign nonchalance at the PLA's space-bound juggernaut. "We don't think China will outpace us in space *research*," Yuriy Nosenko declared. "We'll most probably move along in step with each other, as partners. And China will compete with us in space *exploration*."[1]

Then—caught like a deer in China's ASAT headlights—other world powers scrambled to voice surprise at its January 2007 kinetic kill of an aging weather satellite. But by 2002, the People's Liberation Army (PLA) had already warned, "The prelude of the race to win 21st-century space dominance has begun."[2]

Not surprising in a totalitarian society—and largely owing to Russian military theory and technology—the PLA has already pole-vaulted into a swift military buildup. Even in the face of technological superiority, they say, a man can always strike with the "assassin's mace" (*shashoujian*). Speaking of which, current PLA training exercises include a certain counterspace scenario—the Chinese government jams the communications frequency satellites supporting U.S. carriers in the vicinity of Taiwan.[3]

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[1] *Moscow Interfax in English*, 9 November 2006 (emphasis added).

[2] Wei Qiyong, Qin Zhijin, and Liu Erxun, "Analysis of Changing Emphasis in U.S. Military Strategy," *Daodan yu Hangtian Yunzai Jishu*, 10 August 2002, 1-4.

[3] For example, see Cheng Hsin-hua, "Capturing Taiwan within Seven Days: An Exposure of the PLA's Top-Secret Strategies," *Tung Chou Kan* (Hong Kong), 5 January 2005, 28-32. See also Mary C. FitzGerald, "China's Evolving Military Juggernaut," in *China's New Great Leap Forward: High Technology and Military Power in the Next Half-Century* (Washington, D.C.: Hudson Institute, 2005): 35-86.

THE CHINESE WAY OF THE RMA

While the rest of the world has generally accepted the Marshal Ogarkov/Andrew Marshall definition of the RMA, Chinese military scientists have defined this global revolution in military affairs as an RMA "with Chinese characteristics." The energetic promotion of the RMA with Chinese characteristics is said to be the most brilliant writing in Comrade Jiang Zemin's thinking on national defense and army building. Efforts to study the "Selected Works of Jiang Zemin" in depth—particularly those to fully understand and energetically promote the guiding ideology of the RMA with Chinese characteristics—are of great significance in answering the challenge of the new worldwide RMA, in realizing leapfrog development in the modernization of the armed forces, and in doing a good job in fulfilling the PLA's historical missions for the new stage in the new century.[4]

These military scientists assert that Comrade Jiang Zemin has correctly analyzed the major impact of this new RMA on the international strategic situation and has scientifically exposed the essence, characteristics, and laws of the new worldwide RMA. They claim that he clearly put forward the following concepts:

- Noncontact and nonlinear operations will become a major form of military operations.
- System confrontation will become the basic pattern of battlefield confrontation.
- Space will become a new strategic point in international military competition.
- Informationization will become a multiplier of the army's combat effectiveness.

Here it should be noted that, for a variety of reasons, Chinese military scientists have long been reluctant to acknowledge their military-theoretical debt to Soviet/Russian military scientists—especially in the realm of the RMA. In the early 1970s-early 1980s, Marshal N. V. Ogarkov, then chief of the Soviet General Staff, was the first to articulate

[4] Huang Weimin, "Scientific Guide to Promoting Revolution in Military Affairs with Chinese Characteristics: Experience in Studying Selected Works of Jiang Zemin," *Jiefangjun bao*, 31 August 2006, 6 (hereafter cited as *JB*).

the impending military sea change now known globally as the RMA. And when Desert Storm awakened the PLA to the reality of the RMA in 1991, they lagged behind Soviet/Russian RMA theory (not to mention practice) by about two decades.

By that time, Soviet/Russian military scientists had already produced an impressive body of military theory on the technological, operational, and organizational imperatives of the new RMA.[5] For example, beginning with his seminal 1971 article in *Red Star*,[6] and continuing to his pivotal 1985 book,[7] Marshal Ogarkov predicted the essence of 21st-century warfare as mandated by the new RMA.[8]

During the years immediately following Desert Storm, Chinese military scientists decided to extract the critical sections of Marshal Ogarkov's writings VERBATIM—and without attribution. They subsequently decided to shed outright plagiarism and began to *paraphrase* the later writings on the RMA by Russian military scientists.

The Chinese assertion that Comrade Jiang Zemin "clearly put forward" the above-mentioned four concepts is nothing short of preposterous, to wit:

- ***"Noncontact/Nonlinear Operations":*** Less than a month after the U.S. success in Desert Storm, General-Major V. G. Slipchenko coined the phrase "noncontact war." Until his untimely death in February 2005, he served not only as Marshal Ogarkov's instant military-theoretical successor vis-à-vis the RMA, but also as

(b)(6) *Soviet Views on SDI*, The Carl Beck Papers in Russian and East European Studies (Pittsburgh: University of Pittsburgh, 1987); and (b)(6) *The New Revolution in Russian Military Affairs* (London: Royal United Services Institute for Defence Studies, 1994).

[6] MSU N. V. Ogarkov, *Krasnaya zvezda*, 3 September 1971 (hereafter cited as *KZ*).

[7] MSU N. V. Ogarkov, *History Teaches Vigilance* (Moscow: Voenizdat, 1985).

(b)(6) "Marshal Ogarkov on the Modern Theater Operation," *Naval War College Review* 39, no. 4 (1986).

the source of considerable controversy within the Soviet/Russian military regarding this very concept.[9]

- ***"System Confrontation":*** Long before Chinese military scientists appropriated this concept, Soviet/Russian military scientists had preceded even their U.S. counterparts by defining the comprehensive concept of the "reconnaissance-strike combat system," and the theory of "systems of systems."[10]

- ***"Space will become . . . .":*** In the 1960s and 1970s, Soviet military scientists published several books and pamphlets about U.S. space weapons. The military use of space was mentioned in several volumes of the "Officer's Library" series of books that were published between 1965 and 1973.[11] Much of the U.S. weaponry discussed in the 1980s in conjunction with SDI had already been described in considerable detail by these and other Soviet writers.[12] The threat of space-based systems striking ground targets was also widely discussed.[13]

In the early 1980s, Soviet military scientists described a spectrum of specific countermeasures to SDI, a spectrum that the Chinese have also appropriated.[14] In 1986, the Soviets entered "space" as a "theater of military

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(b)(6) [redacted] "The Soviet Military and the New 'Technological Operation' in the Gulf," *Naval War College Review* 44, no. 4 (1991).

(b)(6) [redacted] *The New Revolution in Russian Military Affairs*, 47-50.

[11] For example, see MSU V. D. Sokolovskiy, *Voennaya strategiya* (Moscow: Voenizdat, 1968).

[12] For example, see I. I. Anureev, *Antimissile and Antispace Defense* (Moscow: Voenizdat, 1971).

(b)(6) [redacted] *Soviet Views on SDI*, 15-17.

[14] Ibid., 42-45. See also (b)(6) [redacted] *The New Revolution in Russian Military Affairs*, 32-43.

operations" in their *Military Encyclopedic Dictionary*,[15] a concept that the Chinese appropriated 17 years later.

- ***Informationization will become a multiplier of the army's combat effectiveness":*** Long before the PLA awoke in 1991 to begin the process of comprehending and implementing the new RMA, Soviet/Russian military scientists had defined the impact of information warfare on the nature of future wars. Warfare has indeed shifted, they wrote, "from being a duel of *strike* systems to being a duel of *information* systems.[16]

According to some Chinese military scientists, the U.S. military is the world pioneer in the new RMA. Analyzing the experiences and lessons of the transformation of the U.S. military can provide important revelations, such as the following:[17]

> (1) The goal of the U.S. military transformation is set too high. The conditions in different aspects are limiting. This leads to the contradiction of subjective will and objective reality and their disconnection. It reveals that on a macroscopic level, military development requires unity of the goal and methods of the transformation, and that on a microscopic level, it requires appropriate tensility between the rationality of the goal and the effectiveness of the methods.

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[15] MSU S. F. Akhromeev, *Voennyi entsiklopedicheskiy slovar'* (Moscow: Voenizdat, 1986): 732.

(b)(6) *The New Revolution in Russian Military Affairs*, 47. See also the following by the same author: *Impact of the MTR on Russian Military Affairs* (Washington, D.C.: Hudson Institute, 1993); *Russian Views on Electronic and Information Warfare* (Washington, D.C.: Hudson Institute, 1996); *Impact of the RMA on Russian Military Affairs* (Washington, D.C.: Hudson Institute, 1998); and *RMA Theory and Practice in Russia: Innovations and Niche Capabilities* (Washington, D.C.: Hudson Institute, 2000).

[17] Wang Jia, "Observing Several Problems in the Transformation of the U.S. Military That We Should Pay Attention to Regarding the Informationization of Our Military," *Zhongguo junshi kexue*, no. 4 (2006) (hereafter cited as *ZJK*).

(2) Different branch and departmental interests conflict with each other, which leads to high internal costs, huge waste, and slow progress of the U.S. military transformation. This reveals that when advancing new military transformation and informationization, China must integrate strategic interests with partial interests and plan and guide with a systematic and structural rebuilding in mind.

(3) The U.S. military pursues technology and overly relies on the development of informationized weapon equipment. In comparison, its system structure transformation lags behind and prevents the efficiency of advanced technology equipment from being fully realized. This reveals that system innovation must take high priority in the new military transformation to absorb new technology and to transform it into combat efficiency.

The first systemic obstacle to the U.S. military transformation is the redundant, cumbersome, and traditional operational chain of command. Future information warfare requires the retirement of the "division, brigade, and battalion" hierarchy—built for mechanical needs—and the development of a materially integrated unitary combat organizational structure. This calls for revoking the authority of service chiefs over the research and procurement of weapons and equipment, and for combining redundant logistical, medical, and C^3I (Command, Control, Communications, and Intelligence) units into a single integrated organization.

The second systemic obstacle is that the planning, layout, and budget systems are still to a great extent the products of the Cold War era. Planners' views are restricted within certain specific demands and cannot adapt to the rapidly changing security situation.

The third systemic obstacle is that the research and development (R&D) system lags behind future informationized combat demands. Serious technological parochialism exists within the realm of research and development. The current U.S. R&D system is the product of the Cold War era that adopted a system management mode based on threats. Under the management of such a linear developmental mode, R&D personnel pay more attention to individual, specific research projects and pay less attention to the integration of projects. Many U.S. R&D personnel often treat tanks, aircraft, and naval vessels as independent combat systems. They concentrate on improving the combat capability of separate services and their ability to execute active tasks instead of treating them as components of the "sensor-to-shooter" system.

Ultimately, say the Chinese, the new military transformation is the transformation of the system. Continuing to use the old system is not true military transformation. ***Only by looking for solutions through the transformation and by developing through the transformation can China make full use of the later-development advantage, realize leapfrog development, and "remain invincible."***[18]

Citing Comrade Jiang Zemin, Chinese military scientists stress that the PLA must therefore have a "megasystem concept" in order to implement the RMA "with Chinese characteristics." They have dubbed this concept "comprehensive integration with Chinese characteristics." In short, the "comprehensive integration" of all dimensions of the Chinese military establishment—theoretical, technological, operational, and organizational—will generate the "leapfrog" development required for a "later-developed" military advantage. This "leapfrog" development will then generate both the symmetrical and asymmetrical combat potentials required for victory in 21st-century warfare.[19]

Comprehensive integration *(zonghe jicheng)* will encompass the following:

- National Defense and PLA Building
- National Strategic Resources
- Military Theories
- Weapons and Armament Systems

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[18] Ibid.

[19] Senior Colonel Ma Gaihe and Lieutenant Colonel Feng Haiming, "Comprehensive Integration and RMA with Chinese Characteristics," *ZJK* (20 April 2004): 96-100.

- Countermeasures of Weapons and Armament Systems
- Combat Configurations and Forces
- Structures and Organizations
- Composite Development of Mechanization and Informationization
- "Leapfrog" Development
- Asymmetrical Development

According to Major-General Sun Hong, deputy commandant of the Armament Command and Technology Academy, the mode of advancing weapons and equipment development (WED) "with Chinese characteristics" is the embodiment of the scientific development concept as applied to armaments development. He has outlined five requirements for fulfilling this scientific mandate.[20]

First, combine symmetrical development with asymmetrical development. In a nutshell, asymmetrical development means researching and developing whatever the enemy fears the most—especially those weapons capable of attacking his "soft rib." If China adheres only to the symmetrical development mode, then it may forever lag behind others. But if China adheres only to the asymmetrical mode, then heavier burdens may be added to national economic development due to the intensified requirements imposed on military science and technology. At the same time, the development of hallmark weapons and equipment systems may also be affected, resulting in an inferior position in the system-to-system confrontations of wartime.

The combination of symmetrical and asymmetrical WED is realized in the reasonable planning of weapons and equipment systems. First, China should adhere to the symmetrical mode because if one side lacks a strong overall system-to-system confrontational capability—even if it does not lack individual advanced weapons—it will still be difficult to dominate the war and overpower the enemy. Second, while China develops specific weapon models, it should adhere to the asymmetrical mode and focus

[20] Major-General Sun Hong and Senior Colonel Li Lin, "On the Mode of Advancing Weapons and Equipment Development with Chinese Characteristics," *ZJK*, no. 6 (2005).

the effort on developing the "assassin's mace" weapons in order to fight in the Chinese way.

Second, propel leapfrog development and well-balanced development by coordinating the two. Leapfrog development refers to the effect made by a country remaining at a relatively low level of WED to narrow the gap or even catch up with advanced countries by exploiting the advantages of being a latecomer, by breaking the conventional step-by-step development mode, by skipping certain stages, by effecting dramatic leap-ahead development, and by directly reaching a more advanced development stage.

Third, enhance importation of key technologies and independent innovation by incorporating the two. Independent innovation and importation are unified and complementary—neither is dispensable. Independent innovation is China's basic foothold, the embodiment of independence and self-reliance. And importation provides lessons that allow China to ultimately surpass the imported technologies.

Fourth, focus on composite development of mechanization and informationization. With informationization as the driving factor, China should stress "lateral technology integration," a revolution in the realm of WED. This process requires that the software, standards, and rules of existing technologies be used to laterally modernize existing weapon systems, thus making them interconnected and interactive. Informationization adds "eyes" to mechanized weapons and equipment, but "fists" must also be available—hence the composite development of both.

Fifth, make spiral connections among the "four generations." That is, in the process of developing weapons and equipment, China should simultaneously explore a new generation, arrange advance research of another generation, and arrange formal research and development of one more generation—all the while producing one generation. As a result, "four generations" of weapons and equipment systems can be developed in different stages at the same time. ***The development of China's arsenal can***

thus be advanced in a spiral and rolling style to maintain both its continuity and its prescience.

According to Chinese military scientists, the "metasystem" concept of "comprehensive integration with Chinese characteristics" applies especially to establishing an integrated military system, with informationization as the bond that both optimizes and integrates all subsystems. Information integration is the core; weaponry integration is the foundation; and operational integration is the purpose. But organizational and institutional integration is the guarantee.[21]

When a breakthrough is implemented in organizational integration, it demonstrates not only that systems integration has been accepted by the military decision-making level and the general troops, but also that corresponding changes will be implemented in other dimensions of the military system. The integration of organizations requires the adoption of the following concepts:

- The Concept of Elite Forces and High Efficiency
- The Concept of Reasonably Reducing Command Levels
- The Concept of Integrating Functions of the Various Services and Branches
- The Change from the Concept of Concentrating Forces to the Concept of Concentrating Operational Functions
- The Change from the Concept of Serial Operations to the Concept of Parallel Operations.

DEFENSE INDUSTRY PRIORITIES

For more than a decade, Chinese military strategists and aerospace scientists have been quietly designing a blueprint for achieving space dominance. As a result, equipping the "Space Theater of War" will dictate the military-technical priorities of China's defense industry for the first quarter of the 21st century.

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[21] Chen Xiaoming, "Thoughts on Systems Integration," *ZJK*, no. 1 (2006): 50-61.

From 1997 to1999, a fundamental restructuring of the Chinese defense industry shifted control of defense enterprises from the military to the civilian government, and integrated their operations with commercial advanced technology enterprises. This has resulted in an accelerated rate of military system modernization—especially for defense electronics—and portends China's emergence as an advanced technology "superstate." Against this backdrop, the prospects for the PLA's swift emergence as a challenger in space are said to be "bright."[22]

According to Chinese military scientists, the PLA revamped its RDT&E program in the late 1990s. The Chinese decided to cancel weapons projects that had been active for 10 years or longer and to direct these funds to developing so-called "new-concept weapons": laser, beam, electromagnetic, microwave, infrasonic, climatic, genetic, biotechnological, and nanotechnological. The results demonstrate that—besides solving the problem of modernizing its conventional forces—China now has three military priorities: space, nuclear weapons, and "new-concept" weapons.[23]

Chinese aerospace scientists argue that "as we produce one generation, research and develop one generation, and pre-search one generation, we must move on to explore one generation."[24] Indeed the "leaps-and-bounds" theory has become the linchpin of Chinese military development for 21st-century warfare.

China aims to achieve at least two objectives in its advancement of military space capabilities and military-technological development:[25]

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[22] Wen Tao, "China to Speed up Military Transformation with Chinese Characteristics, Push for Informationization of Armed Forces," *Ching Pao*, 1 June 2003, 40-42.

[23] "Assessment of the 1998 Situation of China: Military Affairs," *Ch'uan-Ch'iu Fang-Wie Tsa-Chi* (Taipei), 1 May 1999, 34-43. See also Vladimir Lyashchenko, "The Weapons Products of the Near Future," *Promyshlennyi yezhenedel'nik*, no 9 (14 March 2005).

[24] Wen Tao, "China to Speed up."

[25] "China Military Space Power Advancing," *Yazhou Zhoukan* (Hong Kong), 14 November 2004.

(1) To develop strong-propulsion carrier rockets to carry digital reconnaissance satellites in a bid to form a "round-the-clock" spatial image reconnaissance system; and

(2) To develop a new generation of solid-fuel rockets to carry microsatellites in an endeavor to establish a space network for precise positioning, communications, and electromagnetic jamming and reconnaissance. These rockets use 120-ton liquid oxygen engines and 50-ton liquid oxygen/liquid hydrogen engines, and their carrying capacity can reach 15 tons. They are also capable of launching satellites into near-Earth orbit.

The path for the development of the RMA "with Chinese characteristics" consists in exploiting Chinese advantages as a late-developing nation and implementing development by "leaps and bounds" ("leapfrog" development). This requires skipping some stages of mechanization and informationization and pursuing both at a higher starting point. The PLA will be able to develop at the same (or faster) speed as developed countries only by avoiding the latter's pitfalls and detours.

IMPLICATIONS FOR THE UNITED STATES

During the Cold War, the Soviets used the arms control process to gain time to overcome a perceived lag in emerging military technologies. And, like all good Marxist-Maoists, Chinese political leaders rarely say what they mean. But their PLA helmsmen do. Viewed as a military museum at the time of Desert Storm in 1991, the PLA has engineered a quantum leap into the "space club," even imposing its own terms in the process. So the recent blinding and pulverizing of satellites can hardly be cryptic to anyone who reads their open exhortations to their own cadres.

"Whoever loses space loses the future," they say and really mean.[26] Among other "new-concept" weapons openly earmarked for space dominance, laser technology

[26] Colonel Dai Xu, "Space: A Rising Power's New Opportunity," *Huanqiu shibao*, 21 December 2006.

appears to be the PLA's current "holy of holies." Based on China's colossal progress to date, the United States should cease to be complacent about the sanctity of its orbital assets. Citing Nikita Khrushchev's warning about *nuclear* weapons, one PLA writer warns that a *new* "Sword of Damocles" now dangles over the planet.[27]

[27] Zhao Ruian, "The Concept of Orbital Ballistic Missile," *Zhongguo Hangtian*, no. 1 (2004).

II. CHINESE VIEWS ON SPACE WARFARE

SPACE TECHNOLOGIES

"The weaponization of space," say the Chinese, "is an inevitable developmental trend."[28] And the "commanding height" of strategic competition in the 21st century "will not be on Earth, but in space."[29]

According to the Chinese, the United States and Russia are engaged in a race to develop ground-, air-, and space-based weapons for achieving space dominance. These are said to include ground-based kinetic and airborne ASAT systems, high-altitude antimissile weapons, space weapons platforms, aerospace aircraft, and space combat aircraft designed to execute simultaneous space and ground strikes.[30]

The Chinese also charge that the United States is developing "some new-concept weapons" for its 21st-century space force, including kinetic, directed-energy, and non-antipersonnel weapons. Kinetic-energy weapons use ultra-high-speed warheads with extremely high kinetic energy such as electromagnetic cannons and intelligent intercepting bombs to collide with and destroy targets directly.

Directed-energy weapons (laser, microwave, particle-beam, etc.) can be used not only to destroy various ground targets and flying targets such as aircraft, ballistic missiles, cruise missiles, satellites, and space stations, but also in both electronic warfare and photoelectronic warfare. Non-antipersonnel weapons include chemical energy-losing agents, low-energy-laser-blinding weapons, omnidirectional irradiation weapons, etc.

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28 Wan Ziming, Yang Yuguang, and Deng Longfan, "The Concept of Kinetic Orbital Weapons and Its Development," *Xiandai fangyu jishu*, no. 2 (2005) (hereafter cited as *XFJ*).

29 Liu Yidai and Zhang Jun, "Opening up New Vistas in Nuclear Strategy Theory," *Huojianbing bao*, 20 September 2005, 3.

30 Wei Qiyong, et al., "Analysis of Changing Emphasis," 1-4.

The Chinese agenda for space weaponry includes the following "new-concept" weapons, which will make outer space "the fifth-dimension operational space after land, sea, air, and electromagnetism": laser weapons, ultra-high frequency weapons, ultrasonic wave weapons, stealth weapons, mirror-beam weapons, electromagnetic guns, plasma weapons, ecological weapons, logic weapons, and sonic weapons.[31]

HIGH-POWER MICROWAVE (HPM) WEAPONS

According to Chinese military scientists, the high-power microwave (HPM) weapon has triggered "a new revolution in electronic warfare systems and technology."[32] Not only is it compatible for creating integrated systems with radar for low-power detection, target tracking, and target jamming, but its power can also be rapidly increased for hard damage/destruction of targets and for inflicting damage on the electronic equipment of enemy targets. These weapons portend extremely wide applications extending to aeronautic, astronautic, warship, and battlefield weaponry.

The Chinese charge that rapid advances are being made in U.S. HPM and high-power radio-frequency weapons development, and that they have already entered the applications stages. But designers of electronic systems can adopt many countermeasures for reducing HPM interference and damage, such as protective measures for the coupling and cable connections of systems and subsystems. Transmitters and receivers can be designed to be very sensitive to HPM; their duty ratios can be reduced; and redundant circuitry can be designed to further reduce HPM interference and damage.

HYPERSONIC TECHNOLOGIES

In early 2006, Chinese military strategists announced that "space weapons systems composed of hypersonic weapons will be the crack space troops with uniform tri-service land, sea, and air coordination and a widely increased scope of joint operations

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[31] For example, see Ch'en Huan, "The Third Military Revolution," *Xiandai junshi*, no. 3 (1996): 8-10.

[32] Tan Xianyu, "Present Status and Development of High-Power Microwave Weapon Concepts," *Hangkong bingqi*, no. 1 (February 2004).

capability."[33] They will be united in informational completeness, and the enemy—thus exposed to space weapons attack—will be forced to protect friendly land, sea, and air forces against such attack. Hypersonic weapons will become ***"the dominant combat ordnance"*** in future high-tech battlefields, and aerospace integration will be the primary mode of operations in future high-tech warfare.

According to these experts, the interest of the major world nations in the development of hypersonic weapons will accelerate the development of this technology. It will thus generate new focal points and new circumstances for aerospace countermeasures. Whatever complications may arise in their technological development, ***"these types of weapons will be the nucleus of military competition in the early period of the 21st century."***[34]

In addition, hypersonic aerospace aircraft represent ***"one of the key weapons to be employed for controlling space and vying for 21st-century space dominance."***[35] These aircraft can 1) ensure inexpensive, high-speed access to space; 2) counter satellites; 3) reconnoiter, monitor, and issue early warnings; 4) be used as space platforms for weapon launching; 5) be used as high-speed transport airplanes; and 6) be used as reserve command nodes in space during wartime.

ASAT INTERCEPTOR WEAPONS

According to Chinese aerospace scientists, the two different kinds of ASAT weapons can be distinguished by their two different launching modes: vertical and co-orbital. Space-based vertical ASAT weapons are also called non-co-orbital ASAT weapons.[36]

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[33] Fan Jinrong, "The Hypersonic Weapons in Development," *XFJ*, no. 2 (2006): 1-5.

[34] Ibid.

[35] Li Hechun and Chen Yourong, "Sky War: A New Form of War That Might Erupt in the Future," *JB*, 17 January 2001, 11.

[36] Zhang Liying, Zhang Xixin, and Wang Hui, "Preliminary Analysis of Antisatellite Weapon Technology and Defensive Measures," *Feihang Daodan*, 1 March 2004, 28-30.

ASAT satellites, also called interceptor satellites, refer to manmade Earth-orbit satellites that threaten to disable or destroy enemy satellites. The combat methods used in ASAT satellite interception include elliptical orbit attack, in which the ASAT satellite is launched to an elliptical orbit and approaches the target satellite's orbit at its apogee. This is mostly used in intercepting high-orbit satellites.

Another method is circular orbit, in which the ASAT satellite's circular orbit is coplanar with the target satellite's orbit. This makes it easy to initiate orbital maneuvers and to approach the target satellite, while also conserving propellant.

A third method is fast vertical attack. The ASAT satellite is launched to a low orbit and initiates an orbital maneuver to one orbit below the target; it quickly intercepts and destroys the target satellite. However, it needs to consume a greater amount of propellant. Under normal circumstances, the previous two attack methods are used against target satellites at higher orbits, but the ASAT satellite needs to make a few orbits around the Earth before completing the interception mission. For target satellites in orbits below 500 km, the last attack method is usually used.

ASAT KINETIC KILL VEHICLES

Kinetic-energy ASAT weapons rely on high-speed kinetic energy to destroy target satellites through direct collision. Kinetic-energy weapons are mainly composed of the propulsion system, the warhead, the detector, and the guidance-and-control system. The propulsion system can use artillery, rockets, electrical fields, or magnetic fields as acceleration devices to provide the power needed for acceleration up to Mach 5 and higher. The warhead is effective for implementing kinetic-energy collisions. The detector uses detection, identification, and tracking of targets. The guidance-and-control system ensures that the warhead reliably seeks and intercepts the target satellite.

Currently, the most maturely developed kinetic-energy ASAT weapon is the ASAT missile, which is used to destroy enemy satellites and other spacecraft in low orbit. The ASAT missile may employ ground-based or air-based launching modes. The ground-launched ASAT missile is a kind of infrared-seeking interceptor missile, composed of a multistage rocket and a warhead. The warhead has a long-wave infrared detector, a data processor, and an impact warhead. The long-wave infrared detector can detect objects that possess human body temperature over 1,600 km away in space. The data processor can implement hundreds of millions of calculations per second. The warhead opens up seconds before the collision with the target and forms an umbrella-shaped structure 4-5 m in diameter. The skeleton of its umbrella shape is composed of dozens of light alloy spokes with steel plates to enhance its impact function. The rocket engine uses bi-propellant to control the thrust.

The air-launched ASAT missile is usually only 4-5 m long and mainly depends on a kinetic-energy collision to destroy the enemy satellite. It has high accuracy, fast reactions, and strong survivability, with stronger attack ability against spacecraft at an orbit below 1,000 km.

In addition, kinetic-energy weapons like space-based or ground-based electromagnetic guns are becoming an important component of ASAT weapons. These guns use electromagnetic launch technology to drive shells to high speeds, with electrical energy for thrust.

DIRECTED-ENERGY ASAT WEAPONS

Laser ASAT weapons damage satellites or their sensors and photoelectronic instruments with directed beams through the integrated effects of high heat, impact, and radiation. They possess the characteristics of high volume, fast speed, high accuracy, and strong antijamming functions. The radiance required by a high-energy ASAT laser device is 1 to 10 watts per square centimeter, changing the target energy density to hundreds of joules per square millimeter and destroying the satellite's average power at one million watts and higher. The more mature ASAT laser weapons are ground-based mid-infrared high-energy laser devices and space-based infrared chemical laser devices. The functional distance of ground-based high-energy laser devices is 500 to 1,000 km.

Particle-beam weapons accelerate the electrons, protons, and neutrons of subatomic particles and neutral atoms to speeds approaching the speed of light through a high-energy accelerator, concentrating them in a dense beam that is fired at the target. There are two main kinds of particle-beam ASAT weapons: space-based particle-beam weapons installed on space stations or satellites and ground-based particle-beam weapons. The methods used by particle-beam weapons to attack satellites are as follows:

- The first method is attacking the satellite's sensors or electronic instruments, damaging them or causing loss of function.

- The second method is attacking the satellite's power systems. The great majority of satellites depend on solar energy to operate, and they have solar-powered battery packs and a photoelectronic system that provide electrical power. This equipment is exposed on the exterior and is easily attacked.

- The third method is attacking the satellite's shaded side. A satellite's shaded side has a higher density of electronics, and when it is hit by a particle beam, the instruments and equipment easily produce an electrical arc, thus damaging the satellite. At the same time, the particle beam's extremely high energy can make the target soften or change shape, thus reaching the goal of damaging the satellite.

The radiation emitted by the microwave source of electromagnetic pulse weapons and high-power microwave weapons can damage the electronic systems of satellites. High-power microwave weapons require smaller, lighter, and higher fuel efficiency. Extensive sensitivity research of the target is made to decide the best attack method. The key technologies of high-power microwave weapons are the controller, the high-power microwave source, and the antenna. It uses strengthened control of radiation beams to lower the requirements of size, quality, and power. The short-term development objective of high-power microwave weapons is exploring new concepts of high-power microwave sources, such as interference of the modulation of high-power microwave sources, as well as broadband klystron used in an experiment and in sensitivity experiments. The mid-term objective is developing high-power antennas. The long-term objective involves using the research results of chaos theory to improve the control of high-power microwave weapons.

SPACE WARFARE

Published by the Chinese Academy of Military Sciences, a recent book entitled *Strategy* defines the components of "military space strategy" as 1) the policies and principles for building military space forces; 2) the fundamental principles for employing military space forces; 3) the significance and role of space dominance; and 4) the characteristics, forms, and tactics of space war.[37]

Since 1996, Chinese military scientists have defined space warfare as combat operations whose major goal is to seize and maintain space dominance, whose major combat arena is outer space, and whose major combat strength is military space forces.[38] The features of space warfare are said to include dogfights between the space-based combat systems of both belligerents; intercepts of strategic ballistic missiles by space-based combat platforms; strikes by space weapons on Earth targets and Earth-based counterspace or space defense operations; and strikes from the land, sea, and air on enemy space launch platforms and command-and-control organs.[39]

Since 2005, Chinese military scientists have contended that space warfare will become the core of future non-contact combat. The integrated space-based "metasystem" of combat platforms, weaponry, and C^4ISR components will guide the various combat

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[37] Liao Wen-chung, "Chinese Communist's Development of Space Forces Will Lead to U.S.-Sino-Taiwanese Arms Race," *Ch'uan-Ch'iu Fang-Wei Tsa-Chih* (Taipei), 1 May 2005, 86-89.

[38] Ch'en Huan, "Third Military Revolution," 8-10.

[39] Senior Colonel Wang Jiangqi, "Space Warfare Is Certainly Not Far Off," interview by Zhao Yiping, *Guangming ribao*, 28 December 1999, 7.

elements of the three armed services to launch long-distance precision attacks on ground, sea, air, and space targets.[40]

Defensive campaigns will more often take offensive forms. Offenses and defenses will permeate, stimulate, and rely on each other; and the two will have a synergistic and systems-intimate relationship. Sea, air, and electromagnetic dominance will gradually subside and become subordinate to space dominance.[41]

Because the space theater of war is in outer space and more than 120 km above the Earth's surface, there are no restrictions concerning national boundaries and sovereign air space. The side possessing space dominance, say the Chinese, can therefore exercise complete freedom of action. The use of space-based weapons systems to strike endoatmospheric air, land, and sea targets demonstrates a unique superiority.[42]

These unique, high-altitude advantages of space have strategic and decisive significance for the side exercising space dominance. If strike weapons are deployed in space, it will be possible to execute such offensive operations as satellite attack, missile intercept, and ground firepower support. It will be possible to guarantee the operational independence of friendly military space forces, and to translate these advantages into information, air, and sea dominance. Without space dominance, say the Chinese, one is actually putting oneself in the disadvantageous position of "being defeated first and then going to war."[43]

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[40] Zhang Yining, "Information Warfare Will Change Future Battlefields," *JB*, 2 March 2005.

[41] Fan Jinrong, "The Hypersonic Weapons," 1-5.

[42] Major General Zhang Ling, "Initial Appearance of the Characteristics of Informationized Warfare," in Transcript of May 2003 CPC Central Committee Conference, *Liaowang*, 4 July 2003, 9-15.

[43] Senior Colonel Zhang Zhiwei and Lieutenant Colonel Feng Chuanjiang, "Analysis of Future Integrated Air and Space Operations," *ZJK*, no. 2 (2006).

III. CHINESE VIEWS ON SPACE IW/EW

SPACE INFORMATION WARFARE

Both China and Russia have long contended that the "space-information continuum" constitutes the nucleus of the current RMA. The "Space Epoch" thus requires a colossal revision of military-strategic thought. ***"As informationized war advances," say the Chinese, "space will truly become the new theater of war and thereby establish a new milestone in mankind's history of warfare."***[44]

Echoing their Russian counterparts, Chinese military scientists assert that information warfare (IW) missions are accomplished most effectively by using space-based assets. The Chinese delineate at least three reasons for the critical importance of space warfare to IW missions. First, space is the "commanding height" for future IW. Second, seizure of space control constitutes "the first combat operation in future IW." With the continuing development of space weaponry and equipment, belligerents will conduct such new modes of space warfare as 1) space information warfare, 2) space electronic warfare, 3) space antisatellite warfare, 4) space antimissile warfare, and 5) space-to-Earth warfare.

The "core of space warfare" is thus the struggle for information dominance, so IW in space constitutes its main mode. The principal forms of space IW are 1) conducting space electronic and space network warfare to inflict "soft" strikes on enemy space platforms, thereby disrupting and destroying their electronic equipment and computer systems; and 2) employing all types of ASAT weapons to inflict "hard" strikes on enemy platforms, thereby fundamentally destroying his space-information system.

Finally, the decisiveness of space dominance in future IW is clearly reflected in the ever-escalating preparations by world military powers to win future space wars. The pace of competition for the militarization of space has increased dramatically since Desert Storm, to include the 1) vigorous development and deployment of offensive and

[44] Major General Zhang Ling, "Initial Appearance," 9-15.

defensive weapons for space operations, 2) accelerated development of the space theater of war, 3) creation and organization of space combat troops, and 4) development of theories on space combat.

SPACE ELECTRONIC WARFARE

Owing to its strategic significance, say Chinese aerospace experts, space electronic warfare (EW)—aimed at jamming, sabotaging, and destroying satellites—has become the most important way to gain information dominance in future wars.[45] It should include countermeasures against 1) space platforms (and denial of specific orbits), 2) spaceborne sensors, 3) satellite transmission links and information nodes, and 4) terminal equipment. To thereby sabotage the normal operation of an enemy satellite's communications system, they readily confess, is a hostile operation.

SPACE-BASED RECONNAISSANCE

According to Chinese military scientists, a space-based electronic reconnaissance and electronic countermeasure system that can operate safely should contain at least several basic functional modules: the passive location module; the active radar detection module; the complex signal detection, sorting, and processing module; and the electronic jamming module.[46]

- ***Single Machine Passive Location Technology:*** Radiation source precision location technology is an important component in the field of electronic warfare, and passive detection is one of the major means of long-range reconnaissance and location. It has such strong points as high covertness, good maneuverability, and, in general, much longer operating ranges than those of active detection technology. Based on the radiation parameters of the target body detected by a single passive detector or multiple detectors deployed in a distributed pattern, the

[45] Wang Yong, Hu Yihua, and Yan Fei, "Study on Countermeasures against Satellite Communications," *Hangtian dianzi duikang*, no. 2 (2006) (hereafter cited as *HDD*).

[46] Zhang Fenghui and Yao Chongbin, "Space-Based Electronic Reconnaissance and Countermeasures," *HDD*, 1 August 2006, 22-24.

location of the target in three-dimensional space can be pinpointed with the appropriate data-processing means.

- ***Ultralow Interception Probability Radar Based on Fiber-Optic Modulation Demodulation Copying Technology:*** Although the passive location technology has many strong points, it is necessary to adopt active detection technology if the opponent does not generate a radiation source. During active detection, however, especially when the commonly used coherent/incoherent integration is implemented, the signals from the side conducting active detection can also be easily detected by the opponent. In order to reduce the probability of detection by the opponent, therefore, it is necessary to apply low interception probability active radar technology. Low interception probability radar technology includes the application of ultralow antenna side lobe, the application of low peak power-transmitted waveform, and waveform parameter random variation, as follows:

(1) Through careful design, as well as meticulous machining and installation of the antenna, the power of the side lobe of the modern radar antenna can be controlled below that of the main lobe by 50-60 dB. This is called ultralow side lobe, and it allows the opponent's reconnaissance system to intercept the radar signals only when the main beam of the opponent's radar of the reconnaissance system points directly at the friendly radar, thus greatly reducing the chance of detection of the friendly radar.

(2) Using a sophisticated broad pulse waveform, the radar can achieve low peak transmitting power without changing total power. Since it has no way of knowing in advance the pattern of the radar signal, the reconnaissance system still operates in the narrow pulse reception and processing mode. As a result, it only utilizes the radar signal power for a very short time. Consequently, its signal power utilization ratio is considerably lower than that of the radar. This will reduce the detection range of the reconnaissance system.

(3) The radar increases the difficulty for the reconnaissance system in signal processing and reduces its success rate in the interception and identification of radar signals by using transmitting signals that do not have a distinctive signature and, therefore, are difficult to identify. For example, the radar can use such techniques as frequency agility and pulse repetition period dither to change the waveform parameters randomly, thereby disturbing the signal sorting and radar identification of the enemy's reconnaissance system.

- ***Detection and Sorting of Complicated Signals:*** In the complex electromagnetic environment in space, the high signal density and the tendency of diversified signal forms increase the difficulty for electronic reconnaissance. The mean value of the pulse signals that occur per unit time is tens of thousands at the least, and several million at the most. This causes simultaneous occurrence (overlapping) of multiple signals at the same time. In an ordinary electronic reconnaissance system, the signal arrival direction, the signal arrival time, the carrier frequency, the pulse width, and the pulse amplitude are the main measurement parameters for radar signal sorting and identification. In a situation in which the signal environment is complicated, however, the measurement method based on the five major parameters as the basis for radar signal sorting and identification can no longer meet the requirements of the reconnaissance mission.

The five characteristics of the radar signal in the domains of time, frequency, airspace, polarization, and modulation are not only manifested in the five distinctions of the signal itself, but also in the overall characteristics and change of the signal. The analysis of the five characteristics of the radar signal, therefore, is precisely a direction of the technical development of the processing of radar signal identification in a complicated environment.

In order to intercept multiple signals simultaneously, the front end of the receiver must conduct signal dilution and separation. The most common method is to separate the signals at different frequencies with the channeling method, to convert them to a certain deterministic and same intermediate frequency base band through frequency conversion processing, to utilize high-speed A/D to conduct sampling, to transform the analog signal into the digital domain, and then to perform digital orthogonal transformation of the directly sampled digital signal to acquire the two orthogonal components of the signal (analytic signals). This makes it easy to conduct intrapulse modulation and analytical processing of the signal with various detection and analytic algorithms.

Intrapulse analysis mainly includes such analytical methods as the instantaneous correlation integration technique, the time-frequency analysis, and the high-resolution spectral estimation. These methods are very effective in the single-carrier and multiple-carrier diversity, as well as in the intrapulse modulation and analysis of such signals as the linear frequency-modulating signal, the phase-coded signal, and the frequency-coded signal. In addition, they have been applied in engineering practice to a certain extent. Nevertheless, they all have some weak points.

A common problem that exists in these methods is that their analytical capability is strong for certain modulating signals, but limited for other types of modulating signals. Parallel algorithmic structure is one way of solving this problem. It conducts multiple algorithmic processing of the digital signals simultaneously, implements fusion of all the processing results, and acquires the optimal signal detection and sorting results through analysis. This parallel structure, however, acquires real-time reconnaissance and sorting of the signals as well as the reliability of the results of the reconnaissance and sorting by increasing the complexity of the hardware equipment for signal processing.

SPACE-BASED JAMMING

When combining the passive location technology and low interception probability radar technology for reconnaissance, effective electronic jamming measures can be implemented to confuse or deceive an opponent's reconnaissance equipment. In general, there are two types of jamming: 1) noise blanket jamming techniques and 2) deception-type decoy target techniques.

- ***Noise Blanket Jamming:*** Conventional blanket jamming is used to obstruct radar detection of targets, preventing them from correctly positioning targets or creating considerable difficulty for radar to do so. One of the most commonly used active blanket jamming devices is the noise jammer. It does not require the acquisition of many parameters or the operating mode of the radar, and its requirement for the jammer is not very high, either. Its weak point is that effective jamming power is relatively low. In addition, it is prone to detection by other radars when it is jamming a radar unit.

  But a jamming pattern employing smart digital-correlated noise can be used to conduct effective jamming. Its jamming signals have the maximum degree of correlation with the radar signals, thus reducing to the minimum the loss of the jamming signals after the pulse compression. At the same time, the application of the smart jamming can concentrate jamming power in the frequency band intended for jamming, thereby making full use of the jamming power.

  In addition, this kind of smart noise blanket jamming mode conducts modulation directly on the received radar signals. It does not require the acquisition of many parameters or the operating mode of the radar, nor is its requirement for the jammer very high. It is fair to say, therefore, that this smart noise blanket jamming mode not only possesses conventional noise blanket jamming capability, but that it can also make full use of jamming power. The expected jamming result can be achieved as long as the jamming signal can enter the radar receiver.

- ***Deception-Type Jamming:*** Deception-type jamming is primarily used to confuse the radar's automatic detection system. It generates ghost signals that simulate real signal parameters to make it difficult for the automatic tracking system of the radar to select the real target from the acquired signals. Its strong point is that the utilization ratio of the jamming power is relatively high. It can also deceive the radar imperceptibly. Retransmission-type jamming based on DDS or DRFM can be used for deception-type jamming.

The basic principles of both of these two types of jamming are modulation, copying, and retransmission of the received radar signals. It is not necessary, therefore, to gain more knowledge of the radar signal parameters and the operating mode of the radar. However, once detected, deception jamming loses effect. In addition, the jamming will not affect the detection of real targets by phased-array radar in search mode; it can only increase false alarms.

Chinese EW experts stress that it is necessary to be flexible in practical applications. Based on the actual situation, either one jamming measure or a combination of the two jamming measures can be implemented.

Chinese military scientists conclude that, in a signal environment that is becoming more and more complicated every day, it is impossible for space-based electronic reconnaissance systems to rely on a certain single reconnaissance measure to carry out location and detection of the radiation source signals. It must adopt the mode that integrates a variety of techniques, such as passive, active, and low interception probability techniques. The detection and sorting of electromagnetic signals must not rely on a single analytical method, either. It is necessary to utilize the advantages of all kinds of algorithms to acquire optimal detection results through integrated analytical processing. In addition, the reconnaissance system must be able to counter jamming and to release effective jamming. Otherwise, the space-based reconnaissance system does not possess survivability in a modern warfare environment.

UPLINK RECONNAISSANCE/JAMMING

An unmanned drone usually flies at an altitude of a few thousand meters, which is far lower than the orbit of a communication satellite. Consequently, the advantage of using an unmanned drone for reconnaissance is that its path loss is relatively small. Furthermore, the communications between an unmanned drone and its ground station is line-of-sight in nature. "Multipath fading" and ground transmission loss are no longer in play.

The drawback of using an unmanned drone is that it cannot penetrate deep into enemy territory to get close to an enemy ground station. Therefore, its receiver can only aim at the side lobe of the antenna located at the enemy ground station. Compared to the voltage level in the main lobe, the side-lobe voltage is typically 30-40 dB lower. However, after taking everything into account, the loss of main-lobe voltage can be completely offset by the advantage in reduced path loss. Therefore, the sensitivity of an ordinary reconnaissance receiver can meet the needs for reconnaissance using an unmanned drone.

The orbit of an electronic reconnaissance satellite typically ranges from several hundred kilometers to a few thousand kilometers. Compared to enemy geosynchronous satellites, there is also some advantage in path loss. Furthermore, a reconnaissance satellite is not limited by geographic borders.

The drawback of using an electronic reconnaissance satellite is that its orbit is not necessarily synchronous. It usually cannot aim at the main lobe of the enemy satellite's antenna. Furthermore, it is also susceptible to Doppler frequency shift. But as long as a reconnaissance satellite enters the 30 dB lobe width of an enemy's transmitting antenna on the ground, the signal energy received by the reconnaissance satellite will be higher than that received by the enemy satellite. It is, therefore, entirely feasible to use an electronic reconnaissance satellite to detect upward signals.

The biggest problem associated with uplink jamming from a ground station is its radiated power. The distance between a ground jamming station and an enemy satellite is about the same as the distance between an enemy ground station and an enemy satellite. As a result, its path loss is comparable. However, a ground jamming station can only aim at the side lobe of an enemy satellite antenna. It will be attenuated by approximately 30 dB. Therefore, effective jamming from a ground station can only be realized with high-power or super-high-power jamming. High-power microwave technology and directional energy technology are effective countermeasures against satellite communications.

A jamming station on board an unmanned drone or any other type of aircraft is closer to the ground. The jamming signal is comparable to the path loss between an enemy ground station and an enemy satellite. Nevertheless, the advantage of an airborne jamming station is that it can enter the main lobe of an enemy satellite antenna. It does not have to deal with the so-called side-lobe attenuation problem encountered by ground jamming stations. The issue associated with such an aerial platform is that high-power jamming is difficult to realize. The gain and efficiency of an airborne transmitting antenna are also not as high as those on the ground.

DOWNLINK RECONNAISSANCE/JAMMING

Downlink reconnaissance can be realized using ground reconnaissance stations and aerial platforms. If a ground reconnaissance station is in the vicinity of an enemy ground station and the reconnaissance antenna can aim at the main lobe of an enemy satellite's transmitting antenna, then the enemy downlink can be detected by the reconnaissance station on the ground. If the reconnaissance antenna can only aim at the side lobe of an enemy satellite's transmitting antenna, it would be very difficult for the ground reconnaissance station to detect the downlink. Under these circumstances, an aerial reconnaissance platform may be used. An unmanned drone can fly into an area covered by the main lobe of the transmitting antenna of an enemy satellite. It is possible to detect a downlink when the sensitivity of the airborne receiver is close to that used by a ground reconnaissance station.

Due to effects such as the curvature of the Earth and ground transmission loss, it is difficult to jam a downlink with jamming equipment on the ground or on board a surface vessel. Furthermore, due to effects such as long-range loss and other limiting factors such as space, quality, and power on board a spacecraft, jamming with a low-Earth orbit satellite is not very effective either. In relative comparison, using an aerial platform is an effective jamming technique. Similar to reconnaissance of upward signals, an unmanned drone has an advantage in path loss. Effective jamming can be done with a low level of power using an unmanned drone to approach an enemy ground station by aiming at the side lobe of the receiving antenna.

JAMMING SYNTHETIC APERTURE RADAR (SAR)

As the pivotal role of space-based synthetic aperture radar (SAR) becomes increasingly manifest, various countries are rushing to develop countermeasures. Active jamming—said to be the most effective technique among asymmetrical countermeasures—is divided into active suppressive and active deception jamming. Active suppressive jamming includes barrage, spot, and random pulse jamming. Active deception jamming includes repeater, responsive, and scattered wave jamming. Chinese algorithms demonstrate that, in order to achieve the ideal jamming effect against SAR, the jamming signal must be highly coherent with the radar echo—a technique deemed feasible from a Chinese engineering perspective.[47]

One of the major weaknesses of SAR is that it is unable to form a narrow beam before a predetermined number of pulses are received. Prior to that, a wide beam still plays an active role at every element of the synthetic aperture. Thus, the jamming signal in the side lobe of the synthesized pulse is still located with the uncompressed half-power beam width of the antenna. As a result, both the target signal and jamming signal are present at the same time. This opens the door to jamming.

Because SAR is typically mounted on a platform that is in flight, any type of SAR jamming is only regional. Therefore, SAR jamming is usually done to protect a specific region. (Noise jamming and deception jamming also belong to this category.) To protect a specific target by noise jamming, it must be able to generate a jamming signal at the front end of the SAR receiver.

In theory, as long as the power level of the noise generated by the jammer is sufficient in magnitude to compensate for the processing gain or loss of SAR (i.e., 40-60 dB), noise will be included in the two-dimensional imaging process. In this case, it can

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[47] Jiao Xun, Li Xiuhe, and Chen Yongguang, "Active Jamming and Suppressing Power of Space-based SAR," *HDD*, no. 1 (2006).

influence the image produced by the SAR. For instance, gray scale may be diminished, the image may be distorted, and the real image may be buried under a bright fake image. It will make the radar image reading more difficult. In some cases, images may not even be recognizable. This is particularly effective against any automatic target recognition (ATR) system, which is being developed in large numbers.

A jammer may operate in different modes against space-based SAR. Barrage jamming with frequency agility and frequency diversity capabilities is the most effective jamming method against SAR. A barrage jammer can continuously transmit jamming noise over a wide frequency range. However, only the noise that goes through the pass band of the radar has the jamming effect. It creates a background noise to shield the target or to conceal its true characteristics. For narrowband radar, the frequency spectrum mismatch factor is of the order of -20 dB. However, for high-resolution wideband radar, it is usually of the order of -60 dB. Therefore, the disadvantage of barrage jamming is that its effective jamming power is very low.

The jamming noise is uniformly distributed across the entire image frame. It produces spots on the radar image. In addition, the jamming noise also covers the entire radar-ranging bandwidth and its potential Doppler frequency range. After two-dimensional image processing, the size of the spot in the image produced by the SAR is of the same order of magnitude as that of its range and azimuth resolution element. Due to incoherent superposition of noise in large amounts, the jamming effect of barrage jamming is similar to that of thermal noise jamming.

COUNTERJAMMING

Chinese experts in space EW note that the counterjamming capabilities of radar systems have been continuously advancing. The production of jamming signals with the same frequency and coverage as the radar signals has already been realized. However, the jamming signal created by countermeasures equipment is often not in the same direction as that of the target echo. Space adaptive jamming suppression technology can suppress the jamming signals in different directions compared to the direction of the signal echo.[48]

Furthermore, the jamming suppression system can correspondingly provide adaptive variations following changes in the jamming direction. This technology has thus gained wide recognition and has become an important technological measure in the development of radar counterjamming capability.

ELECTRONIC "KILLING"

The air-space battlefield is said to be the quintessential battlefield for information counterattack. EW satellites traveling in geosynchronous orbits or 300-1,000 kilometer orbits can conduct electronic reconnaissance and jamming in wide areas. EW aircraft in flight can execute high-intensity electronic killing of enemy long-range radar stations, command centers, and communications centers to paralyze their command capabilities and disable their firing systems. They can also directly launch antiradiation missiles to totally destroy the enemy.[49]

Reputed to be the nerve and brain center as well as the force multiplier, early-warning aircraft serve as important platforms for information exchange, control, and countermeasures. Various unmanned aerial vehicles and fighter aircraft are now equipped with powerful EW capabilities. Again echoing their Russian counterparts, the Chinese contend that unmanned aerial vehicles will become an important means of supplementing and reinforcing the missions of both manned aircraft and satellites.

EW COUNTERMEASURES

Due to increasingly worsening situations, say Chinese EW experts, countries with space-based optoelectronic and telemetry devices and platforms are forced to develop

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[48] Gu Jie, "Research on Countermeasures against Space Adaptive Jamming Suppression Systems," *Dianzi xinxi duikang jishu*, no. 2 (2006): 23-26.

[49] Major General Cai Fengzheng and Major Deng Fan, "Introduction to Air-Space Battlefields and National Air-Space Security System," *ZJK*, no. 2 (2006).

protection technology for their space-based optoelectronic and telemetry devices and platforms, such as the following:[50]

- ***Space-Based Self-Defense Warning Technology:*** Laser-based ASAT and anti-space-based optoelectronic sensor weapon technology is maturing. There is an urgent need for "all-direction, real-time" laser-warning technology to protect space-based platforms such as satellites. A self-defense laser-warning device issues a warning by sensing the laser probe beam emitted by the enemy prior to launching an attack. This is the premise for taking countermeasures against a laser attack. Hence, a great deal of attention is paid to it.

- ***Multispectral Decoy Technology on Space-Based Platforms:*** A satellite-based optical decoy is a low-cost measure to counter reconnaissance and attack by effectively confusing a variety of ASAT weapons. Lightweight materials can be used to make hermetically sealed, gas-filled balloons showing visible/infrared satellite signatures to simulate the satellite. A decoy can also simulate a radar signature. These balloons may be deployed on board the satellite to be protected. When the satellite is threatened, these decoys can be deployed to confuse and deceive the enemy. The cost associated with development and installation of multiband decoys is relatively low, making them extremely well suited for protecting space-based platforms.

- ***Multiband Stealth Technology on Space-Based Platform:*** Stealthy camouflage may be applied to spacecraft to weaken and conceal its signature in the visible, infrared, and radar wave bands to reduce the probability of detection and to enhance resistance against destruction. For instance, the popular multiband stealthy camouflage technology may be used by applying a photoelectronic/radar stealth coating on the surface of the satellite to alter its photoelectronic and radar radiation signatures to conceal itself.

[50] Li Yong, et al., "Threat to Space-Based Optoelectronic Imaging and Telemetry System and Its Countermeasure Technology," *Tianjin Hongwai Yu Jiguang Gongcheng*, 1 December 2005, 631-35, 640.

In addition, plasma stealth technology is a novel stealth technology developed in recent years. Its operating principle is as follows: A plasma layer is formed on the surface of the target under protection with a plasma generator or a radioactive isotope. Plasma parameters, such as energy, ionicity, oscillation frequency, etc., may be controlled to allow incident radar waves to interact with ions in the plasma. A portion of the energy is transferred to charged particles and is absorbed by the charged particles. As a result, the energy of the electromagnetic wave is decaying. Another portion of the incident electromagnetic wave undergoes a series of physical reactions. It either goes around the plasma or is refracted. Its direction of propagation is altered. Very little energy actually reaches the target. Consequently, the target is being protected.

- ***Reinforcement Technology for Space-Based Optoelectronic Imaging Sensors:*** Space-based optoelectronic imaging sensors are being fortified by a variety of means. It is the most direct countermeasure to protect space-based optoelectronic imaging equipment. It is also the most heavily invested field by satellite-owning countries. Since intense lasers pose the biggest threat to optoelectronic sensors, protection against laser attack is on the top of the list.

  Presently, antilaser attack reinforcement technology is being developed at a fast pace. The following is a list of popular protective countermeasures: selective band-pass filters, mechanical shutters, amplitude limiters, optical switches, and fusible or sacrificial materials. In addition, the latest new developments include the following: variable wavelength liquid crystal thin film protection technology, self-focusing and self-defocusing amplitude limiters, optical amplitude limiters, nonlinear optical location/nonlinear reflective mirrors, etc.

- ***Shutter Technology:*** Protective shutter technology provides an "eyelid" to space-based optoelectronic sensors. When a warning is issued after a threat is sensed, an "eyelid" type of shutter protection system is activated to close the optical path. It allows the "shutter" to block off the attack of the intense laser beam. After interference from the intense laser beam disappears, the "shutter" may be reopened to allow the system to operate again. This is how it offers total protection.

- ***Absorptive Protection Material Technology:*** Organic or inorganic dye molecules may be used to selectively absorb incident light to offer protection to optoelectronic devices in space-based optoelectronic systems. Usually, light useful to the optoelectronic sensor would also be attenuated by an absorptive protection material. In recent years, some progress has been made in the in-depth study of a new class of nonlinear reverse saturation absorption (RSA) materials (such as metal-prophyrin). This class of material absorbs incident light only minimally when it is below a certain threshold. When the intensity of the incident light exceeds this threshold, its absorption coefficient rises very rapidly (by a factor of approximately 100). However, it only works at ultra-intense light intensity and its effectiveness only lasts a few nanoseconds.

- ***Reflective Protection Material Technology:*** Reflective protection often involves filtering out a specific band with a multilayered optical thin film, a progressively varying optical thin film, or a holographic film. This technique is widely used at the present time. The drawback is that it only protects against a laser at a fixed wavelength. If it is necessary to protect against too many laser spectral lines, then the signal light would be seriously attenuated. The U.S. military is said to be actively pursuing an alternative scheme.

- ***Variable Wavelength Liquid Crystal Thin Film Protection Technology:*** Chiral liquid crystal molecules are lined up along a screw axis. If the incident wavelength is equal to its spiral gap, then the reflected light is circularly polarized. Its chirality is identical to that of the liquid crystal structure. The transmitted light is also circularly polarized. However, its chirality is opposite to that of the liquid crystal structure. By overlapping two liquid crystal thin films with opposite chirality, one can totally reflect incident light no matter how it is polarized.

The unique features of chiral liquid crystal molecular reflective film are as follows. Its spiral gap can be adjusted by an applied electric/magnetic field. The spiral gap increases with increasing field strength of the applied electric/magnetic field. Through this type of mechanism, it is possible to find a narrowband reflective mirror (-10 nm), and its center wavelength is adjustable. Therefore, it is possible to realize dynamic laser protection. Dichroic liquid crystal molecules can also be used for laser protection.

- ***Carrying Weapons for Self-Defense on the Platform:*** According to Chinese military scientists, it is a wise move to equip a high-value satellite system with self-defense capability, such as an optical or radar sensor and a small interceptor. In addition, it may also include a lightweight optical or radio-frequency jamming system to destroy or disrupt the homing device on board enemy ASAT weapons. As microsatellite technology advances, small high-energy laser or high-power microwave systems may be incorporated for self-defense or satellite protection.

Chinese aerospace scientists stress that China should significantly reinforce the cutting-edge design of satellite protection. The concept of ***"system-based countermeasures"*** can be implemented by combining countermeasures against both "soft kill" and "hard kill." China should also initiate preliminary research on low-cost, novel protection technologies. By closely monitoring the progress made by foreign militaries in these technologies, the PLA can adjust and alter the focus and development of countermeasures correspondingly. The Chinese say that we must "know ourselves as well as our enemy in order to win every battle."[51]

[51] Ibid.

IV. CHINESE VIEWS ON COUNTERSPACE OPERATIONS

ANTISATELLITE (ASAT) WARFARE

Chinese military scientists assert that ASAT warfare is the most effective way to achieve space dominance. The principal forms are 1) use aircraft, warplanes, and rockets to launch ASAT missiles to destroy enemy satellites; 2) install "space landmines" on the orbits of enemy satellites for destruction once they hit the landmines; and 3) use positioning weapons such as lasers, clusters of particles, and microwaves to attack enemy satellites. According to the Chinese, the United States has conducted successful experiments using laser weapons to destroy targeted satellites. Russia has also conducted tests using clusters of particles to disrupt and destroy the electronic equipment of satellites.[52]

Destroying space targets by means of directional energies has the advantage that their powers can be adjusted, the weapons can be reused over and over again, their speed is high, and they can attack targets in a vast space.[53] Modern ASAT weapons can also destroy enemy satellites by employing nonlethal destructive measures, such as spraying chemicals on them.

Their cost-effectiveness is high and their deterrence powerful. Currently, space systems have increasingly become systems in which countries' key interests lie. If an ASAT weapon destroys a space system in a future war, the destruction will deal a heavy blow to the side that owns and uses the space system by obliterating its space dominance, weakening its information dominance, and paralyzing its initiative in the war at large. ASAT weapons that can be developed at low cost and that can strike at the enemy's enormously expensive yet vulnerable space system will become an important option for the majority of medium-sized and small countries with fragile space technology to deter their powerful enemies and protect themselves.

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[52] Major General Zhang Ling, "Initial Appearance," 9-15.

[53] Li Hechun and Chen Yourong, "Sky War," 11.

ASAT OPERATIONS

Offensive counterspace operations are those activities involving the use of various lethal or nonlethal means to both neutralize and destroy enemy space systems or the relevant information. These activities can be divided into five categories: deception, disruption, denial, degradation, and destruction.[54]

According to Chinese military scientists, the development and proliferation of various offensive counterspace weapons and technologies may have posed serious threats to the space systems of the United States. The offensive counterspace measures include denial and deception; attack on or sabotage of ground segments; direct attacks on space systems; and electronic attack on the communications, data, and command links of the satellites and ground stations. At the present time, the direct attack and sabotage measures on space systems mainly involve the following: indirect ASAT nuclear weapons, ASAT interceptor weapons, and directed-energy ASAT weapons. These counterspace operations will weaken or eliminate the effectiveness of the U.S. space system as a multiplier, weaken the combat strength of the U.S. military, and make it pay a price politically, economically, and militarily:

- ***Destruction and Deception:*** These counterspace operations involve sabotage, distortion, and deception of the various in-orbit satellites that are conducting intelligence monitoring and reconnaissance missions. The United States will have to deal with various active and passive technological measures such as camouflage, concealment, obscurants, corner reflectors, communications security, radiation emission control, jamming, and so on.

- ***Attack on or Sabotage of Ground Segments:*** Space systems involve various special ground installations such as satellite communications, data reception, and command-and-control and launch facilities. While these ground facilities are

[54] Lu Liang, "Threats Facing American Space Systems," *Hsien-Tai Chun-Shih* (Hong Kong), 1 September 2003, 43-45, 47.

critically important for both the continuous operations and effective uses of satellites, they are vulnerable to attacks. The U.S. globally located, location-fixed ground-monitoring stations and the antennas of the space system (for instance, GPS), as well as the ground-based launch facilities, are likely to be attacked and sabotaged. Furthermore, hackers may also possibly attack the relevant computer networks.

- ***Indirect ASAT Nuclear Weapons:*** If nuclear weapons are detonated in space, the resulting effects of the detonation, such as the resulting radiation and electromagnetic pulses, will disrupt and sabotage enemy satellites and operations in the vast vicinity of the detonation. Aggressors can even launch such attacks in the name of scientific tests. In the meantime, it will be very difficult for the United States to respond strongly and appropriately, both militarily and diplomatically, after its various satellites are damaged.

ASAT INTERCEPTOR WEAPONS

ASAT interceptor weapons can be launched normally from either the ground or the air into the interception trajectories or orbits that are nearly the same as the intended target satellite. Then the interceptors can approach and attack the target satellite. Since various interceptors have various complexities, destruction mechanisms, relative velocities, and distances from the target, they can be divided into the following three distinct categories:

(1) ***Low-Altitude Direct-Ascent Interceptors:*** A low-altitude direct-ascent interceptor can be launched on a booster from either the ground or an aircraft into the suborbital trajectory designed to intersect that of the target satellite in a low-Earth orbit. The in-orbit life span of this type of interceptor is measured in minutes. It is the simplest ASAT interceptor weapon.

(2) ***Low- and High-Altitude Short-Duration In-Orbit ASAT Interceptors:*** A low-altitude short-duration in-orbit ASAT interceptor can be launched from the ground into a temporary stationing orbit from which it can maneuver and launch an attack on a specific low- and high-altitude Earth orbit satellite. The in-orbit life span of this type of interceptor is measured in hours. It is slightly more complex than the direct-ascent interceptor weapons.

(3) ***Long-Duration In-Orbit ASAT Interceptors:*** The long-duration in-orbit ASAT interceptor can be launched into a storage orbit and wait possibly for several months and even several years before it maneuvers and launches a strike on a target satellite. This type of ASAT weapon may be either stand-alone or carried by a "mother satellite," and it can be divided into the following categories:

- "Far-satellite" interceptors, as either independent satellites or "son" satellites of the "space mother satellite," can be launched early and can subsequently be maintained in relative storage orbits different from those of the target satellites. After receiving commands from the ground, the interceptor satellites can activate the relevant ASAT packages and then maneuver, approach, and launch attacks on the targets.

- "Near-satellite" interceptors, as either independent satellites or "son" satellites of the "space mother satellite," can be launched early and can subsequently be maintained in relevant orbits close to those of the intended targets. These interceptor satellites have capabilities both to keep appropriate distances from and to detect the target satellites independently. After receiving commands from the ground, they can quickly maneuver, approach, and launch attacks on the targets.

- "Space mines" are nonmaneuverable ASAT satellites, which can be launched into relevant orbits designed to intersect the orbits of the intended targets. They can subsequently launch attacks on the target satellites in any periodic close encounter by means of explosions detonated either by the onboard fuses or by ground commands. This specific counterspace operation may result in a long delay of time between the decision to attack and the actual attack. As a result, the deployment of numerous space mines in the same orbit may be required to target a particular satellite.

- The "fragmentation cloud" concept is an extended "space mine" idea in which the number of the interceptors is increased while both the size and complexity of an individual "space mine" are reduced. A huge amount of metal shots, sands, debris, or ice particles are deposited from one or more satellites in order to form "fragmentation clouds" in a specific orbit. All satellites orbiting through such "fragmentation clouds" will suffer disastrous damage.

- Space-to-space missiles are rocket-propelled ASAT interceptors launched from an in-orbit carrier platform into the orbits of the intended targets. They consist of carrier satellites, interceptor missiles, and command-and-control equipment. The carrier satellite may carry multiple missiles of the same type.

- Microsatellites can also be used as long-duration in-orbit ASAT interceptors. Microsatellites can be deployed in the relevant interception orbits to track target satellites according to the preinstalled programs and subsequently launch attacks on the satellites after receiving attack commands. This type of counterspace operation is difficult to detect and prevent. The Chinese warn that some countries, which have already mastered microsatellite technologies, are developing nanosatellite ASAT weapons called "parasitic satellites."

ORBITAL BALLISTIC MISSILES

Chinese aerospace scientists describe the "new-concept" orbital ballistic missile (orbital missile) as a multitask, multirole strike weapon capable of implementing random orbit transfer from Earth orbits. It can function as an intercontinental ballistic missile, an ASAT weapon, and an orbital bomber weapon. The missile is a cross between a ballistic missile and a satellite; it is a ballistic missile in a satellite orbit or a satellite with weapons capability. These missiles should be developed using the mutually interchangeable ground-based and space-based missiles, ground-ground missiles, and ASAT missiles.[55]

[55] Zhao Ruian, "The Concept of Orbital Ballistic Missile."

To attack a target satellite, the orbital missile may ascend to the intercept point or it may enter a holding orbit around the Earth, and then encounter the target by changing the orbit. The advantages of the direct-ascent approach are that it is simple, its early-warning time is short, and its fuel-to-mass ratio is low. But this approach means that each launch has only one chance to attack.

In contrast, the approach of attacking from orbit has several chances in a single day. The possible operations include: 1) making the orbit of the missile coaxial with the orbit of the target satellite, and achieving interception by expanding the orbit with thrust impulse; 2) placing the missile in an Earth orbit lower than that of the target satellite, so that its apogee is almost coincident with the perigee of the target satellite's orbit, and achieving interception by faster orbital speed; and 3) still placing the missile into an Earth orbit lower than that of the target, but intercepting it at a certain orbit position by a dynamic jump. But this method requires a more complex control technology and a higher fuel-to-mass ratio. The target satellite will also have a longer early-warning period.

As early as 40 years ago, research and testing of ICBMs equipped with nuclear warheads for attacking satellites on their ascent were performed. It was reported that the explosion of the nuclear warhead created an artificial radiation layer that indiscriminately destroyed satellites over a fairly long period of time. This "kill-all" approach did not receive much support; instead, conventional warheads (explosive warhead, fragmentation warhead, and continuous-rod warhead) seemed to offer a better compromise between the complexity of the detonator and the effectiveness of the explosion.

A fragmentation warhead consists of the explosive and a shell; the fracture of the shell releases a large amount of fragments when the explosive is detonated. It is estimated that 500 g of any material traveling at a speed of 3 km/s has an equivalent kinetic energy equal to 500 g of high explosive. Satellites are fragile structures moving at high speed; they can be easily damaged by a small mass moving at a relatively modest velocity.

Another approach is to create a mesh of small fragments across the satellite orbit with a small amount of explosives. The fragments are held by metal wires or fiber threads. The effect of gravity may be countered with a small thrust, and the mesh can be extended to a diameter of 30 m and maintained for about 1.7 seconds. For a 15 kg warhead containing a detonator, 5 kg of fragments, and other mesh material, the 5 kg of fragments can be 5,700 steel cubes of 5 mm size distributed at a density of one per 12 mm. This type of expanded mesh warhead can tolerate a greater detonation error and afford a greater probability of kill.

Although laser weapons can travel thousands of kilometers of distance at the speed of light and destroy targets instantaneously, without the constraint of orbital dynamics and aimed at any target within the line of sight, it is still not practical to use lasers as onboard weapons for satellites. Aside from the technological obstacles, the weight of tons of materials required by hydrogen fluoride and oxygen iodide chemical lasers, under development in some foreign countries, can cost $2 billion and weigh 17.5 tons. Therefore, the onboard ASAT mission calls for a new paradigm in high-energy laser weapons.

DIRECTED-ENERGY ASAT WEAPONS

Directed-energy ASAT weapons mainly include laser beams, radio-frequency beams, and particle beams. In comparison with the interceptor weapons, the directed-energy weapons can attack multiple targets simultaneously from a long distance. Both target positioning and attack with this type of weapon could possibly be accomplished in a few seconds.[56]

Laser weapons include the following two types: low-power and high-power laser weapons. In counterspace operations, the low-power laser weapons will normally use the radiation that is in the working band of the onboard sensor designed either to jam the elecro-optical sensor of the satellite or to "blind" it. The high-power laser weapons can permanently either damage or destroy a satellite through the use of various high-power

[56] Lu Liang, "Threats Facing American Space Systems," 43-45, 47.

laser beams to overheat and melt or vaporize the parts or components of the target satellite. The Chinese warn that some countries, such as Russia and Israel, are developing ground-based, air-based, and space-based laser ASAT weapons.

Radio-frequency ASAT weapons are those weapons using high-power energy pulses designed to disable the electronic components of the intended target. Radio-frequency weapons include two categories: ultra-wide-band radio weapons and high-power microwave weapons.

In counterspace operations, the ultra-wide-band and low-energy-density radio radiation generated from an ultra-wide-band radio weapon can be the main radiation that is used to jam the target satellite, whose signal-receiving frequency is in the radio-spectral band of the weapon. If the power of the radio emitter of a weapon is high enough or very close to the target satellite geographically, then the radiation received may possibly result in major damage to the internal communications hardware of the satellite, such as radio-frequency amplifiers and other devices on the front end of the receiver.

High-power microwave weapons can generate radio-frequency beams with higher directivity at a very narrow frequency band ranging from 100MHz to 100GHz. This type of high-power radio-frequency beam can penetrate into the interior of the target satellite through antennas or cracks, etc. The penetrated energy can be absorbed by the various electronic components on board the satellite. As a result, the satellite may suffer either disruption or damage. The Chinese warn that Russia is probably developing radio-frequency weapons at the present time.

Particle-beam ASAT weapons are capable of firing an intense particle beam at a target satellite after accelerating the relevant elemental particles up to a certain velocity using a particle accelerator. Large enough energy from the beam may overload and permanently damage the electronic components of the target satellite. This type of weapon includes both charged particle-beam weapons and neutral particle-beam weapons. Since the charged particle beam cannot penetrate the atmosphere, and since it may reflect away under the magnetic field of the Earth, the space-based neutral particle-beam weapons may be the most likely particle-beam weapons in the next 15 years.

SEA-BASED ASAT PLATFORM

According to Chinese naval experts, counterspace operations have become an important mission of a 21st-century sea power, and ASAT capabilities constitute the linchpin. The vulnerability of a military space system has made it the first link to strike in modern war, possibly triggering a "space Pearl Harbor."[57]

The ASAT operation can be divided into the two levels of armed conflict and war. In a state of war there will be no constraints on the antimissile system. In armed conflicts, the ASAT operation can be divided into low-intensity and high-intensity. Based on the maturity of ASAT missiles and their impact, there can be the following approaches:

- ***Low-intensity armed conflicts:*** jamming and blinding interference of surveillance satellites (including imaging satellites, electronic surveillance satellites, and ocean reconnaissance satellites), communication satellites, and navigation satellites; and

- ***High-intensity armed conflicts:*** destructive attack of surveillance satellites in medium- and low-Earth orbits by directed-energy weapons; command jamming and blinding of surveillance satellites, communication satellites, and early-warning satellites in high orbits; and jamming of navigation and weather satellites.

ASAT platforms can be divided into space-based platforms and conventional platforms, including land, sea, submarine, and air. The attack capability of space-based platforms is better, but the cost is high, the payload is small, the platform is more vulnerable to jamming, and the adaptability is poor. Also, the deployment of a space-based weapons platform is currently restricted by the rules for a space arms race. The

[57] Liu Huanyu, "Sea-Based Antisatellite Platform," *Jianchuan kexue jishu*, 1 February 2004.

high level of operation makes space-based platforms suitable only for war. To disable the space military system of the enemy in an armed conflict, only the conventional platform can be used.

The effectiveness of a sea-based ASAT platform depends on the following three factors:

> **(1)** ***The ability to destroy enemy space systems in a large area:*** The platform should have the ability to conduct sustained interference and attack so as to totally disable the space systems of the enemy in the war zone.
>
> **(2)** ***The ability to survive*****:** Like early-warning planes, sea-based ASAT platforms are the "must-kill" targets of the enemy. Survivability is therefore the first factor to consider in choosing a platform.
>
> **(3)** ***The ability to move and fight a long-term battle:*** High-speed mobility is important for a sea-based force to survive and to stay effective. The ability for long-term operations is essential in fighting a war on the ocean.

Nuclear submarines are not only well concealed, but can sail for a long time. By deploying just a few ASAT nuclear submarines in the ocean, a country can seriously threaten the entire military space system of the enemy. In addition to ASAT operations, these nuclear submarines can also be used for launching low-orbit tactical microsatellites to serve as powerful real-time battlefield intelligence support. The main weakness of a submarine is that it is difficult to install detection systems on it. Submarines have a weak capability for autonomous searching and therefore need the support of the national space-monitoring system.

Surface ships built for ASAT operations can adopt more effective stealth technology and can serve as a useful ASAT platform. The main advantage of large ASAT ships is their strong autonomous searching capability. The platform can be equipped not only with spatial-detection radar, but also with large-scale electro-optical detection systems. The operations of ASAT ships are more complete and can effectively conduct electronic jamming. ASAT cruisers are therefore an indispensable support force for a sea power.

What China needs now is an effective capability to intervene on the ocean, which means a new sea power. The sea-based ASAT platform is a major component of the new sea power and must be given a high priority. If this new avenue is explored as soon as possible, China may be able to improve its sea power dramatically within 10 years.

ASAT COUNTERMEASURES

In the environment of space warfare, the vulnerability of satellite systems is obvious. Since the onboard fuel is limited, the orbit of the satellite is more fixed; the maneuverability is extremely limited; and the exterior is hard to conceal. Therefore, in space warfare, the survivability of the attack satellites must be enhanced while they are proactively attacking and damaging the enemy's satellites. The following measures can be used to accomplish this goal:[58]

> (1) Use hardening or protecting of the satellite's outer surface and of parts easily damaged by irradiation by lasers and particle beams, such as infrared equipment, photoelectronic sensors, and optical lenses. For example, install protective armor on the outer structural layer. Add a hoistable protective cover or cap to optical lenses. Use nuclear power to replace the exposed solar battery packs that are easily damaged. Use mechanical parts with strong anti-electromagnetic interference capabilities to replace electronics that easily suffer electromagnetic interference.
>
> (2) Enhance the satellite's orbital maneuverability by installing detectors that can warn of approach and tracking by enemy spacecraft. Based on the detector's information or the orders of the Earth-based tracking, telemetering, and command-and-control center, the satellite can change its orbit and avoid the

[58] Zhang Liying, Zhang Xixin, and Wang Hui, "Preliminary Analysis," 28-30.

enemy's spacecraft. Enhancing the orbital maneuverability of satellites requires expending a large amount of fuel.

(3) Deploy decoys or false targets in the vicinity of the satellite. For example, on a false satellite spray a thin metal film that reproduces as much as possible the same exterior, size, and quality of the real satellite to attract the attention of the enemy's ASAT weapons or Earth-based radar and thus to prevent the enemy's tracking and pursuit of the real satellite.

(4) Conceal the satellite by covering the exterior with wave-absorbing material to absorb the radio waves emitted by the enemy's ASAT spacecraft or Earth-based radar. Also, temporarily halt the satellite's radio signal for temporary concealment. However, since a satellite's exterior must have a certain amount of heat-radiating surface, and since it has antennas and solar battery packs installed, it is difficult to improve on its concealment. Use autonomous navigation as much as possible to conceal electromagnetic signals.

(5) Distribute small, scattered satellites in different positions in the same orbit, or distribute them in different orbits to make it hard for them to be totally destroyed by ASAT weapons. Even if a portion is damaged, the remainder can still continue to operate and to enhance the survivability of the whole satellite system.

(6) Deploy space blockades by deploying a satellite network at low-Earth orbit. The network can continually monitor signal transmission in space and give strategic warnings to make an advance assessment of the enemy's space capabilities.

According to Chinese military and aerospace scientists, satellites will be the main space system for seizing space dominance in the 21st century. Attacking the enemy's satellites and protecting one's own satellites are the primary tasks of space warfare. To seize an advantage in space, and to protect national security, the competition for ASAT weapons and satellite defense will become more and more intense. The global trends of advanced satellite technology should be correctly followed, and ASAT weapons should be enthusiastically developed.

ASAT SCENARIOS

Based on the capabilities of reconnaissance satellites, Chinese aerospace scientists have compiled the following list of "space-information countermeasures":[59]

- Aim for the satellite's effective payload by applying suppression interference to cause overload in the satellite's receiving system, data processing system, and memory;

- Target the satellite's remote control system by 1) establishing a space target monitoring system to acquire the satellite's technical parameters and character information, and 2) effectively detecting and analyzing the satellite's operational system and down-link remote signal;

- Attack the satellite's space-to-ground communication and command nodes to weaken the connection, link, mutual operation, and networking flexibility in order to degrade its operational effectiveness; and

- Use high-energy and kinetic weapons to blind **[2006]** or destroy **[2007]** the reconnaissance satellite [dates added by author].

While Chinese military experts applaud the "brilliant" performance of the U.S. Global Positioning System (GPS) in recent high-tech military operations, they continue to

[59] Que Wenyan and Yang Bo, in *Xiandai Leida*, 1 February 2004.

clarify its inevitable "Achilles' Heel."[60] They have delineated three major operations to defeat GPS:

- Defeat GPS at its source by exploiting the weakness of the low orbits of navigation satellites. This is accomplished by attacking with 1) ASAT satellites, 2) high-energy laser weapons, and 3) high-altitude weather-monitoring rockets.

- Defeat GPS in the middle by exploiting the scattered and exposed ground stations.

- Defeat GPS at the end by exploiting the fact that navigation signals are highly attenuated. After attenuation by natural causes, the ground signal is very weak and easy to jam. To prevent the enemy from locating and destroying the GPS jammers and to avoid personnel losses, the GPS jammer can be carried on a variety of platforms—such as numerous aircraft and projectiles—and thrown into a designated region for effective jamming.

The Chinese also allege a "U.S." counterspace scenario against the Galileo system, which is said to consist of: 1) attacks by ground-based laser weapons, 2) attacks by airborne laser weapons, and 3) attacks by orbital weapons. (Orbital weapons capable of attacking enemy targets include laser and beam weapons.)[61]

These experts also propose three measures that China and other countries could employ to counter the above-mentioned three "U.S." tactics:

- ***Passive Defense:*** Create a protective shield in space to disperse laser attacks.
- ***Active Defense:*** Establish ground-based ASAT systems and orbital weapons platforms and deploy orbital weapons to attack and destroy hostile targets.
- ***Offense:*** Develop strategic weapons to counter space weapons.

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[60] Chen Xuejun and Lang Daqiang, "Methods for Defeating GPS," *Junshi wenzhai*, 1 November 2004, 52-53.

[61] *Wen Wei Po* (Hong Kong), 25 October 2004.

ANTIMISSILE WARFARE

Antimissile warfare refers primarily to the employment of an antimissile system composed of space-, air-, and ground-based platforms to detect, identify, and track enemy ballistic missiles. Antimissile space warfare also refers to the employment of positioning, kinetic, and other antimissile weapons to intercept and destroy enemy missiles. The United States, say the Chinese, is currently developing a national missile defense (NMD) system "which is actually an antimissile system anchored primarily in space warfare."[62]

Chinese aerospace scientists note that, compared with ground-based, sea-based, and air-based antiballistic missile weapons, space-based antiballistic missile weapons have the following advantages: 1) they can intercept missiles on a global basis, 2) they can carry out highly efficient boost-phase interception, and 3) the virtually vacuum space is advantageous for improving an interceptor's capabilities, such as reducing the attenuation of laser energy in the atmosphere. (Space-based antiballistic missile weapons, however, have the shortcoming that they need enormous amounts of resources to build.)[63]

In analyzing the capabilities of the air- and space-based laser systems that underpin the ballistic missile boost-phase interception stage of the U.S. NMD system, Chinese scientists have also analyzed the feasibility of boost-phase evasive measures, to include the following four methods: 1) employ fast-burning rocket motor to shorten the duration of the boost phase and hence the duration for a laser attack; 2) perform active rolling of the missile body during the boost phase so that the energy of the laser spot at a given location remains lower than the damage threshold; 3) apply high-reflectivity, low-conductivity, antilaser coating on the missile surface to reduce the thermal coupling

[62] Major General Zhang Ling, "Initial Appearance," 9-15.

[63] Li Hechun and Chen Yourong, "Sky War," 11.

coefficient of the laser and keep the temperature rise rate in the safe region; and 4) employ other countermeasures such as smoke.[64]

Chinese military strategists stress that the creation of ballistic missile defense systems and corresponding "penetrating measures" again prove the "shield-spear" dialectic, each of which will always generate the other and advance competitively. For today, the Chinese propose the following "penetrating measures": 1) multiple warhead attack, 2) decoy penetration, 3) interruption and concealed penetrations, 4) enclosing balls (huge metallic membrane balloons), 5) trajectory change penetrations, 6) mobile launch, and 7) preemptive strike: "attack and destroy a certain part" of the NMD system.

Conducting a preemptive strike includes: 1) use "suicide satellites" (an orbital type of cruise satellite) or laser weapons to destroy the early-warning satellite system and space-based infrared systems of the NMD system to paralyze them, and 2) launch preemptive attacks against each component of the NMD system. According to the Chinese, Russian scientists state that it is possible to use a mid-air nuclear explosion to destroy the "command, control, and communication management center" of the NMD system to both paralyze and attack its essential defensive capabilities.

PLASMA WEAPONS

Again echoing their Russian counterparts, Chinese aerospace scientists describe "plasma antimissile warfare" as follows: launch a high-power microwave energy beam or a high-energy laser beam from the ground and focus it at a "special spot" in the atmosphere in front of the targeted missile's trajectory; then ionize the air in that area to an immense intensity with high-density and highly ionized plasma clouds to break that trajectory.[65]

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[64] Dong Han-quan and Lu Ming-hua, "Penetrating National Missile Defense Systems," *Dangdai fangyu jishu*, no. 3 (June 2004).

[65] Yang Liming and Cao Xiangyu, "Military Applications of Plasma and HPM," *Hangtian* (Shanghai), 1 February 2002.

Since microwave and laser beams propagate at the speed of light, a missile will never match them, regardless of its speed. These intense beams will thus provide more operational time to prepare for defending against the attack missiles and improving combat efficiency.

Russian scientists, say the Chinese, have opened a new road for themselves and proposed the adoption of the new method of using plasma weapons to intercept missiles. The principle of plasma weaponry is using the generator and antenna installed on the ground to discharge high-frequency electromagnetic beams that will be focused at a high altitude. Air at the focal point will start to have a strong ionized reaction and form a densely ionized plasma "cluster." Such a "cluster" will be an electromagnetic "obstacle" to the missile of the opposing side, causing a moment of rotation and making it diverge from its flight path.

Due to a drastic change of flight path and according to inertial theory, the missile will endure a great inertial force and eventually be damaged and destroyed. The entire interception process will take only 0.1 second. To the plasma generator, the flying missile is almost like a "still" target. The system can very accurately intercept multiple incoming targets in a short time.

Russia is said to have successfully developed plasma weaponry on a trial basis. It is composed of an ultra-high-frequency electromagnetic wave generator, a directional antenna, and an electric source and control system. It uses a container-type modular structure. The experimental device has successfully hit artillery shells. It was revealed that a module of the above-mentioned systems would underpin practical plasma weapon systems for Russia. The oscillator of modules can deliver super-powerful microwave beams at the speed of light.

The interesting thing is that the weapon system combines the radar system for detecting targets with the electromagnetic beam launching system for creating plasma "clusters." It fulfills the multiple functions of searching, acquiring, and striking targets. It will not need to spend time discerning true or false targets and determining positions of targets. It can shoot down flying targets upon discovery. Plasma weaponry will greatly raise the efficiency of the existing antimissile fighting system in Russia.[66]

Chinese strategists assert that for the long term, "we must intensify new and high-tech pre-research in this field, focus on aerospace threats and missile-attack and defense confrontations, and establish an all-dimensional and integrated missile defense system as soon as possible."[67]

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[66] Le Junhuai, "Plasma Technology: Another Military Advantage Point," *Zhongguo guofang bao,* 23 October 2001.

[67] Dong Han-quan and Lu Ming-hua, "Penetrating National Missile Defense Systems."

V. CHINESE VIEWS ON SPACE OPERATIONS

INTEGRATED AIR-AND-SPACE OPERATIONS

"This revolution," say the Chinese, "is first of all a revolution in concepts."[68] Like their Russian counterparts, Chinese military strategists have long been articulating a body of operational concepts for conducting integrated "air-and-space operations" (ASO).[69]

The boundaries dividing military aviation and aerospace will gradually disappear to create a unified aviation and aerospace entity whose range extends from the surface of the Earth to outer space. Ground, air, and space already constitute an indivisible operational environment, as demonstrated by the experience of recent wars. Conducting integrated ASO is now only a matter of perfecting the relevant technologies, and no longer a matter of their feasibility.

Owing to the technological breakthroughs in systems such as the space shuttle, aerospace aircraft, space weapons, and "new-concept" weapons, integrated ASO are becoming a new operational form of informationized warfare. For example, the space shuttle will become a completely new space weapon that combines aviation and spaceflight strikes, transportation, and information operations. This kind of milestone weapon, say Chinese scientists, will create the conditions for multidimensional, stereoscopic operations conducted from space to Earth, from Earth to space, and from space to space—thereby transforming integrated ASO from theoretical to actual.

An integrated air-space maneuver platform can transport troops to any location on Earth in a few hours, while the attack weapons—such as laser and beam weapons—can

[68] For example, see Fang Fenghui, "Preparations for Military Struggle Assume New Importance in the Age of High-Tech Local Warfare, May Avoid War," *JB,* 27 August 2002, 6; and Fan Zhenjiang, Zhao Tianliang, and Zhang Guoyu, "Military-Theoretical Innovation Is Needed for Preparing for Information War, High-Tech War," *JB,* 21 January 2003, 6.

[69] Senior Colonel Zhang Zhiwei and Lieutenant Colonel Feng Chuangjiang, "Analysis of Future."

execute precision strikes at the speed of several hundred thousand kilometers per second. This speed is hardly something that defensive weapons can withstand.[70]

The notable characteristics of integrated ASO are reflected in four areas:

> (1) The range of the battlefield extends into outer space, and the original concepts of the ground battlefield, sea battlefield, air battlefield, and space battlefield are combined together to create a new concept of the battlefield as a seamless entity. All forces—sea, ground, air, space, and electromagnetic—conduct coordinated operations within the new concept of the battlefield.
>
> (2) A unified reconnaissance and support system is created on the ground, at sea, in the air, in space, and in the electromagnetic spectrum. Full advantage is taken of the unique superiority of outer space to provide strong operational support for the operational activities of one's own side. The range that it covers includes all battlefields below the atmosphere.
>
> (3) Many kinds of attack measures are used together in all the realms—ground, sea, air, space, and the electromagnetic environment—to create a complete attack power and conduct comprehensive, omnidirectional, full-depth attacks across the different physical realms.
>
> (4) The integrated space and ground C^4ISR system is used to implement integrated command and control of the ground, sea, air, space, and electromagnetic battlefields. This ensures seamless, integrated operations from the ground and air and even into the atmosphere and outer space.

Whether it be system architecture, battlefield utilization, or the pursuit of operational objectives, integrated ASO give prominence to the dominant roles of information, information technology, and the utilization of information. They reflect the central objective of achieving information dominance in future wars.

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[70] Lieutenant Colonel Pan Youmu, "Exploring National Air-Space Security Strategies in View of Air-Space Integration," *ZJK*, no. 2 (2006).

The high-technology characteristics of integrated ASO completely reflect the supporting role of information technology. Regardless of whether it supports the reconnaissance, surveillance, communications, or command systems for its operations, or the weapons for ASO that are directly employed in the war, information has already become a dominant, intrinsic element in the system architecture for operations.

Integrated ASO must be supported by an integrated information network system that includes a real-time, effective information retrieval system; a fast, reliable information transmission system; and a highly effective, intelligent system for information processing, handling, and decision making. Only then is it possible to create a complete, integrated force with which to engage the enemy.

The goal of integrated ASO is to gain and maintain air and space dominance. A prerequisite is first gaining and maintaining information dominance—that is, control of the information activities in the air and space battlefield. If it is not possible to gain and maintain effective information dominance, then it will be difficult or fundamentally impossible to gain air and space dominance.

The principles behind integrated ASO consist in "attacking systems" and "attacking the whole." Implementing a whole system-to-system confrontation is completely consistent with the Chinese concept of "whole operations" in informationized warfare (i.e., "integrated network-electronic warfare"). As space weapons continue to be developed, the speed at which targets can be acquired and attacked from outer space will undergo an Einsteinian change. Targets can be obliterated in an instant from distances of up to 10,000 kilometers, which makes the course of operations measurable in minutes or seconds. ***The concept of time in operations will thus move from the "time of combat vehicles" and "time of missiles" to the "time of the speed of light."***[71]

[71] Senior Colonel Zhang Zhiwei and Lieutenant Colonel Feng Chuangjiang, "Analysis of Future."

Chinese military strategists predict that the emergence of integrated ASO will inevitably trigger a sea change in military strategy. The expanding space battlefield will compel new theories such as space threat warfare, space mobility warfare, space blockade warfare, space attack warfare, and space defense warfare. As "new-concept" weapons continue to be developed, the expanding space arsenal will generate such operations as laser attacks, microwave attacks, meteorological attacks, genetic attacks, virus attacks, and nonlethal attacks.

The first wave of war will develop from "firepower attack" and "electromagnetic attack" to "satellite paralysis." ***Space will become, say the Chinese, "the first true battlefield."***[72]

ORGANIZATIONAL IMPERATIVES

Chinese military scientists note that, in order to implement space warfare, all organizational elements of the PLA must undergo both quantitative and qualitative changes. In general, the operational forces will now elevate technical elements, and operational systems will endure major adjustments.[73]

First, the PLA will transform the current large unit formations. Operational units will become smaller, the number of combatants within the formations will be greatly reduced, and science and technology personnel within the PLA will increase dramatically.

Second, significant changes will occur in the composition of the PLA services and branches. In addition to eliminating some of the older military branches, a series of new technical and combat branches will be organized. These will include a "space force," an "aviation and aerospace corps," and "drone operations units."

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[72] Ibid.

[73] Ibid.

Third, operational command systems and logistics (and technical) support systems will also be substantially adjusted and transformed. The command organization for space forces will be given prominence in the command system in order to constantly strengthen command-and-control capabilities for the operational air and space forces.

Chinese military strategists believe that the "space force" to be formed must be a new breed of army. It should be small in scale, complete in capability, integrated in combat structure and missions, and remotely commanded in all situations. China's Central Military Commission (CMC) believes that the "space force" must be composed of "composite" command and technical cadres from the navy, army, air force, and Second Artillery Corps.[74]

The "space force" will be formed by combining the General Armament Department, the National Space Administration, and the Second Artillery Corps. Based on reports and information from the top military brass in Beijing and others, the most likely basic components of the "space force" will be the four satellite launch bases at Jiuchuan, Taiyuan, Xichang, and Xian satellite-monitoring and control centers under the direct jurisdiction of the General Armament Department, joined by top talent selected from the State Council's State Astronautics Bureau, the Science and Technology Commission of National Defense, the Astronautics Science and Technology Group and its Aerospace Science and Technology Institute, and the Carrier Rocket Technology Institute (with a branch in Shanghai).

To develop its space enterprises and to build its future "space force," China is in urgent need of a large number of technical generals and military leaders. To meet this need, Beijing formulated a "1,000 generals" plan to systematically train personnel for "integrated air-and-space information wars." China's highest National University of Defense Technology and the Institute of Command and Technology of Equipment are given the task of training personnel with both command and technology expertise. In addition, the National Defense University, the highest academic institute of the PLA, is

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[74] Jin Qianli, "The People's Republic of China Is Preparing to Form a Space Force," *Chien Shao* (Hong Kong), 1 July 2005.

gradually increasing its course content on information war in order to raise the technical command level of the generals in training.

Before China forms its "space force," it will step up its "theory first" task. A team of military experts from the General Staff Department, the General Armament Department, the National Defense University, the University of Science and Technology of China, and the Institute of Command and Technology of Equipment have written a number of academic papers in anticipation of space wars and future spaceflight technology. These papers have theoretically investigated the feasibility and inevitability of establishing a "space war experimental team." These academic studies predict that future high-tech wars will integrate the space force and the air force, will be asymmetrical and unrestricted, and will be a competition for air, sea, space, and information dominance in order to win.

Chinese military scientists have compared the three organizational structures and development patterns for building the space and strategic missile forces in the United States, the former Soviet Union, and Russia. They note the "plain fact" that for performing the same missions, fulfilling the same tasks, managing and commanding the same types of military units, the United States has consistently taken the path of air-and-space integration by establishing the Space Command inside the Air Force to manage the strategic missile units and the space units. The practical results show that this method achieves the highest efficiency in appropriately distributing and using military resources.[75]

On the other hand, the former Soviet Union and Russia adopted the method of establishing independent services or arms, but the drawbacks of this organizational concept are rather distinct. First, the larger number of services and arms complicated the structure of military forces and impeded the conduct of joint operations. Second, this concept contradicted the rule that governs the establishment of an independent service or

[75] Senior Colonels Min Zengfu, Ji Yan, and Wei Dexing, "Comparative Analysis of the United States (U.S.), Former Soviet Union, and Russia in Their Deployment of Space and Strategic Missile Strength," *ZJK*, no. 2 (2006).

arm. In addition to the objective needs, the establishment of an independent service or arm must meet certain necessary and sufficient conditions. The main necessary condition is that the service or arm must control its own battle domain.

For example, the battle domain for the army is the ground; the battle domain for the navy is the sea; and the battle domain for the air force is the airspace. Because of different battle domains, the main battle weapons have different basic technology requirements; the operational forces have different characteristics; and the forms and methods of employing the weapons are also different. However, the Strategic Missile Troops did not control its relatively independent battle domain; and its strategic functionality was simple and single, so it did not have the necessary and sufficient conditions for becoming an independent service. Third, military resources were wasted and used inefficiently.

In addition, say the Chinese, the organizational concept of the U.S. military has resulted in great benefits in the wars since Desert Storm and has generated colossal changes in the essence of modern warfare. In particular, the seamless connection of the integrated air-and-space force and other military forces has demonstrated the U.S. superiority now known to all military watchers in the world. The organizational concept of the former Soviet Union and Russia did not achieve notable results. In the Chechen War, for example, its strong space force did not perform a role in supporting other forces or multiply the overall capability of the military forces as effectively as the U.S. space force did in its own high-tech operations.

APPENDIX A:

SINO-RUSSIAN OPEN-SOURCE INTELLIGENCE

For reasons that include a penchant for secrecy, Russian and Chinese military writers use a rigorous system of esoteric communication techniques whose decoding requires an equally rigorous cryptography. But the painstaking application of a system of decoding techniques has long proven to be notably effective for ferreting out Sino-Russian intentions and emerging military options.

In analyzing Soviet military writings from the late 1970s to the early 1980s, for example, I was able to identify a Soviet shift away from nuclear options and toward the utility of emerging conventional weapons and "weapons based on new physical principles" (EMP, laser, etc.). For Marshal N. V. Ogarkov, then Chief of the Soviet General Staff, these developments heralded a new "Revolution in Military Affairs" (RMA)—whose emergence was *first* ascertained by a meticulous decoding of open-source Soviet military writings.

Indeed, studies of now-declassified Soviet military writings have demonstrated that open-source Soviet writings contained little if any divergence from classified sources. And more often than not, these open-source forecasts of emerging options have also been subsequently confirmed in Sino-Russian hardware, exercises, and operational behavior. In recent years, Russian military scientists have even introduced an entire discipline called "Military Futurology," whose objective is to forecast and identify the emergence of "military-technical revolutions."

For a variety of reasons, Chinese military writers have long been reluctant to acknowledge their military-theoretical debt to Soviet/Russian military scientists. (For example, they have often cited Marshal Ogarkov's RMA theories verbatim and conveniently omitted attribution.) But in 2001, the PLA's Academy of Military Science (AMS) published a comprehensive (and fully attributed) tome entitled *The Science of*

Military Strategy. Here the leading AMS military scientists openly welcomed their reliance on Marxist-Leninist and Soviet/Russian military science.

According to the editor, "the project team tried their best to write a theoretical work which is guided by the Marxist scientific concepts of war and strategy…." One author noted that when Mao articulated his set of complete strategies for revolutionary war, he was concretely applying and developing the Marxist theory of strategy in China. In seeking the best definition of "military strategy," another author singled out the following four "out of the multifarious definitions of modern strategy": 1) Liddell-Hart, 2) Mao, 3) Marshals V. D. Sokolovskiy and N.V. Ogarkov (especially for their precise delineation of the *categories* of military science and military art), and 4) various U.S. military theorists.

In a section entitled "The RMA in the Contemporary World," the author stressed that "In the late 1970s, the leaders of the Soviet armed forces deemed the introduction of computer-based information technology into the domain of military affairs and the emergence of precision-guided munitions were leading to changes in military affairs and a new technological revolution."

Thus, in addition to sharing an obsession with esoteric communication techniques, Russian and Chinese military writers share a rich heritage of Marxist-Leninist and Soviet/Russian military theory. And here the analyst of Russian and Chinese military writings can breathe perhaps the only sigh of relief in an otherwise rigorous methodological mining process. The critical *categories* of military science and military art required for effective analysis are practically identical for both Russian and Chinese military scientists.

Indeed, the analyst's first task is to identify those categories of Sino-Russian military art that seem to offer the most promise of obliquely indicating Sino-Russian military options that will be developed in the future or have reached (or are about to reach) the hardware-operational stage.

"Military art," the principal component of "military science," encompasses the spheres of military strategy, operational art, and tactics. In this analyst's experience, the following five categories have yielded the earliest harbingers of Sino-Russian intentions and emerging military options:

- "The nature and specifics of future war." This category includes the scale of state participation in the war, its coalitional or non-coalitional character, the types of weapons used, the scope of combat action, the intensity of combat, its expected duration, and the political objectives of the opposing sides;
- The "methods of warfare";
- The impact of these methods on critical "principles of military art" (especially the principle of "surprise");
- The "types and forms" of strategic actions; and
- The factors influencing the "course and outcome of war."

For example, even when describing possible nuclear scenarios, Soviet writers stated that the war's "initial period" would exert a "decisive" influence only on the "course," and not on the "outcome" of the war. But when describing scenarios involving PGMs and "weapons based on new physical principles," the Russians have stated that the "initial period" (read "surprise with high-tech weapons") *is* the outcome of the war.

Having selected the appropriate categories of Sino-Russian military art, the analyst must now sharpen each of the mining implements available for the slow extraction of intelligence "nuggets" from the Sino-Russian caverns of *intentional obscurity*. In this analyst's experience (and despite the occasional Western skeptic), the following rules of analysis have always proven to accelerate the decoding process and produce the most accurate results:

- ***Pay close attention to the views and intentions attributed to the West by Russia and China.*** The Sino-Russian penchant for secrecy is an important factor in their use of surrogates. Analysts who reject surrogate interpretations out of methodological scruple are renouncing an important source of intelligence. For example, if Russia has developed an option for which there is no U.S. counterpart, it must nevertheless attribute the option to the United States. Marxist-Leninists never initiate; they only react.

- ***Similarly, pay close attention to historical treatments; lessons of the past are often surrogate lessons for the present.***

- ***Pay close attention to definitions.*** Examples here include changes or divergences in categories like "military superiority" or the war's "immediate" and "intermediate" strategic objectives. When a definition does float by, grab it; you may never see it again. (Although signals redundancy is more common.)

- ***Pay close attention to hierarchies of terminology.*** For example, it is crucial to know whether the influence of a factor (e.g., PGMs) on the "course and outcome" of the war is said to be "decisive," "vital," or simply "significant."

- ***When key subject matter is encountered, pay careful attention to every word in the passage.*** For example, until Brezhnev's 1977 speech at Tula, Soviet military scientists consistently proclaimed that any use of nuclear weapons "*will inevitably escalate* and lead to the *extinction of all mankind*." But later, coincidentally with the emergence of limited nuclear options and PGMs, the formula shifted to any use of nuclear weapons "*might escalate* and lead to *catastrophic consequences*."

- ***In Sino-Russian military writings, what is* not *said is just as important as what is.*** This elliptical approach is typical, and much more difficult to spot.

- ***Read as widely as possible in the relevant literature.*** Besides the books published by both the Russian General Staff Academy and the PLA's Military Science Publishing House, each has a premier military-theoretical journal. The Russian *Voennaya mysl'* (Military Thought) and the Chinese *Zhongguo junshi kexue* (China Military Science) clearly offer the mother lodes of military-strategic thinking. But both the Russian and Chinese Academies of Military Science; other journals published by the Air Force, Navy, etc; and military-oriented research institutes like China's National Defense University all offer potential intelligence nuggets to the indefatigable miner of Sino-Russian open-source military literature.

In sum, such an analyst must be an active participant in the communication process. Russian and Chinese military writers employ myriad forms of what might be dubbed a general "implicative" technique. The obsessive resort to surrogate intentions; the legerdemain of changing definitions, formulas, and hierarchies of terms; and the ever-elusive ellipsis all combine to achieve their targeted effect: obfuscation of the West and education of their own military cadres. But if we take the trouble to learn the Sino-Russian "language within a language," then the analytical results can be startling.

On one memorable occasion, however, a Soviet communication technique was not cryptic at all. In his pivotal May 1984 "Victory Day" article in *Red Star*, Marshal Ogarkov stressed the urgency of shifting Soviet defense funds away from obsolete options and into development of PGMs and *especially* "weapons based on new physical principles." In September 1984 he was stripped of his title as Chief of the Soviet General Staff and shipped away to command the Western TMO. And the rest is RMA history….

APPENDIX B:

SOVIET/RUSSIAN ROOTS OF CHINA'S SPACE STRATEGY

In 2002, the Chinese warned that the Russian Security Council had approved Russia's ten-year aerospace development plan for 2001-2010. The program includes the following goals: 1) to manufacture and enhance existing dual-use satellites; 2) to develop and launch new Earth atmosphere and maritime observation satellites, military reconnaissance and navigation satellites; and 3) to explore both Mars and the moon. All of these Russian objectives are said to be tailored precisely to break the U.S. outer space monopoly. "The prelude of the race to win 21st-century space dominance," said the Chinese, "has begun."[76]

SPACE TECHNOLOGIES

General-Major V. Starukhin, then Chief of the Operations Directorate of the Russian Military Space Troops, has described both the offensive and defensive systems that operate in the three-tiered "space theater of war":[77]

- ***Airspace Tier:*** Constitutes the area from the Earth's surface up to altitudes of about 20-30 km
  - ***Operative Offensive Systems:*** Include 1) operational-tactical, tactical ballistic, and aeroballistic missiles; 2) air-, sea-, and ground-based cruise missiles; 3) guided missiles of various classes; and 4) airplanes, helicopters, and unmanned aerial vehicles
  - ***Operative Defensive Systems:*** Include 1) weapons of the Radiotechnical (Radar) Troops; and 2) SAMs of the Air Force, Navy, and Ground Troops

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[76] Wei Qiyong, Qin Zhijin, and Liu Erxun, "Analysis of Changing Emphasis," 1-4.

[77] General-Major V. Starukhin, "Once Again on the Problem of Aerospace Defense: Its Solution Lies Not in Organizational Unification, But in the Improvement of Interaction," *Voenno-promyshlennyi kuryer*, 31 March 2004 (hereafter cited as *VPK*).

- ***"Boundary" Tier:*** Constitutes the area from 30-100 km above the Earth's surface ("through outer space")
  - ***Operative Offensive Systems:*** Strategic ballistic missiles
  - ***Operative Defensive Systems:*** Include 1) information-reconnaissance systems, 2) missile-attack warning systems, and 3) strategic missile defense weapon systems
- ***Outer Space Tier:*** Constitutes the area above 100-120 km from the Earth's surface ("in outer space")
  - ***Operative Offensive Systems:*** Include weapons for destroying orbital groupings of satellites
  - ***Operative Defensive Systems:*** Include outer space monitoring systems for conducting information–reconnaissance operations in space

HYPERSONIC TECHNOLOGIES

Along with numerous other senior Russian military officials, General Starukhin stresses the escalating threat from U.S. development of those hypersonic technologies required to design hypersonic flying craft capable of operating at speeds ranging from Mach 5 to Mach 25 in the altitude range of 30-120 km, which is poorly monitored by the air defense system. These systems promise to be capable of attaining intercontinental ranges with a flight time comparable to that of strategic ballistic missiles.

General Starukhin also categorizes these U.S. projects according to his three-tiered "aerospace realm":

- ***AirspaceTier:*** Hypersonic airplanes and cruise missiles are operational-tactical aerial vehicles and targets for counteraction by battlefield air defense and missile defense systems.
- ***"Boundary" Tier:*** Strategic missiles are typically targets for counteraction by strategic missile defense systems. But hypersonic strategic missiles with

maneuverable (gliding) reentry vehicles differ from them in their flight features: traveling on ballistic trajectories near the upper limits of the atmosphere and using a lift-to-drag ratio for defensive maneuvering against strategic missile defense systems.

- ***Outer Space Tier:*** Hypersonic orbital and aerospace aircraft are essentially a new generation of space vehicle. Their flight occurs mainly in outer space on the orbits of man-made Earth satellites. They differ from conventional space vehicles (space missiles and satellites) not in their vertical launch and descent on a ballistic trajectory, rather in their use of the lift-to-drag ratio for takeoff and landing in the lower tiers of the atmosphere.

Virtually all countries involved in space activity are developing reusable hypersonic space airframes. The Russians delineate three basic technical concepts for such systems:[78]

- Space missile systems with vertical launch by a launch vehicle and horizontal (aircraft) landing for the recoverable craft;
- Space aviation systems with sub- or supersonic aircraft platforms used as the first stage, and a hypersonic aircraft that reaches space orbit and follows an aerodynamic trajectory when returning to Earth as the second stage; and
- Aerospace systems in the form of a single-stage aircraft with horizontal takeoff and landing, equipped with a combined power plant based on air-breathing engines.

A possible employment of hypersonic technologies developed on the bases of the Ajax concept could include:

[78] Interview with Leninets Holding Company President and General Designer Anatoliy Turchak by Mikhail Tulyev, "The New Defense Developments of the Leninets Holding Company," *VPK*, 19 May 2004.

- Destruction of spacecraft (reconnaissance, communications, navigational, etc.);
- Use of hypersonic cruise missiles virtually invisible to air defenses, including missiles launched from hypersonic airframes; and
- An order-of-magnitude increase in combat mobility with the use of hypersonic transport aircraft, etc.

LASER TECHNOLOGIES

In the late 1980s, Soviet military experts identified the "new types of offensive weapons—space strike weapons"—that could be used to conduct strategic operations. They included laser, particle beam, kinetic, electromagnetic pulse, and nuclear weapons, which were said to possess great destructive power and the capability to quickly and selectively destroy space and terrestrial targets at global ranges.[79] According to Russian military officials, the creation of these systems would enhance the combat efficiency of the Russian Armed Forces by 50-100 percent.[80]

In discussing "space strike weapons," Russian experts have stressed the use of space-based lasers as one of the means of attacking the opponent's strategic offensive forces, strategic defense complexes, and energy and transportation networks. According to military authors, "American specialists" believe that only in space is it possible to realize most fully the main potential advantage of laser weaponry—the super fast, highly directed propagation of the kill energy over large distances.[81]

According to Russian space experts, ***"the development of space-based lasers is comparable to the birth of nuclear weapons. Whoever possesses them first could***

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[79] For example, Yu. V. Lebedev and A.I. Podberezkin, *Voenno-strategicheskiy paritet: dve pozitsii* (Moscow: Voenizdat, 1990): 70.

[80] Interview with Colonel-General A. Maksimov, "A Portrait in Light of *Glasnost'*: The Logic of Large Numbers," *Krasnaya zvezda*, 29 July 1989 (hereafter cited as *KZ*).

[81] Lieutenant Colonels I. Ivanov and I. Chekanov, "Laser Weapons in Space," *Tekhnika i vooruzhenie*, no. 1 (1990): 8.

dictate their terms to the world community." Space-based lasers are said to be capable of striking "all targets" at global ranges instantaneously.

According to Russian military writings, space-based lasers can be moderately effective against soft ground-based targets, such as mobile ICBMs, which could be attacked almost instantaneously. Their effectiveness would increase substantially against targets at higher altitudes, such as strategic bombers and airborne command centers. Space-based lasers will also be capable against ballistic missile early-warning satellites and soft ground-based C^3I targets. Experts conclude that space-based kinetic energy weapons and particle beam weapons can be used effectively against early warning satellites that detect the opponent's ICBM launches, giving these weapons a modest capability against the opponent's C^3I network.[82]

Russian military experts also argue that space-based electromagnetic pulse (EMP) weapons will accomplish strategic missions similar to those of lasers. Unlike lasers, the effects of EMP weapons are not dissipated by atmospheric conditions, and will be effective against targets at any altitude.[83] Primary targets for space-based EMP weapons will be aircraft (ground-based and in flight), and C^3I assets that have not been hardened against EMP effects (early warning radars). According to the Russians, EMP weapons might be especially effective against mobile ICBMs. EMP attacks would be virtually instantaneous, and the area of an EMP beam would be hundreds of meters in width, thus greatly reducing the necessity for determining the exact location of mobile targets.

The Russians also envision the development and deployment of space-based nuclear missiles as part of the next stage in the RMA. Military experts note that a space-based nuclear missile or reentry vehicle would be small and lightweight and would make detection or verification impossible. Furthermore, a space-based nuclear reentry vehicle

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[82] For example, see D. Bel'skiy, "Lasers in Orbit?" *Kommunist vooruzhennykh sil*, no. 7 (1990): 53 (hereafter cited as *KVS*).

[83] Ye. Velikhov et al., *Weaponry in Space: The Dilemma of Security* (Moscow: Mir Publishing, 1987): 69-77.

would take only "a minute or so to reach its ground target."[84] Space-based reentry vehicles would be highly effective against softer, time-urgent targets, and moderately effective against aircraft in flight. Priority targets for space-based reentry vehicles could include airfields, unhardened C^3 assets, and mobile ICBMs.

Russian military theorists assert that the primary advantage of these new space-based systems over ground-based missiles is *time*.[85] ICBMs, for example, would still require twenty to thirty minutes to reach their targets, while space-based nuclear reentry vehicles would require only several minutes. Attacks by space-based directed-energy weapons would be almost instantaneous. Military experts state that, in the opinion of "American specialists," space-based lasers ensure the simultaneous destruction from all directions of a large number of targets with an extremely simple targeting system.

The Russians note two basic directions of development for space-based lasers: 1) mobile units for executing tactical missions, and 2) ABM complexes based on chemical lasers. Space-based lasers are capable of disrupting the operations of navigation systems, television broadcasting, and communications; of effectively defending against enemy missile strikes; and of destroying enemy satellites. The Chinese are said to be interested in the latest Russian laser developments. According to Russian experts, "any state will be able to control all of near-Earth space with 3-4 space-based laser platforms."[86]

The Russian military argues that the new start for NMD has inevitably revived the old fears that large-scale R&D on developing defensive weapons will give a strong impetus also to the development of their technical doubles—offensive space weapons: ASAT systems and "space-to-Earth" systems.

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[84] Ibid.

[85] For example, see D. Bel'skiy, "Lasers," 52.

[86] Ibid.

SPACE WARFARE

The Soviet military studied the use of military space systems for several decades. By 1986, the *Military Encyclopedic Dictionary* stated that space now constitutes a theater of military operations (TMO).[87] Such an organization is essentially a C^2 structure, and the designation of a command implies the existence of a force under it. In a 1990 article discussing the need for a "radical renewal" of Soviet force structure, General-Major V. Ivanov referred to the possession by the Soviets of "space weapons," "Space Troops," and "Space Defense Troops."[88]

The designation of space as a TMO was a logical outgrowth of the Soviet military's analysis of major trends in future warfare. In 1985, for example, General-Major Vorob'yev pointed to the current RMA and noted that as cutting-edge weapons are perfected, they will expand the spatial and vertical dimensions of warfare to the point where first low space and then higher altitudes become a theater of war.[89]

In addition, the emergence of space as a TMO proceeded from Soviet insistence on the integration of space forces with land and sea theater forces. According to General Staff analyses, the emergence of space forces and operations thus proceeded from "a natural expansion in the sphere of deploying strategic forces into space and the acquisition of effective potentials for conducting combat actions in space and from space to Earth."[90]

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[87] MSU S. F. Akhromeev, *Voennyi entsiklopedicheskiy slovar'* , 732.

[88] General-Major V. Ivanov, "Radical Renewal, But Not 'Cosmetic Repair,' " *KVS*, no. 15 (1990): 16-17.

[89] *KZ*, 15 September 1985.

[90] V. G. Glebovich, "Anti-Satellite Weapons in U.S. Military Strategy," *Voennaya mysl'*, no. 10 (1991): 71-73 (hereafter cited as *VM*).

The Russians single out two possible theaters of military operations in outer space: the near-Earth theater and the lunar theater.[91] The near-Earth space theater of military operations (Ne Sp TMO) comprises outer space within 100 km to 40,000 km from Earth, plus regions of dry land and the World Ocean in which forces and assets for the launch, control, and functioning support of orbital groups are deployed. At the present time, it represents the greatest interest because it spans all of the ground-based warfare spheres, and military operations on it are connected with the Earth to the maximum extent. The four specific regions of the Ne Sp TMO have both advantages and drawbacks.[92]

The principal advantages of the first Ne Sp TMO region are 1) minimal power consumption in orbiting; 2) high speed of surveying the Earth owing to the minimal orbit period; 3) comparative ease of detection, interception, and destruction of delivery vehicles and their payloads (ICBMs, warheads, orbiter); 4) high speed of engagement of ground-based targets from outer space using other than beam weapons; and 5) low radio-emission power required for the conduct of electronic warfare.

The principal drawbacks are 1) greater (in comparison with the other Ne Sp TMO regions) inputs of energy for maneuvering, which greatly reduces the opportunity of spatial maneuver by orbiters; 2) comparative ease of detection and interception of orbiters by ground-based assets; and 3) necessity of a great number of orbiters for continuous surveillance of the Earth and performance of combat missions.

As for the other three Ne Sp TMO regions, their probable advantages are 1) the practically unlimited time that orbiters can remain in their assigned orbits, 2) the reduction of energy input for maneuvering as their altitudes increase, and 3) the lesser number of orbiters required for building a global Earth surveillance system. The main

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[91] General-Major V. A. Men'shikov, "Space Orbital Groupings in the Context of Reforming the RF Armed Forces," *VM*, no. 6 (1999): 11-16.

[92] General-Major M. A. Borchev, "Outer Space: Possible Warfare Sphere," *VM*, no. 3 (1998): 20-26.

drawbacks consist of 1) greater inputs of energy for the insertion of orbiters into their orbits and 2) increased time for the delivery of weapons to ground-based targets.

The lunar space theater of military operations has been studied less and is yet to be mastered. It encompasses the sphere of outer space between the altitudes of 300,000 km and 450,000 km and provides an opportunity to establish bases on the moon and the 4th and 5th liberation points.

Based on Desert Storm (and Allied Force), General-Major V.I. Slipchenko articulated the concept of "Noncontact Wars" (NCW). These are characterized by "a global scope on a planetary scale," [*sic*] with the main military operations conducted in the aerospace. They are based on the use of reconnaissance-strike combat systems in air-space-sea strike operations, which creates a coordinated field common to all strategic strike and strategic defensive forces.[93]

The primary targets of space strike weapons are said to include:[94]

- Stationary centers of state management, command, control, and communications;
- Airfields of strategic aviation and stationary nonnuclear missile complexes deep inside the country;
- State-owned mass media, communications, radio and television;
- State and local power supply systems;
- Plants manufacturing PGMs and their storage facilities;
- Other enterprises of the military-industrial complex with no connection to nuclear technologies;
- Oil refineries and storage facilities for fuel and lubricants;
- Main petroleum and natural gas pipelines;
- Chemical and biological weapons research centers, etc.

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[93] General-Major V. I. Slipchenko, *Non-Contact Wars* (Moscow: Gran-Press, 2001): 57-102 (hereafter cited as *NCW*).

[94] Ibid.

According to Slipchenko, NCW permit a "bloodless victory" with no need for the seizure and occupation of territory—thereby "liberating man from the battlefield." Space warfare constitutes "*the ultimate noncontact war.*" It is almost impossible to achieve aerospace superiority if satellites are disabled, say the Russians, and the side that loses it "is doomed to defeat."

SPACE INFORMATION WARFARE

Russian military scientists stress that IW missions are accomplished most effectively by using space-based assets. Space systems can be used to irradiate ground and airborne targets with extremely high power—which, in turn, can be used to launch computer viruses in various C^3 systems, including so-called sleeper viruses introduced to computers in advance and activated on command.

Energy-information effects, including those produced from satellites, are dangerous because they initiate processes whose energy exceeds that of the information message by many orders of magnitude. Explosive-filled robots can be mobilized, air and missile defense systems can be placed in combat readiness, and aircraft can be scrambled, etc., by a purposeful energy-information effect. It is therefore possible to forecast the use of satellites and other space systems as information weapons for energy-information effects. The creation of a global system for controlling human behavior in any locality, city, or region will give "an aggressor" local and global superiority in accomplishing missions on a global scale and will "open the doors to world domination."[95]

SPACE ELECTRONIC WARFARE

According to Russian experts, significant contemporary achievements in the sphere of physics and the equipment of ultrapowerful generators of electromagnetic energy constitute the basis for developing microwave functional kill weapons, with a pulse emission output from tens of gigawatts to tens of terawatts. Based upon this

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[95] A. Fedorov and V. Tsygichko, eds., *Information Challenges to National and International Security* (Moscow: PIR Center, 2001): 69-109.

parameter, microwave weapons approximate the electromagnetic interference (EMI) of nuclear detonations: the effectiveness of their employment against electronic equipment thus reaches the level of nuclear weapons. As a result, both foreign and Russian weapons designers are working intensively to implement their military application.[96]

Currently, say the Russians, the two sources of powerful radiation that possess the greatest technical readiness for employment as functional kill weapons are 1) electronic generators of super-high frequency pulse emissions (SHF generators) with a carrier frequency and 2) pulse emitters of ultrashort pulses (video pulses) without an SHF carrier frequency. Due to their ultrashort pulse emission, the latter possess an ultrawide bandwidth and high spectral energy density. Based on their energy effectiveness, video pulse generators currently approximate SHF generators and can also surpass them in the multipulse cyclical generation modes. While the energy parameters of the electronic emitters approach the EMI of a nuclear detonation, a significantly higher frequency range, compactness, emission manageability, and, above all, ecological friendliness work to their indisputable advantage.

Owing to their use of SHF electromagnetic interference to destroy targets that contain electronic equipment, the Russians classify these systems as "SHF weapon complexes." The electronic equipment of the GLONASS navigation system could prove to be the most vulnerable. As a result, GLONASS ground-based receiver equipment—which constitutes a critical structural element in mobile electronic complexes—urgently requires the development of electronic countermeasures.

ANTIMISSILE WARFARE

In April 1993, Russian military and scientific spokesmen began to publicize the existence of "plasma weapons," which "can hit any object moving in the Earth's atmosphere—be it a missile, a warhead, an aircraft, or some other artificial or natural heavenly body such as a meteorite." This is accomplished using an existing

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[96] V. V. Zorin, D. K. Bystritskiy, and A. E. Bagramov, "The Distinctive Features of the Functional Vulnerability of Modern Electronic Systems," *Strategicheskaya stabil'nost'*, 16 March 2004.

technological base without putting any components into space and using the kinetic energy of the object itself, which is intercepted electronically by a plasmoid created by facilities on the ground—microwave or optical (laser) generators, and antennae and other systems.[97]

The energy directed by the Earth-based components of the gun is focused not on the target itself but on its flight path in the area of the atmosphere directly ahead of it. It ionizes that area of the atmosphere and totally upsets the aerodynamics of the missile or aircraft. The object leaves its trajectory and is destroyed by enormous stresses. It is virtually impossible to counter this effect of terrestrial energy. In addition, it is possible for the first time to combine in a single unit radar observation systems and systems for the electronic delivery of the plasmoid—the kill mechanism—to the target at the speed of light. This makes the plasmoid a "virtually invulnerable weapon providing guaranteed protection against any attack from space or the upper or lower strata of the atmosphere."

In February 2004, the Russian press began to claim that the Russian military had developed a "revolutionary" new warhead deemed to constitute "the Death Knell" for the U.S. NMD system. According to then Deputy Chief of the Russian General Staff Yu. Baluyevskiy, the recent testing of a fundamentally new warhead for the Topol ICBM "confirmed that we can create weapons that will render the missile defense system ineffective." He added that "an aerial vehicle of a future system" that is "capable of flying not only on a ballistic trajectory at hypersonic speed but also can overcome all existing and also future missile defense systems" was launched during the same exercises.[98]

The novel feature of the new warhead—which could enter service with the Russian Strategic Nuclear Forces as early as 2008—consists in its hypersonic engines, which permit it to maneuver at a speed of Mach 6 during the final section of its flight

[97] "Joint Testing of 'Plasma Weapon' Proposed with U.S.," in FBIS-SOV-93-065, 7 April 1993.
[98] Cited in Fedor Rumyantsev and Yelena Shiskunova, "Russian Missile Breaks Through U.S. Missile Defense System," *Gazeta*, 19 February 2004.

trajectory. This maneuver can be conducted repeatedly because the warhead's engines can be activated alternately. Since the hypersonic engines are capable of swiftly changing the warhead's trajectory to a totally different target, all attempts at interception become pointless. According to the Russians, existing computer systems are simply not capable of computing the flight trajectories of such a target in real time—for at least another 30 years, according to the most optimistic estimates by "Russia's potential enemies."

According to General-Major V. Belous, studies have demonstrated that "asymmetrical measures" against the U.S. NMD system are preferable for Russia in terms of cost-effectiveness. The spectrum of possible countermeasures could include the following three directions:[99]

- ***Improvement of Strategic Offensive Arms to Penetrate the NMD System:*** Equipping missiles with penetration aids is both effective and economical.

- ***Innovative Methods of Employing Strategic Offensive Arms:*** A combined launch of combat and decoy missiles with shallow flight trajectories dramatically impedes their detection and interception.

- ***Combat Means and Methods of Delivering Strikes against Enemy Missile Defense System Facilities:*** Space- and ground-based facilities of the information-reconnaissance system are especially vulnerable. For example, if a large nuclear charge were to be detonated at an altitude of hundreds of kilometers above the U.S. geographic center (Nebraska), then a powerful electromagnetic pulse would disable the entire country's electronic and power systems for a certain period of time.

General Belous has also stated that the Topol-M intercontinental ballistic missiles are "almost invulnerable" to any existing and future missile defense system. The exotic

[99] General-Major V. Belous, "The Answering Move: How Can the American 'Star Wars' Be Nullified?" *Trud*, 22 December 2004.

air- and space-based laser weapons that the United States plans to deploy in 2008 "are not that simple to operate, and they also require some time to be armed."[100]

According to R. Sagdeyev of the Russian Academy of Sciences, "anyone possessing ground-based interceptors of an NMD system will also possess the prototype of a ground-based antisatellite system." Should the United States deploy the NMD system, he warns, China or Russia may choose to do the same.[101]

SPACE OPERATIONS: "SYSTEMS OF SYSTEMS"

The Russians argue that reconnaissance-strike combat systems (RSCS) transform warfare into a process wherein complex organizational-technical systems—"systems of systems"—mutually influence each other.[102] "These military systems of systems will henceforth be operating in place of all traditional weapons, concepts, and organizational formations: Wars of the not-too-distant future will be wars without soldiers."[103]

According to Russian experts, the main forms of noncontact warfare will be air-space-sea strike and defensive operations. Strike operations will be conducted not by Air Force and Navy groupings, but by RSCS created on their basis—***"where a space-based infrastructure will be the system-forming element."***[104]

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[100] General-Major V. Belous, in *Agentstvo voennykh novostey*, 1 March 2005 (hereafter cited as *AVN*).

[101] Cited in Moscow *Interfax*, 24 January 2005.

[102] General-Lieutenant V. A. Sapozhinskiy and Colonel Yu. N. Fesenko, "Effective Engagement of the Enemy in Operations: Operational Objective or Creation of Conditions for Success in Close-Range Combat?" *VM*, no. 3 (1999): 56-62.

[103] V. V. Kruglov, *Future Warfare* (Moscow: Military Academy of Strategic Missile Troops, 1999), book cover, and V. V. Kruglov, *The System of the Laws of Warfare: Composition, Structure, Characteristics, and Mathematical Concepts* (Moscow: Military Academy of Strategic Missile Troops, 1998): 51.

[104] V. Slipchenko, "The Infantry is Withdrawing into the Past: Russia Needs a New Army—the State and Armed Forces Must Be Readied for Future, Not Past Wars," *Nezavisimoe voennoe obozrenie*, 5 September 2003 (hereafter cited as *NVO*).

Since their emergence, high-precision weapons portended the ultimate integration of various means of warfare into RSCS. They represent the aggregate of functionally interconnected means of intelligence collection, software, command and control, delivery, and destruction. The sophistication of RSCS presents no obstacle to their immediate use in war.

Russian military futurologists predict that between 2020 and 2040, the strategic air-space-sea strike operation will be conducted by RSCS. The first stage (10-15 days) will consist of massive strikes to destroy enemy retaliatory-strike assets, the most important military and military-economic installations, state/military command-and-control systems, and air/missile defense assets, in order to seize the initiative in war. The second stage (20-75 or more days) will consist of massive strikes by space-, air-, and sea-based PGMs and weapons based on new physical principles to complete destruction of the enemy's economic potential and state/military command-and-control systems—essentially achieving both the strategic and political objectives of war.

RSCS are capable of detecting and destroying stationary radio-frequency-emitting and heat-emitting military targets and economic installations, ground elements of air-space-sea defense assets, and radar-emitting sources to the full depth of enemy territory: this changes the content and nature of war. RSCS—not masses of troops (forces)—will clash in noncontact wars. Their capabilities are characterized not by quantitative and qualitative superiority, but by structural and organizational factors, unity and effectiveness of command and control, and quality/functioning of intelligence collection, communications and navigation systems, and other components in comprehensive support of operations. After 2020, RSCS with space-based platforms may be created covertly in advance as dual-purpose systems, all of which can be targeted preliminarily or at the necessary point in time against the most important stationary civilian and military installations.

The Russians also project certain new features of RSCS between 2007 and 2010. The newest radar intelligence collection spacecraft will be capable of obtaining terrain images with a resolution of several tens of centimeters in darkness and with dense clouds. The newest optical intelligence collection satellite equipment will have a resolution of 10-15 cm, which will provide a detailed, continuous daylight survey of the entire Earth's surface and all economic installations of countries in a single day. The information of space intelligence collection assets will be transmitted via relay and communications satellites to ground control centers, and images/intelligence will be dispatched directly to ground, air, and sea command posts, forces, and assets of RSCS and will become the basis for planning massive high-precision strikes in strategic air-space-sea strike operations.

Russian military futurologists characterize armed conflict of the future by the indices of space and time and the information continuum. As regards space, an armed conflict can be waged at any point on the planet. It will comprise the sum of simultaneous and sequential strikes primarily from the aerospace sphere, delivered selectively against the most important, discrete targets. The result will be that continuous fronts will disappear on the ground but appear in the air. Hence, armed confrontation will become focal and zonal.[105]

The main forms of military operations in the near-Earth space can be as follows: action to engage strategic nuclear or conventional systems in flight and blocking outer space; action to engage orbital and ground space groupings to capture and hold strategically (operationally) important near-Earth space areas; action to suppress EW systems of orbital and ground-based space groupings; and strikes from space on ground, sea, and airborne targets.[106]

Space strikes with laser and electromagnetic pulse weapons can pose a special threat in the event of a surprise outbreak of hostilities, when command posts are blinded, airfields and launching positions are paralyzed, and the capability to organize retaliation is impaired. According to the Russians, strikes can be delivered from outer space by

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[105] Colonel V. V. Kruglov, "On Future Armed Conflict," *VM*, no. 5 (1998): 54-58.

[106] For example, see General-Major M. A. Borchev, "Outer Space: Possible Warfare Sphere," *VM*, no. 3 (1998): 20-26.

"super new weapons of mass destruction capable of paralyzing command and control of a state or coalition of states and groupings of its (their) armed forces for a certain period of time, or attaining a mass effect on the country's population without destroying installations and the environment."

In the wake of Iraqi Freedom, General-Major V. Men'shikov asserted that "foreign specialists" believe that ***"the achievement of space control and the delivery of strikes from space are inevitable"*** (Men'shikov's emphasis). In the future, it will be entirely possible to destroy not only the enemy's space-based assets, but also to deliver strikes from space on ships, aircraft, ground targets, and warheads in flight.

In addition, weapons developed on the basis of information and nonlethal technologies can be deployed on space assets and should ensure a continuous and periodic "mass effect" on selected regions in order to demoralize the population, etc. at a designated time. ***"The possibility of accomplishing these tasks from space has engendered qualitative and quantitative changes in both the forms and methods of conducting combat actions and the organization of warfare as a whole"*** (Men'shikov's emphasis).

Russian military scientists continue to assert that the "Space Epoch" requires a colossal change in military-strategic thinking. The Russian Military Space Troops, for example, have already retired the concept of a space "theater of military operations" (TMO). Russia now views space as a "theater of global war."[107]

INTEGRATED AIR-AND-SPACE OPERATIONS

In early 2005, General-Lieutenant G.P. Kupriyanov examined the basic trends in the evolution of aerospace warfare. Because the air space so closely abuts outer space with no distinct border between the two, they constitute together a single air space / outer space (ASOS). The concept of "space warfare" thus comprises actions based in the

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[107] V. V. Baskakov, "The Space Troops as the Guarantee of the Country's Defense: The Geopolitical Situation in the World Requires the Creation of a New Branch of the Armed Forces in Russia," *NVO*, 1 October 2004.

ASOS or passing through it, and the assets employed there can be classified as the military space component (MSC) of the Russian Armed Forces.[108]

The development of advanced weapon systems is proceeding primarily in the direction of employing weapons based on "new physical principles" (NPPs): information weapons and laser, photon, infrasonic, and super-high-frequency radiation—whose application is most effective from space-based platforms. The current trend toward priority development of long-range PGMs and weapons based on NPPs—whose casualty-and-damage effects approximate those of tactical nuclear weapons—portends a critical impact on future space warfare. The impending emergence of intercontinental space aircraft and unmanned aerial vehicles will dramatically expand the potential of military space assets on a global scale.

Owing to the vulnerability of industrial installations to ASOS strikes by these systems, the enemy's main objective in future military operations will be not the destruction of personnel or the routing of forces but the destruction of vital military and civilian production complexes in order to undermine a country's economy as a whole. Armed forces will then be bereft of state technical and logistical support, thus losing a critical degree of their operational effectiveness. Priority targets will include information centers and related assets, air defense and air force assets, and retaliation systems.

Success in space warfare will depend largely on information dominance. Electronic weapons can be employed not only against enemy weapon systems but also directly for jamming and suppressing information and command-and-control systems, which yields "bloodless" warfare. The fast-flowing and three-dimensional situation in space, coupled with the time pressure, mandates the creation of a common information space—and above all for ASOS operations. The continually expanding range of missions and spatial scope of action will decisively influence the modes of employing large MSC strategic formations, combined-arms units, and units—i.e., the evolution of the theory, strategy, and operational art of the Russian Armed Forces.

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[108] General-Lieutenant G. P. Kupriyanov, "Basic Trends in the Evolution of the Forms of Warfare in the Aerospace Sphere," *VM*, no. 1 (2005): 12-17.

The most expedient form of conventional strategic action by the Russian Armed Forces in the ASOS will be a strategic air/space operation. It is strategic because in the course of employing modern—and in the future even more effective—weapon systems, strategic objectives can be attained. It is an air/space operation because the methods of conducting it have an essentially air/space character.

In describing this operation, the attribute "space" does not literally mean conducting all combat actions from or via space. While Russian military scientists do not rule out such an operation in the near term, they tend to view 2015-2020 as the most likely timeframe. But the strategic air/space operation also presupposes actions by Russian military space forces and assets (reconnaissance, command and control, navigation, communications, etc.) without which effective engagement of the enemy is impossible—especially one armed with reconnaissance-strike complexes.

General V. Mikhailov, then CINC of the Russian Air Force, warned in March 2007 that, by 2015, airspace and outer space will become a single sphere of armed combat.[109]

[109] *AVN* (Internet Version), 5 March 2007.