Center for Strategic and Budgetary Assessments

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The Maturing Revolution in Military Affairs

By Barry D. Watts

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Acknowledgments

The impetus for this report came from Andy Marshall's renewed interest in recent years in how the maturing precision-strike regime may alter war's conduct by 2030 to 2040. While most observers had lost interest in the revolution in military affairs by 2002 or 2003, Marshall recognized that the maturation of information-enabled precision strike had not been unfolding as most observers had anticipated in the mid to late 1990s. By the early 2000s the United States was the only nation that had developed long-range reconnaissance strike complexes with global reach, although the Chinese were certainly working toward these sorts of capabilities in the western Pacific. By 2007 Marshall was encouraging the defense analytic community to take a fresh look at the maturing precision-strike regime. This paper is one result of Marshall's renewed interest in how information-enabled precision strike is likely to change war's conduct in coming decades.

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About the Author

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CHAPTER 1 > **OVERVIEW**

In 1992, the Office of Net Assessment (ONA), Office of the Secretary of Defense, began circulating an assessment of a prospective late-twentieth-century military-technical revolution (MTR). Soviet military theorists had been discussing the possibility of a third twentieth-century revolution in military affairs (RMA) since the mid-1970s.[1] Written by (then Army Lieutenant Colonel) Andrew F. Krepinevich, ONA's MTR assessment sought to explore the hypothesis that Soviet theorists were right in predicting that advances in precision munitions, wide-area sensors, and computerized command and control (C2) would bring about fundamental changes in the conduct of war.[2] As Marshal Nikolai Ogarkov, then chief of the Soviet General Staff, observed in 1984, these developments in non-nuclear means of destruction promise to "make it possible to sharply increase (by at least an order of magnitude) the destructive potential of conventional weapons, bringing them closer, so to speak, to weapons of mass destruction in terms of effectiveness."[3] The Soviets introduced the term "reconnaissance-strike

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1 According to Soviet theorists, the first twentieth-century MTR was precipitated by the advent of motorization, the airplane, and chemical weapons during the First World War (William E. Odom, "Soviet Military Doctrine," *Foreign Affairs*, Winter 1988/89, pp. 120–121). The maturation of this MTR was manifested in the Second World War with *Blitzkrieg* (mobile armored operations) based on the tank and the Panzer division, strategic bombardment as epitomized by the Anglo-American Combined Bomber Offensive against Germany, and the displacement of battleships by aircraft carriers in naval warfare. The second twentieth-century MTR was triggered by the development of ballistic missiles and atomic weapons at the end of World War II. It reached maturity in the early 1970s when the Soviets achieved rough nuclear parity with the United States.

2 See Andrew F. Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," Center for Strategic and Budgetary Assessments, 2002, pp. 1, 3 (available online at http://www.csbaonline.org/4Publications/Archive/R.20021002.MTR/R.20021002.MTR.pdf). This published version of the 1992 ONA MTR paper contains reflections by Marshall and Krepinevich.

3 Marshal N. V. Ogarkov, "The Defense of Socialism: Experience of History and the Present Day," *Красная Звезда [Red Star]*, May 9, 1984; trans. Foreign Broadcast Information Service, *Daily Report: Soviet Union*, Vol. III, No. 091, Annex No. 054, May 9, 1984, p. R19.

complex" (or "RUK" from the Russian Рекогносцировочно-ударный комплекс) to describe the integration of missiles with precision-guided sub-munitions, area sensors such as the airborne Pave Mover SAR/MTI (synthetic-aperture radar/moving-target-indicator) radar, and automated C2.[4]

By 1987, Andrew Marshall, the Pentagon's Director of Net Assessment, had concluded that the Soviets were correct in their judgment that these new technologies would not merely make current forces marginally better in fighting with existing operational concepts and organizations, but would revolutionize war's conduct.[5] In late January 1991, with Operation Desert Storm underway and mounting evidence of the efficacy of "stealthy" F-117s and F-111Fs delivering laser-guided bombs (LGBs) against key Iraqi targets, Marshall asked Krepinevich to undertake what became the 1992 MTR assessment.[6] Krepinevich had originally been hired by Marshall to work on the military balance in Europe between North Atlantic Treaty Organization (NATO) and Warsaw Pact forces. But with the tearing down of Berlin Wall in November 1989, German reunification in October 1990, and serious negotiations between George H. W. Bush's administration and the Soviet leadership under Mikhail Gorbachev on reducing conventional forces in Europe, further work on this assessment had obviously been overtaken by events.

ONA's 1992 MTR assessment precipitated the debate within the U.S. national security establishment during the 1990s over the RMA and, later, over defense transformation. In time, discussion of the RMA and transformation spread overseas. In the case of NATO, the institutional manifestation of this ongoing debate is the Allied Command Transformation organization, created in 2003 to lead the military transformation of alliance forces and capabilities using new operational concepts and doctrines.[7]

What kind of transformation did the MTR assessment and ONA anticipate? As early as the summer of 1993, Marshall was suggesting that one plausible way in which warfare might change was that long-range precision strike would become "the dominant operational approach."[8] The other idea about how warfare might change was the emergence of "what might be called information warfare."[9] Starting in July 1993, Marshall also began substituting the term "revolution in

4 The Russians used the term reconnaissance-fire complex (рекогносцировочно-огневой комплекс) when they were thinking about precision strike using short-range weapons such as artillery.

5 A. W. Marshall, "Future Security Environment Working Group: Some Themes for Special Papers and Some Concerns," ONA memorandum for Fred Iklé, September 21, 1987, p. 2.

6 Krepinevich, Jr., "The Military-Technical Revolution," p. iii.

7 As of April 2010, General Stéphane Abrial, French Air Force, is NATO's Supreme Allied Commander, Transformation. His headquarters is collocated with the U.S. Joint Forces Command in Norfolk, Virginia.

8 Andrew W. Marshall, "Some Thoughts on Military Revolutions—Second Version," ONA memorandum for record, August 23, 1993, p. 3.

9 Marshall, "Some Thoughts on Military Revolutions—Second Version," p. 4.

military affairs" for "military-technical revolution" to emphasize his sense that while technological advances were making this particular MTR possible, the revolution itself would only be realized when new operational concepts had been developed and, in many cases, new military organizations had been created.[10] Contrary to the presumption of many observers, he thought that technology would be the least important element of a mature RMA predicated on precision strike.

What exactly is a revolution in military affairs? Building on his 1992 MTR assessment, Krepinevich argued in 1994 that an RMA is:

> what occurs when the application of new technologies into a significant number of military systems combines with innovative operational concepts and organizational adaptation in a way that fundamentally alters the character and conduct of conflict ... by producing a dramatic increase—often an order of magnitude or greater—in the combat potential and military effectiveness of armed forces.[11]

A decade later, Michael Vickers and Robert Martinage wrote that military revolutions "are periods of discontinuous change that render obsolete or subordinate existing means for conducting war."[12] Their characterization is very close to Richard Hundley's 1999 definition of an RMA as a paradigm shift in military operations that obsolesces one or more core competencies of a dominant player or creates one or more new core competencies.[13] In all these definitions, it is not the speed with which changes in war's conduct occur but their magnitude as reflected in the emergence of new operational concepts and organizations, thereby generating new military competencies or obsolescing earlier ones.[14]

By 2009, more than a decade and a half had passed since ONA's 1992 MTR assessment. Given the protracted nature and exigencies of ongoing conflicts in Iraq and Afghanistan, very few in the U.S. national-security establishment were giving much thought to RMAs and transformation during 2008 or 2009. For this reason, the time seemed ripe to take a fresh look at past progress and future

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10 A. W. Marshall, "Some Thoughts on Military Revolutions," ONA memorandum for record, July 27, 1993, p. 1.

11 Andrew F. Krepinevich, Jr., "Cavalry to Computer: The Pattern of Military Revolutions," *The National Interest*, Fall 1994, p. 30.

12 Michael G. Vickers and Robert C. Martinage, *The Revolution in War* (Washington, DC: Center for Strategic and Budgetary Assessments, December 2004), p. 2.

13 Richard O. Hundley, Past Revolutions, Future Transformations: What Can the History of Revolutions in Military Affairs Tell U.S. About Transforming the U.S. Military? (Santa Monica, CA: RAND, 1999), p. 9.

14 Krepinevich, Jr., "The Military-Technical Revolution: A Preliminary Assessment," p. 3. Not everyone agrees that these definitions suffice to characterize an RMA. Stephen Biddle, for instance, insists that all the definitions offered by RMA proponents fail to identify a single period of revolutionary change in war's conduct since 1918 (Stephen Biddle, "Military Power: A Reply," *The Journal of Strategic Studies*, June 2005, p. 457). To make this view more plausible, Biddle restricts his claim to conventional warfare, thereby avoiding the need to explain the atomic and thermonuclear revolutions that grew out of the Manhattan project.

prospects for changes in war's conduct fundamental enough to be considered revolutionary or a paradigm shift. Toward this end, in 2009 ONA sponsored a series of three workshops aimed at addressing the following questions:

> First, how much progress has the American military made since the early 1990s in exploiting the late-twentieth century revolution in military affairs foreseen by Soviet theorists since the mid-1970s?

> Second, what progress have other nations or competitors made in exploiting the RMA?

> Third, assuming one or more RMAs are in fact underway, will their further development or maturation necessitate major adjustments in military technology, weaponry, operational concepts, and organizational structures between now and 2050—particularly for the U.S. military?

CHAPTER 2 > METRICS FOR ASSESSING PROGRESS

The initial RMA workshop in March 2009 largely floundered over the first of the preceding questions: How much progress has the U.S. military made since 1992 in exploiting an emerging RMA precipitated by precision munitions, wide-area sensors, and computerized C2? Marshall had long used the interwar years 1918–1939 as a yardstick for estimating how much progress the U.S. Army, Navy, Marine Corps and Air Force had made in embracing new ways of fighting centered on the prospect of reconnaissance-strike complexes dueling one another from long distances. In 1993, for instance, he argued that the use of precision munitions, the stealthy F-117, and the Joint Surveillance and Target Attack Radar System (JSTARS) in the 1991 Persian Gulf War should be seen as something like the British Army's initial attempt to employ massed tanks to break through German lines and restore movement to the battlefield at Cambrai in November 1917: a "first trial of new technology and new ways of operating."[15] Using this temporal benchmark, the U.S. military Services in the early 1990s were, at best, on the threshold of a new warfare regime but still had a long way to go in mastering it. In the analogy to the military innovations of the 1920s and 1930s, Marshall felt that the American military in 1993 was "perhaps in 1922"—not yet fully able to foresee how war's conduct would change.[16]

Marshall's 1993 assessment that the American military was no further along than 1922 in the analogy to the interwar innovations such as *Blitzkrieg* and carrier aviation was not especially surprising. In 1993 American exploitation of emerging precision-strike capabilities was still immature. What precipitated controversy at

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15 Marshall, "Some Thoughts on Military Revolutions," p. 2. For a firsthand account of the British experiment with tanks at Cambrai, see Brevet-Colonel J. F. C. Fuller, *Tanks in the Great War 1914–1918* (New York: E. P. Dutton, 1920), pp. 140–153. British Mark IV tanks did initially break through German lines at Cambrai, but they were unable to hold the ground gained, much less exploit their breakthroughs as German Panzer units were able to do in France in May 1940.

16 Marshall, "Some Thoughts on Military Revolutions—Second Version," p. 3.

the March 2009 workshop about American progress to date was Marshall's insistence, a decade and a half later, that the American military Services had still not progressed beyond the equivalent of the late 1920s in the analogy to the period between the First and Second World Wars. Asked for his judgment on U.S. progress to date at a March 2008 conference on net assessment, he replied that the U.S. military was still "not at 1930."[17] Nor was Marshall at all inclined to revise this assessment after it was disputed at the March 2009 RMA workshop.

The most substantive argument advanced at the March workshop for thinking that the U.S. military Services have progressed much further than the late 1920s was based on their burgeoning use of precision munitions. The U.S. military, some workshop participants insisted, was already well down the road in making the transition from the unguided weapons regime that had dominated warfare since ancient times to the precision-strike era of guided weapons and battle networks that began emerging late in the Vietnam War. To give a sense of how far the U.S. military has progressed, in 1991 some 92 percent of the more than 230,000 munitions expended in the Operation Desert Storm air campaign were unguided; in 2003, total expenditures in the Operation Iraqi Freedom air campaign were less than 28,000 munitions, of which some 65 percent were guided and included both LGBs as well as all-weather Joint Direct Attack Munitions (JDAMs).[18] Moreover, harking back to the definition of an RMA as an order-of-magnitude increase in effectiveness, after Desert Storm a Defense Science Board task force estimated that precision-guided munitions were twelve to twenty times more effective than unguided ordnance on a per-target-killed basis.[19] Today the U.S. military is the world leader by far in non-nuclear precision strike. No other military has a comparable capability to bring non-nuclear precision weapons to bear at global distances within hours to a few days. In light of these developments, one workshop participant went so far as to argue that, in Marshall's analogy to 1918–1939, the American military had already progressed to the early 1960s.

Marshall did not buy this argument. His reason was that it depended on making the wrong choice of a metric or analytic measure for judging progress. Unquestionably the U.S. military has come a long way in embracing non-nuclear guided munitions since 1991. But like the German campaign in Poland in September 1939, the conflicts the U.S. military has fought in Afghanistan and Iraq have not been against major adversaries with comparable military capabilities. Against the Taliban, the Iraqi army, al Qaeda terrorists, Sunni and Shia

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17 Mie Augier and Barry D. Watts, "Conference Report on the Past, Present, and Future of Net Assessment," Center for Strategic and Budgetary Assessments, 2009, p. 227.

18 Barry D. Watts, *Six Decades of Guided Munitions and Battle Networks: Progress and Prospects* (Washington, DC: Center for Strategic and Budgetary Assessments, March 2007), p. 20.

19 Alexander H. Flax and John S. Foster, Jr., "Report of the Defense Science Board Task Force on Tactical Air Warfare," Office of the Under Secretary of Defense for Acquisition and Technology, November 1993, pp. 16–17.

insurgents, and various jihadist fighters from Iran and elsewhere in the Arab world, the increasing use of guided munitions by American forces has been less about new ways of fighting than about improving the efficiency and effectiveness of traditional methods and organizations. U.S. progress in embracing the precision-strike-based revolution in military affairs should be assessed in relation to capable adversaries with their own precision-strike capabilities rather than relative to opponents with third-rate military capabilities. Until the American military has undertaken the changes in weaponry, operational concepts and organizations needed to cope with an opponent possessing large numbers of guided munitions and effective targeting networks, what a mature precision-strike regime would look like is essentially unknowable. This point goes to the heart of Marshall's insistence that the American military is still not very far along in the precision-strike RMA. In hindsight, then, the disagreement at the March 2009 RMA workshop over U.S. progress to date in embracing the RMA was ultimately a disagreement over the proper choice of analytic measures.[20] Those who thought Marshall was wrong to argue that the American military was still not at 1930 in the analogy to 1918–1939 had, in his view, chosen the wrong metric.

[20] For the classic discussion of the difficulties of choosing analytic measures, see the section on the criterion problem in Charles J. Hitch and Roland N. McKean, *The Economics of Defense in the Nuclear Age* (Cambridge, MA: Harvard University Press, 1960), pp. 158–181.

CHAPTER 3 > **FOCUSING ON PRECISION STRIKE**

Marshall's early hope for the three RMA workshops in 2009 was that they would generate fresh, concrete answers to the question about the changes in war's conduct that a mature RMA might require. To unpack this issue a bit further: What significant changes in how wars are fought seem likely between now and 2050? How consequential might those changes be for the American military Services? And to what extent might other powers field weaponry, develop new operational concepts, or create new military organizations to exploit the unfolding RMA?

Over the course of the three workshops Marshall narrowed his emphasis from future war in general to the narrower issue of a maturing precision-strike regime. In 1996 Michael Vickers had produced a comprehensive vision of how war's conduct might change by 2015–2025.[21] Marshall's initial intention was to have the workshops update Vickers' 1996 forecast and extend it to mid-century. This goal proved too ambitious. By leaving the door open to everything from precision strike to cyberwar, bio- and nano-technologies, and directed energy, the insights on how war's future conduct might change remained too sweeping and lacking in detail to satisfy Marshall. So, by the third workshop, in December 2009, he expressly narrowed the focus to precision strike. From this perspective the key questions seemed to be:

> In what ways, and to what extent, might the proliferation of both long-range and short-range precision-strike capabilities alter war's conduct by mid-century?

> What other nations or groups besides the United States might exploit these capabilities and could they substantially reduce the U.S. lead?

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[21] A somewhat shorter version of Vickers' 1996 paper "The Revolution in Military Affairs and the Military Capabilities: Broadening the Planning Parameters of Future Conflict" was published the following year in Robert Pfaltzgraff and Richard Shultz (eds.), *War in the Information Age: New Challenges for U.S. Security Policy* (London: Brassey's, 1997), pp. 29–46.

> What are likely to be the key warfare areas in which it would be vital for the United States to preserve or create dominant positions in a maturing precision-strike regime?

In the early 1990s, after the 1992 MTR assessment was circulated, ONA began sponsoring a series of meetings, workshops and seminar-style war games aimed at helping the military Services think through the future of conventional warfare. A common assumption in those events—particularly the war games—was that both sides would possess long-range strike systems. Nonetheless, as already mentioned, U.S. conventional forces have not yet been confronted with the challenges of fighting within reach of enemy reconnaissance-strike complexes. Given the accelerating proliferation of guided munitions and targeting networks, however, the day when American forces will face enemy precision-strike systems is surely approaching. The Chinese have developed over-the-horizon (OTH) radars that can locate U.S. carrier battle groups well out to sea along with a variant of the Deng Feng-21 (DF-21) ballistic missile to attack the carrier itself.[22] Fixed installations such as Kadena Air Force Base on Okinawa are already within range of the DF-21.[23] Moreover, OTH radars and an anti-ship version of the DF-21 appear to be elements of a much broader effort by the People's Liberation Army (PLA) to prevent U.S. forces from basing or operating close to the Chinese mainland. As defense secretary Robert Gates observed in 2008, Chinese "investments in cyber and anti-satellite warfare, anti-air and anti-ship weaponry, submarines, and ballistic missiles could threaten America's primary means to project power and help allies in the Pacific," including U.S. bases, air and sea assets, and the networks that support them.[24] More recently, Admiral Robert Willard, commander of U.S. Pacific Command, disclosed that the Chinese were no longer merely trying to develop a conventional anti-ship ballistic missile (ASBM) based on the DF-21/CSS-5; they were actually testing the new weapon.[25]

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22 For the profile of a DF-21 variant with terminal homing to strike surface ships from a Chinese publication, see Office of the Secretary of Defense (OSD), "Military Power of the People's Republic of China," Annual Report to Congress, 2009, p. 21. For further discussion of Chinese target-acquisition and ship-attack capabilities, including OTH radars, see "Report: Chinese Develop Special 'Kill Weapon" to Destroy U.S. Aircraft Carriers," March 31, 2009, online at <https://www.usni.org/forthemedia/ChineseKillWeapon.asp>; Sean O'Connor, "OTH Radar and the ASBM Threat," November 11, 2008, online at <http://geimint.blogspot.com/2008/11/oth-radar-and-asbm-threat.html>; and Tony Capaccio, "China's New Missile May Create a "No-Go Zone' for U.S. Fleet," November 17, 2009, online at <http://www.bloomberg.com/apps/news?pid=20670001&sid=annrZr9ybk7A>.

23 John Stillion, "Fighting Under Missile Attack," *AIR FORCE Magazine*, August 2009, pp. 34–37.

24 Robert M. Gates, Speech at the National Defense University, September 29, 2008, online at <http://www.defenselink.mil/speeches/speech.aspx?speechid=1279>.

25 Andrew Erickson from the U.S. Naval War College's China Maritime Studies Institute, "China Testing Ballistic Missile 'Carrier-Killer'," Wired Magazine's Danger Room, March 29, 2010, online at <http://www.wired.com/images_blogs/dangerroom/2010/03/asbm_graphic_admiral-willard-testimony_chinese-article.png>.

FIGURE 1. CHINESE DEPICTIONS OF THE DF-21/CSS-5 ASBM*

* Source: *Dongfang Ribao [Oriental Daily]*, the website of a Shanghai newspaper at <http://military.china.com/zh_cn/news/568/20100328/15873418.html>. The left-hand image is of a DF-21 on its mobile transporter erector launcher.

Nor is the People's Republic of China (PRC) the only nation developing anti-access/area-denial (A2/AD) capabilities to constrain U.S. conventional military power. Aided by the more confined geography of the Persian Gulf, the Iranians are also fielding offensive and defensive missile systems that, in conjunction with advanced mines and the various naval combatants, could one day enable them to affect the flow of oil through the Strait of Hormuz. While Iran's A2/AD capabilities are unlikely to have the long reach and sophistication of China's, they could eventually be effective enough to make it very difficult and costly for U.S. naval forces to operate inside the Persian Gulf. Indeed, this is precisely the outcome that surfaced in Joint Forces Command's Millennium Challenge war game in 2002. The Red Team, led by retired Marine Lieutenant General Paul Van Riper, mounted an unconventional surprise attack using the forces Iran was projected to have in 2007 and promptly sent sixteen U.S. ships to the bottom of the Persian Gulf.[26] Suffice it to say, as Iran's anti-access/area-denial capabilities mature over

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26 Malcolm Gladwell, *Blink: The Power of Thinking Without Thinking* (New York: Back Bay Books/Little, Brown and Company, 2005), pp. 102–111; also Sean D. Naylor, "War Games Rigged? General Says Millennium Challenge 02 'was almost entirely scripted'," *Army Times*, August 16, 2002.

time, they will be able to make it more difficult and potentially more costly for U.S. forces to operate in and around the Persian Gulf.

While U.S. thinking about an emerging precision-strike regime in the 1990s emphasized long-range RUKs, it is becoming increasingly apparent that the proliferation of short-range precision munitions will also pose challenges for the U.S. military. These systems include: guided rockets such as the U.S. Army's Guided Multiple Launch Rocket System (GMLRS) and Excalibur 155-millimeter guided artillery round; the Precision Guidance Kit (PGK), which adds Global Positioning System (GPS) guidance to ordinary 105-mm and 155-mm artillery shells with a package that screws into the projectile's fuse well; and various guided mortar rounds being developed in the United States and overseas. The fact that countries such as France, Sweden, Israel, Russia, and Germany are making and selling guided rocket, artillery, and mortar rounds argues that, in time, these sorts of precision munitions will even end up in the hands of terrorist organizations such as Hezbollah. Recall that in the summer of 2006, Hezbollah fired some four thousand rockets into Israel, the overwhelming majority of which were unguided 122-mm and 107-mm Katyushas.[27] It does not take much imagination to realize how much more devastating Hezbollah's attacks would have been with precision munitions. Most of Hezbollah's rockets in 2006 were aimed at entire Israeli cities due to their lack of accuracy, much as the Germans had been forced to do with the V-2 in 1944–1945.[28] But with modern guidance technologies, Hezbollah's attacks could have been orders of magnitude more destructive than they proved in 2006. Even with a circular error probable (CEP) of 30 or 50 meters, Hezbollah fighters would have been able to aim at specific facilities rather than whole cities.[29]

The threat that precision weapons in the hands of third-world militaries, insurgents or terrorists will pose for the U.S. military in coming years, then, is an emerging one. In Afghanistan and Iraq, mortars and rockets fired at U.S. bases have rarely been aimed with great precision, much less been precision guided. But as Marine Lieutenant General George Flynn has noted, the prospect of even non-state actors being able to hit more or less everything they aim at with precision-guided mortars, artillery and short-range rockets is not only worrisome, but unavoidable as relatively inexpensive guided weaponry proliferates worldwide.[30]

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27 Uzi Rubin, "The Rocket Campaign against Israel during the 2006 Lebanon War," Begin-Sadat Center for Strategic Studies, Study No. 71, June 2007, pp. 10–11.

28 Mark Wade estimates that the real-world accuracy of the V-2s Germany launched toward the end of World War II was 6-12 kilometers (Mark Wade, "V-2," online at <http://www.astronautix.com/lvs/v2.htm>.

29 CEP is the radius of a circle around the aim point within which 50 percent of the munitions can be expected to fall statistically.

30 Dan Lamothe, "More-Accurate Artillery Concerns General," *Marine Corps Times*, posted April 21, 2010, at <http://www.marinecorpstimes.com/news/2010/04/marine_mortars_042010w/>.

The story of conventional precision strike from the early 1990s to the present, then, has been largely one of U.S. monopoly and dominance. That happy situation, however, is coming to an end. In the years ahead, U.S. forces will be confronted with long-range RUKs such as those the Chinese are developing as part of a broader A2/AD strategy in the Western Pacific. At the same time, it appears to be simply a matter of time before American forces will be confronted with short-range precision weapons. The maturing precision-strike regime, therefore, will be one in which countries large and small, as well as terrorist organizations, will possess a variety of long- and short-range guided weapons.

CHAPTER 4 > **POSSIBLE CHANGES BY 2050**

What are some of the more consequential implications of the accelerating proliferation of precision-strike capabilities? A number of possibilities were discussed during ONA's three 2009 RMA workshops. The December session was particularly fruitful in detailing how future wars between first-rate militaries are likely to be fought. The nuclear missile age matured during the 1960s as both the United States and the Soviet Union began fielding growing numbers of intercontinental-range ballistic missiles with the thermonuclear warheads. Although conventional guided weapons with "near-zero miss" had been foreseen by American strategists as early as 1975,[31] the era in which non-nuclear missiles—from guided mortar and artillery rounds to intercontinental ballistic missiles—would increasingly dominate warfare is only now dawning. Looking to the future, major changes in war's conduct stemming from the maturation of conventional precision strike are likely to include the following:

> Growing U.S. dependence on space and cyberspace may prove a major vulnerability to the operational concepts and organizations American forces have increasingly utilized since the early 1990s.

> Naval surface combatants such as aircraft carriers may no longer be sufficiently survivable when operating within reach of enemy anti-access/area-denial systems.

[31] See Dominic A. Paolucci, "Summary Report of the Long Range Research and Development Planning Program," Lulejian and Associates, Falls Church, VA, February 7, 1975, p. 45. Albert Wohlstetter was the primary drafter of this report. The great promise he saw in "near zero miss" conventional munitions was the possibility of providing the president with strategic-response options that would be alternatives to "massive nuclear destruction" (ibid., pp. 11, 45). This idea was later incorporated in the "New Triad" adopted in the 2001 Nuclear Posture Review.

> The advantages of stealth—understood as mission planning and tactics plus low-observable platform signatures—may be eroded by advances in sensors and surface-to-air missile systems, especially for manned strike platforms operating inside defended airspace.

> Large or massed ground forces, major ports, and bases are likely to become highly vulnerable to enemy guided artillery, mortars, and missiles.

> Finally, traditional approaches to overseas power projection of conventional forces may grow too difficult and costly to sustain.

This list should not be construed as exhaustive. It omits, for example, the possibility that the growing effectiveness of U.S. conventional precision weapons has already provided strong incentives for states such as Iran to develop nuclear weapons as insurance against the kind of regime change that the United States imposed on Saddam Hussein's Iraq in 2003. Nevertheless, these five prospective ways in which significant changes in war's conduct could occur provide considerable insight into the future evolution of the RMA based on the maturation of precision strike. Each will be explored in greater detail below.

Perhaps the most significant implication of these five possibilities is that *the conduct of war is likely to change more fundamentally between now and 2050 than it has since the early 1990s.* If so, then the changes in the dominant cultures, operational concepts and doctrines, and organizations that the U.S. military Services will need to embrace in coming years will be more significant and wrenching than any they have had to make since ONA's 1992 MTR assessment. Here one need look no further than to the possible end of the era in which aircraft carriers dominate the world's oceans.

CHAPTER 5 > **U.S. DEPENDENCE ON SPACE AND CYBERSPACE**

Since the 1980s, the U.S. military's approach to conventional operations has become ever more dependent on access to space-based systems—particularly long-haul satellite communications and the precision navigation and timing information provided by Global Positioning System constellation. During Operation Desert Storm in 1991, laser-guided bombs, Tomahawk Land Attack Missiles (TLAMs) and the GPS-aided Conventional Air-Launched Cruise Missile (CALCM) demonstrated that U.S. strike forces had the capability to hit almost any target whose location could be pinpointed. For this reason, the U.S. military has invested heavily in developing battle networks to detect, identify, and track targets with sufficient precision and timeliness to enable them to be struck. Intelligence, surveillance and reconnaissance (ISR) systems such as the RQ-4 Global Hawk, the GPS constellation, and photo-reconnaissance satellites are examples of systems that reflect how dependent U.S. forces have become on access to the orbital and cyber dimensions of the global commons.

Figure 2 includes target imagery produced during an MQ-9 Reaper training mission at Creech Air Force Base in Nevada. The imagery is high quality and requires high bandwidth (understood as the rate at which data can be sent over a given communications link).[32] Figure 3 illustrates the dependence of the RQ-4 Global Hawk, MQ-1 Predator, and Reaper on Ku-band communications satellites (COMSATs) when these unmanned aerial vehicles (UAVs) are operated over Iraq or Afghanistan from mission control centers located in California or Nevada. Currently, a single Predator orbit requires data rates up to 6.4 million bits/second

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32 Strictly defined, *bandwidth* is the width of the frequency spectrum of a signal in Hertz—John F. Pane and Leland Joe, *Making Better Use of Bandwidth: Data Compression and Network Management Technologies* (Santa Monica, CA: RAND, 2005), p. xi. However, the term is widely used to refer to the rate at which data can be sent over a given channel in bits per second.

FIGURE 2. MQ-9 REAPER OPERATIONS*

* The Reaper at the left is shown landing at an undisclosed location in Afghanistan on November 27, 2007. The MQ-9 has six hard points and can carry up to 1,500 pounds of ordnance.

(Mbps); and the electro-optical, infrared and synthetic aperture radar feeds from a single Global Hawk can potentially consume as much as 274 Mbps. These bandwidth requirements have been met by military and commercial COMSATs in geostationary orbits.[33] In addition, the UAVs themselves depend on GPS for precise geo-location of whatever their sensors are "seeing." Thus, the targeting and battle-management networks integral to current U.S. strike operations contain vulnerabilities ranging from jamming C2 links to the covert insertion of false data into U.S. networks. During the major combat phase of Operation Iraqi Freedom (OIF) in March–April 2003, the Combined Air Operations Center (CAOC) in Saudi Arabia used 31 military and 27 commercial COMSAT terminals with a capacity of nearly 210 Mbps.[34] Overall, the total information flow in and out of theater during OIF's major combat phase is estimated to have peaked around three billion bits per second.[35] As for the dependence of OIF strike operations on space, nearly

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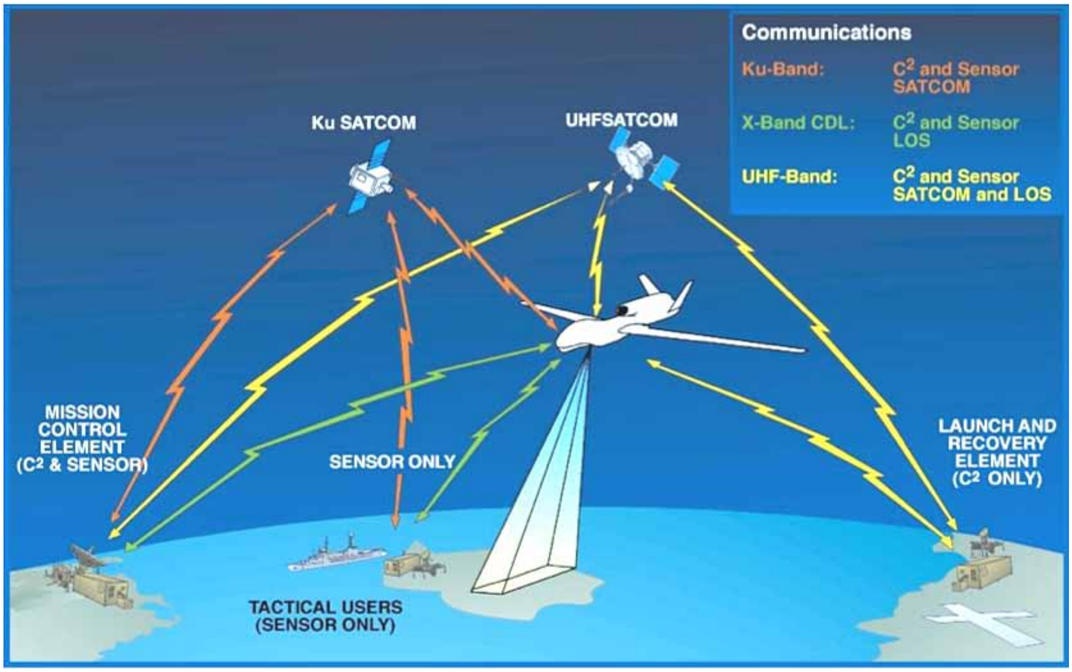
[33] Major Timothy Jacobs, "Unmanned Aircraft Systems (UAS) of Commercial SATCOM," Headquarters Air Combat Command/A8UC, December 7, 2006, slides 10 and 11. Jacobs' projection for 2009 was that the Air Force would be operating 23 Predator and Reaper combat orbits requiring 147 Mbps, plus three Global Hawk orbits requiring another 822 Mbps.

[34] J. R. Wilson, "Satellite Communications Key to Victory in Iraq," *Military & Aerospace Electronics*, August 2003, online at <http://mae.pennnet.com/articles/article_display.cfm?Section=ARCHI&C=News&ARTICLE_ID=183379&KEYWORDS=SATCOM&p=32>. Since the commercial COMSATs had an average capacity of 6 Mbps compared to only 1.5 Mbps for the military ones, the 27 commercial COMSATs provided over 75 percent of the capacity used by the CAOC.

[35] Geoffrey Forden, "How China Loses the Coming Space War (Pt. 2)," *Wired*, January 2008, online at <http://blog.wired.com/defense/2008/01/inside-the-ch-1.html>.

FIGURE 3. GLOBAL HAWK OPERATIONAL CONCEPT*



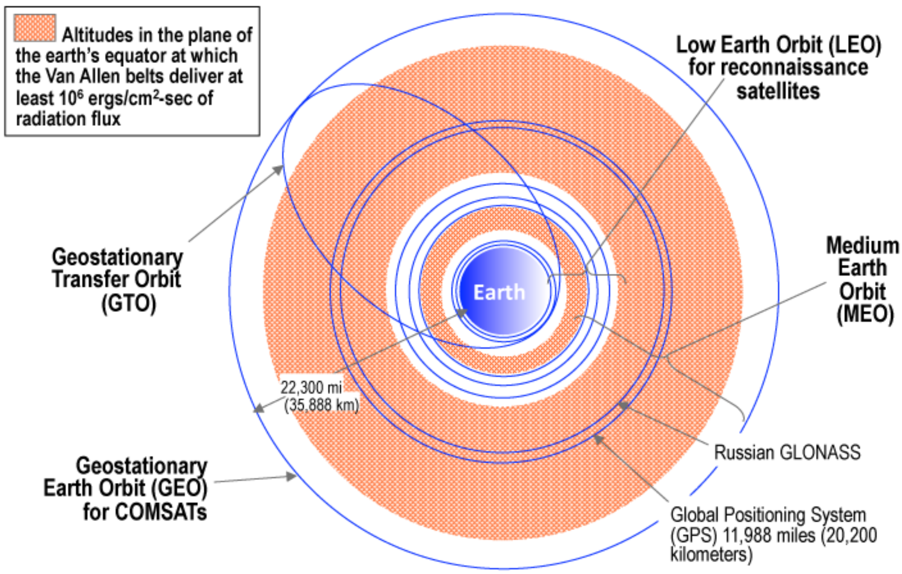
* Northrop Grumman Corporation, "RQ-4A Global Hawk High Altitude Endurance Unmanned Reconnaissance System," November 16, 1999, Slide 2.

44 percent of the guided munitions expended in the air campaign used inertial/GPS-aided guidance to home in on their aim points.

Against the adversaries the United States and its allies have faced in Afghanistan and Iraq since September 11, 2001, dependence on geostationary-earth-orbit (GEO) communications satellites for battle management and operating UAVs from distant locations, on the medium-earth-orbit (MEO) GPS constellation for precision location and timing information, and on low-earth-orbit (LEO) reconnaissance satellites for target identification and battlespace awareness has not been problematic. The Taliban, al Qaeda, Sunni insurgents, and their supporters have had little capability to interfere with any of these systems. Even so, as a sign of things to come, in 2009, Iranian-backed militants in Iraq succeeded in using the inexpensive SkyGrabber software (priced as low as $25.95 on the Internet) to regularly capture unprotected video feeds from U.S. Predator drones.[36]

[36] Siobhan Gorman, Yochi J. Dreazen and August Cole, "Insurgents Hack U.S. Drones," *The Wall Street Journal*, December 17, 2009.

FIGURE 4. EARTH ORBITAL ALTITUDES



A major power such as China, however, is another matter entirely. Specialists on the People's Liberation Army concluded during the 1990s that war in space would eventually be a necessary and logical extension of other forms of military conflict, and that "space supremacy" would become an integral part of overall supremacy over future battlefields.[37] As Larry Wortzel wrote in 2007:

> Space operation and warfare in space are components of what the PLA calls "informationalized," or information age, warfare. In general, PLA strategists are convinced that… "future enemy military forces will depend heavily on information systems in military operations." Therefore, they believe, China needs to break through the technological barriers and develop information system countermeasures in space.[38]

Toward this end, the Chinese are investing in everything from jamming to counter-network attack (the offensive form of cyber warfare), anti-satellite (ASAT) systems, and directed-energy weapons. Retired Vice Admiral Mike McConnell, who has both headed the National Security Agency and been the Director of National Intelligence, argued in February 2010 that the United States

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[37] Larry M. Wortzel, "The Chinese People's Liberation Army and Space Warfare," American Enterprise Institute, 2007, p. 2.

[38] Wortzel, "The Chinese People's Liberation Army and Space Warfare," p. 2.

is fighting a cyber-war today, and losing it, particularly against China.[39] As for more "kinetic" approaches to taking advantage of U.S. dependence on unimpeded access to space and cyberspace, in January 2007 China went so far as to demonstrate a direct-ascent ASAT capability by destroying one of its own aging weather satellites in low earth orbit.[40] The *Feng Yun* 1-C weather satellite was orbiting at an altitude of about 535 miles above the earth's surface. The Chinese destroyed the satellite with a kinetic-kill vehicle launched by a two-stage solid-fuel missile fired from a mobile transporter-erector-launcher at the Xichang space facility in Sichuan province, creating a debris field of more than thirty-five thousand shards larger than one centimeter.[41]

U.S. military dependence on relatively unimpeded access to the global commons in both space and cyberspace has expanded enormously since 1991. At the heart of this dependency is the requirement of current U.S. guided munitions—notably the LGBs and JDAMs that have been three-quarters of combat expenditures—to have precisely located aim points. Recognizing this fact, U.S. adversaries have taken numerous steps to deny this information to U.S. forces by making their forces and strategic assets more and more difficult to locate in time and space. In addition to camouflaging, concealing, relocating, hardening, or deeply burying prospective targets—which even terrorists can do—the PRC, among others, has invested in capabilities to attack the space- and cyberspace-based information flows on which U.S. target acquisition, battlespace management, and C2 depend.

Marshall has long argued that the primary challenge of any revolution in military affairs precipitated by technological advances is

> to be the best in the intellectual task of finding the most appropriate innovations in concepts of operation and making organizational changes to fully exploit the technologies already available and those that will be available in the course of the next decade or so.[42]

In the case of the growing U.S. dependence on unimpeded access to orbiting satellites and cyberspace, the evidence suggests that the American military has yet to heed this advice. The most fundamental line of solution to the potential vulnerability stemming from the need for the pinpoint location of targets in time and space would be to develop guided munitions able to find *imprecisely* located

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[39] Mike McConnell, "Mike McConnell on How to Win the Cyber-war We're Losing," *The Washington Post,* February 28, 20010, pp. B1, B4.

[40] Ashley J. Tellis, "Punching the U.S. Military's 'Soft Ribs': China's Antisatellite Weapon Test in Strategic Perspective," Carnegie Endowment for International Peace, Policy Brief 51, May 2007, p. 4.

[41] Ashley J. Tellis, "China's Military Space Strategy," *Survival*, September 2007, pp. 41. China's three previous ASAT tests failed (ibid., p. 43).

[42] Marshall, "Some Thoughts on Military Revolutions—Second Version," p. 2.

targets on their own. The Low Cost Autonomous Attack System (LOCAAS) program, sponsored by the Defense Advanced Research Projects Agency and the U.S. Air Force, set out to do precisely this. By 2005 it appears that the program succeeded in developing a robotic system that could loiter in a small area and use a laser-detection-and-ranging (ladar) sensor together with automatic-target-recognition algorithms to find and attack a range of targets, including mobile missile launchers. However, due to unease among senior airmen with autonomous battlefield robots, the Air Force walked away from LOCAAS. The technology was preserved for a time as the Loitering Attack Munition (LAM) in the U.S. Army's Non-Line-of-Sight Launch System (NLOS-LS). But in April 2010 the Army terminated NLOS-LS. The reticence regarding LOCAAS and LAM appears to stem from a cultural inclination to maintain tight control over kinetic attacks, combined with an intellectual failure to grasp the importance of being able to address imprecisely located targets. So, while the technology to deal with them has been demonstrated, the U.S. military Services have not chosen to field autonomous robotic weapons.[43]

[43] Dima Adamsky, *The Culture of Military Innovation: The Impact of Cultural Factors on the Revolution in Military Affairs in Russia, the US, and Israel* (Stanford, CA: Stanford University Press, 2010), pp. 132–136.

CHAPTER 6 > **THE DAWNING VULNERABILITY OF NAVAL SURFACE COMBATANTS**

The U.S. Navy has been concerned about the vulnerability of its surface combatants to air attack since late 1943. In September 1943, the sinking of the Italian battleship *Roma* as a result of two hits by Fritz-X radio-controlled glide bombs delivered by German Donier-217s generated early anxiety about the future survivability of U.S. surface combatants, particularly aircraft carriers. This concern was reinforced in October 1944 by the success of the first large-scale suicide attacks by Japanese Kamikaze pilots against American naval forces in the Leyte Gulf, which included the sinking of the escort carrier USS *St. Lo* on October 25. The Navy's institutional response was the establishment of Project Bumblebee in November 1944. Project Bumblebee began development of radar-guided surface-to-air missiles (SAMs) to defend the Navy's carrier battle groups. It eventually produced the first generation of U.S. naval SAMs, which included the short-range Tartar, the medium-range Terrier, and the long-range Talos.[44]

The Navy's second generation of naval SAMs consisted of the Standard Missile (SM) family deployed on Aegis guided-missile destroyers and cruisers. The mature Aegis combat system that emerged in mid-1980s was built around a four-megawatt, phased-array SPY-1 radar able to track up to one hundred targets; the RIM-66C/D SM-2 version of the Standard Missile; high-speed computers; and, starting with CG-52 (USS *Bunker Hill*), twin Mark 41 Vertical Launch System (VLS) installations containing up to 122 Standard Missiles.[45] In conjunction with

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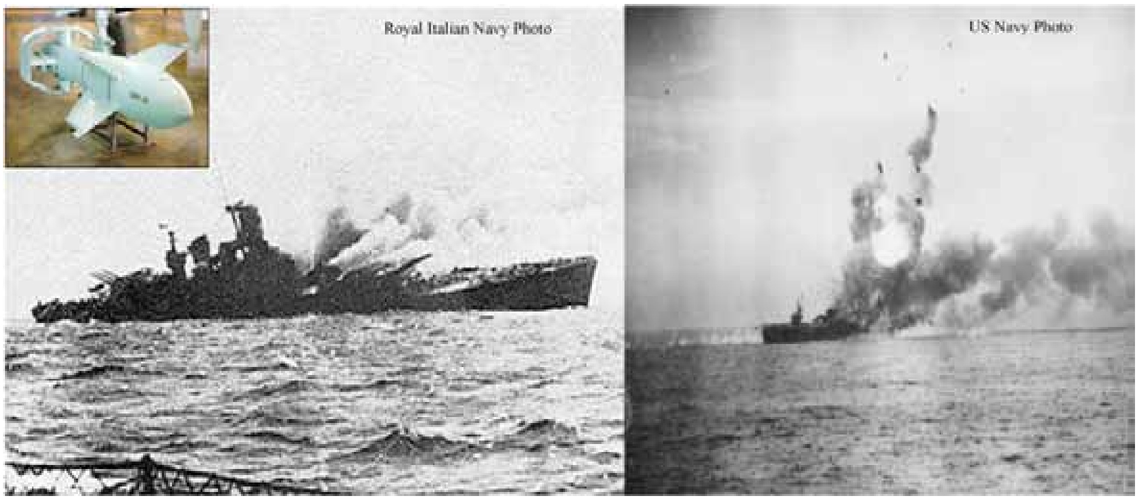
44 Watts, *Six Decades of Guided Munitions and Battle Networks*, p. 4–5. In 1968, the guided missile cruiser USS *Long Beach* downed two North Vietnamese MiGs with Talos, and in 1972 a Talos from the USS *Chicago* got another MiG.

45 VLS cells can hold Standard Missile SAMs, Tomahawk Land Attack Missiles (TLAMs), and Anti-Submarine Rockets (ASROCs). ASROCs could carry a nuclear warhead or an acoustic homing torpedo.

FIGURE 5: THE SINKING OF THE *ROMA* AND THE USS *ST. LO**



* In the left photo the *Roma* is listing after a second Fritz-X hit abreast "B" turret and detonated in the forward engine room; in the right photo, the fireball from a Kamikaze hit on the *St. Lo* is visible above the carrier. The Fritz-X, shown upper left, was a 3,450-pound armor-piercing bomb fitted with a radio receiver and control surfaces in the tail.

the E-2 Airborne Early Warning aircraft and the F-14 Tomcat, equipped with the AWG-9 track-while-scan pulse-doppler radar and long-range AIM-54 Phoenix air-to-air missiles, Aegis provided a fairly robust defensive capability for U.S. aircraft carriers.

Nevertheless, as the "blue-water" capabilities of the Soviet Navy matured in the 1980s, the threat to U.S. carrier battle groups became substantial. The Soviets' first problem was locating American carriers in the vastness of the oceans. After all, if the exact location of a U.S. nuclear carrier is known at one moment in time, within thirty minutes the vessel could be anywhere within a circle of 700 square nautical miles (nm).

Starting in the 1970s, the Soviet solution to the location and over-the-horizon targeting problems was to develop both radar and electronic intelligence ocean reconnaissance satellites (RORSATs and EORSATs). The EORSATs located opposing naval forces by triangulating on their radio and radar emissions. The RORSATs, which had nuclear power plants, used active radar to pinpoint U.S. naval forces. However, the RORSATs were generally launched in conjunction with major Soviet naval exercises and their duration at LEO altitudes was limited, the longest being 135 days.[46] Arguably, locating and tracking U.S. aircraft carriers with sufficient precision and duration for targeting with long-range missiles remained a challenge for the Soviets through the end of the Cold War. But assuming that the Soviets could locate and track a carrier battle group, T-22 Backfire bombers with Raduga Kh-22 missiles, which could be launched up to 400 kilometers from the carrier and attain speeds approaching Mach 4, presented the carrier's F-14s with the formidable challenge of intercepting the Backfires before they could launch their missiles.[47]

Nor were Backfire regiments the only challenge the Soviet Navy posed for U.S. carrier battle groups. In the 1980s the Soviets began fielding Oscar-class nuclear-powered guided-missile submarines (SSGNs), each armed with twenty-four P-700 Granit supersonic cruise missiles, which were specifically designed to attack U.S. carriers from distances of up to 500 kilometers. Through the end of the Cold War, the Soviets commissioned two Oscar-I and six Oscar-II SSGNs.[48] The Granit missile, which the Oscars could launch while submerged, was developed as part of an integrated naval RUK that assimilated intelligence and targeting data from multiple sources.[49] The employment concept of the Oscar SSGNs was to overwhelm a carrier battle group's defenses, including its Aegis combatants, with salvos of Granits. Like Soviet Backfire regiments, Oscar-I/II SSGNs posed a growing challenge to the survivability of U.S. carrier battle groups in the late 1980s, especially if they attacked in conjunction with Backfires.

From the U.S. Navy's perspective, the Soviet Navy's mounting challenge to the survivability of U.S. aircraft carriers rapidly evaporated following the collapse of the communist state in December 1991. But subsequent events led the Chinese to take up where the Soviets had left off. Tension between China and the United States over Taiwanese president Lee Teng-hui's leanings toward independence in 1995–1996 culminated in the United States deploying carrier battle groups into the region to coerce Chinese leaders to back down from their efforts to intimidate

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46 Sven Grahn, "The US-A Program (Radar Ocean Reconnaissance Satellite—ROSAT) and Radio Observations Thereof," online analysis, downloaded December 4, 2009, at <http://www.svemgrahn.pp.se.trackind/RORSAT/RORSAT.html#Summary>. Grahn was a pioneer in Swedish space activities.

47 The Soviets fielded Kh-22 in the early 1960s, and it became the standard armament used by Soviet naval aviation Tu-22M Backfires to attack U.S. carrier battle groups. The early Kh-22 could carry either a 1,000-kilogram high explosive shaped charge or a 250–1,000 kiloton nuclear warhead. Guidance was inertial with an active terminal seeker. In the 1970s, the missile was updated with new attack profiles, increased range, and a data-link for mid-course corrections.

48 The Russians eventually completed eleven Oscar-II SSGNs at Severodvinsk. Three more Oscar IIs were planned but never completed.

49 Richard Scott, "Russia's 'Shipwreck' Missile Enigma Solved," *Jane's Intelligence Weekly*, September 10, 2001, excerpt available online at <http://www.janes.com/defence/naval_forces/news/jdw/jdw010910_6_n.shtml >.

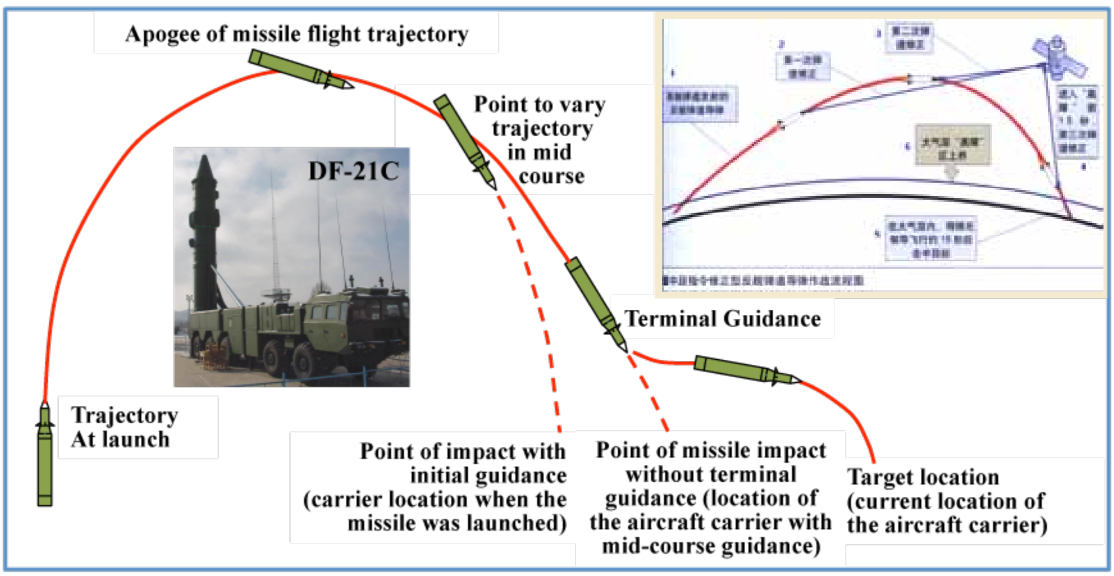
Taiwan through missile firings and amphibious exercises. U.S. military deployments during this period included the transit of the Taiwan Strait by the USS *Nimitz* in December 1995, and the movement of two carrier battle groups into the area the following March. In the aftermath of this crisis, Chinese leaders embarked on a program to develop the military capabilities to "deter or counter third-party intervention in any future cross-Strait crisis" by being able "to attack, at long ranges, military forces that might deploy (anti-access) or operate (area-denial) within the western Pacific."[50] One element of this effort involves "combining conventionally-armed DF-21 ASBMs, C4ISR for geo-location and tracking of targets, and onboard guidance systems for terminal homing to strike surface ships."[51]

The Defense Department estimates the range of the DF-21 ASBM to be 1,500 kilometers (810 nm), and that of the DF-21 intermediate range ballistic missile

[50] OSD, "Military Power of the People's Republic of China," 2009, p. 20.

[51] OSD, "Military Power of the People's Republic of China," 2009, p. 21.

FIGURE 6. THE PRC'S ASBM CONCEPT*



* Figure 6 is a graphic of a CSS-5/DF-21 ASBM's use of mid-course and terminal guidance to strike an aircraft carrier taken from a 2006 article from the Second Artillery Engineering College. The insert with the reconnaissance satellite providing targeting to the missile is from Ian Easton and Mark A. Stokes, "China's Electronic Intelligence (ELINT) Satellite Developments: Implications for the U.S. Air Force and Naval Operations," Project 2049 Institute, February 23, 2011, p. 6.

(IRBM) for attacking fixed targets to be at least 1,750 kilometers (945 nm).[52] The IRBM variant's range is sufficient to reach Guam in the Mariana Islands from the PRC's coast, and the ASBM's range is enough to force U.S. carriers to operate at distances from the Taiwan Strait that are beyond the unrefueled combat radius of their air wings. The unrefueled radius of the F/A-18E Super Hornet is in the vicinity of 390–450 nm depending on the mission profile and ordnance. And while the goal for the carrier variant of the F-35 Joint Strike Fighter is an unrefueled combat radius of 730 nm, the performance threshold is only 600 nm.[53] Aegis combatants armed with the SM-3 offer a capability to defend against limited numbers of IRBMs, and countermeasures such as radio frequency (RF) aerosols could provide carriers and other surface combatants with additional protection from ASBM warheads with terminal radar terminal guidance. Note, too, that the ASBM variant of the DF-21 has only undergone component testing and, as of 2009, DoD estimated the total of DF-21 IRBMs (all variants) actually deployed to be no more than eighty to ninety.[54] Nevertheless, in the long run, growing PRC inventories of ASBMs and anti-ship cruise missiles, which can be launched from a variety of air, surface and sub-surface platforms, are likely to make it increasingly risky to operate carrier battle groups within reach of the A2/AD capabilities the Chinese are developing. Aircraft carriers have ruled the oceans since the early 1940s, and the United States has been able to use them to project power ashore. It is conceivable, however, that maturation and proliferation of the precision strike regime will eventually bring the era of the aircraft carrier to an end.

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52 OSD, "Military Power of the People's Republic of China," 2009, pp. 29, 66.

53 Major General C. D. Moore, F-35 Program Office, "Selected Acquisition Report (DRAFT SAR)," RCS: DD-AT(Q&A)823-198, March 26, 2010, p. 10.

54 OSD, "Military Power of the People's Republic of China," 2009, pp. 29, 66. In December 2010, Admiral Robert Willard, the commander of U.S. Pacific Command, told *Asahi Shimbun*'s correspondent Yoichi Kato that the Chinese had not yet conducted an over water test of the complete DF-21D system against a moving ship (Andrew S. Erickson's blog, at http://www.andrewerickson.com/2010/12/admiral-willard-compacom-tells-asahi-shimbun's-yoichi-kato-that-china's-anti-ship-ballistic-missile-asbm-has-reached-equivalent-of-"initial-operational-capability"/, accessed December 29, 2010).

CHAPTER 7 > **THE FUTURE OF STEALTH**

In 1996 Vickers introduced the notion of a "hider-finder" competition between information acquisition and information denial. He suggested that the balance between acquiring and denying information could well be the central determinant of how theater war would be conducted through 2025.[55] One aspect of this competition involves the requirements of most current precision weapons to have their targets pinpointed in space and time. Another aspect of this competition is the information competition between penetrating strike platforms like the B-2 and advanced SAMs such as the Chinese HongQi-9 or HQ-9 (probably derived from the Russian S-300PMUs that China purchased from Russia), and the Russian S-300P and S-400, which are designated the SA-10, SA-20 and SA-21 by NATO.[56]

In recent years there has been speculation that ongoing advances in radar detection and tracking will, in the near future, obviate the ability of all-aspect, low-observable (LO) aircraft such as the B-2, F-22, and F-35 Joint Strike Fighter (JSF) to survive inside denied airspace. Those taking this view emphasize at least two promising approaches to counter-LO, both of which are being pursued by the Russians, Czechs, and others. One involves very high frequency (VHF) and ultra high frequency (UHF) radars, which use relatively long wavelengths of about 30 centimeters to six meters. The radar cross section (RCS) of an aircraft not only

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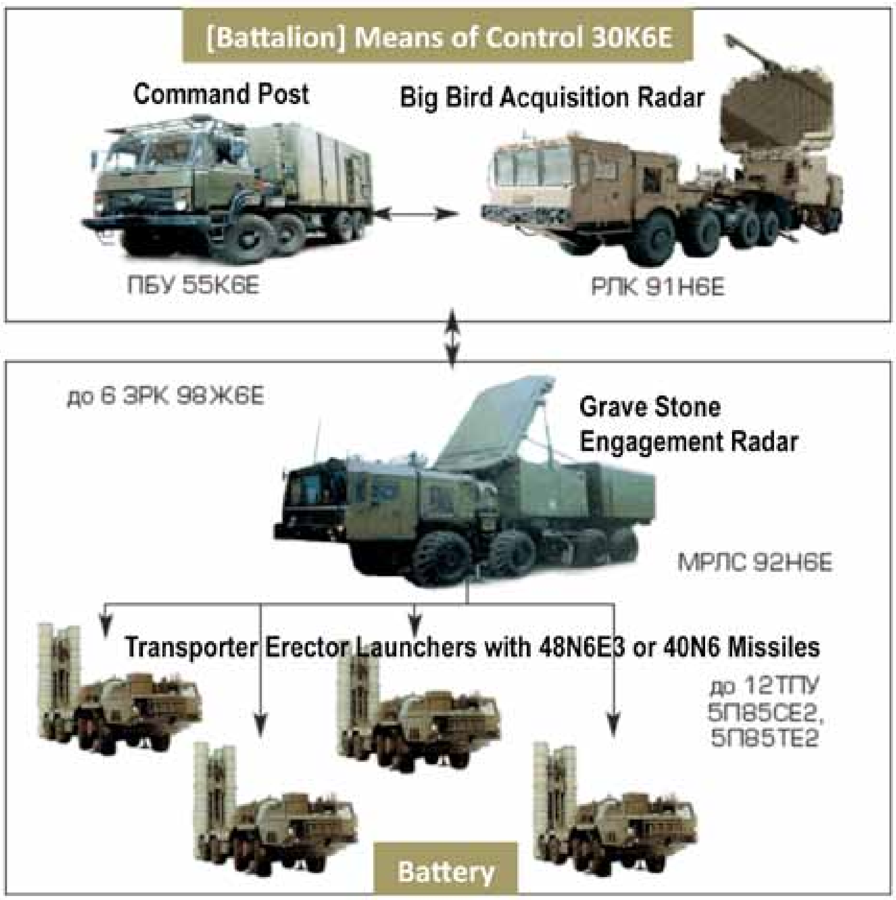
55 Michael G. Vickers, "The Revolution in Military Affairs and Military Capabilities: Broadening the Planning Parameters of Future Conflict," School of Advanced International Studies, Johns Hopkins University, 1996, p. 11; Pfaltzgraff and Shultz, *War in the Information Age: New Challenges for U.S. Security Policy*, p. 40.

56 The Russian have produced four variants of the S-300P family: the S-300PT or SA-10A; the S-300PS or SA-10B (export variant the S-300PMU); the S-300PM or SA-20A (export variant S-300PMU1); and the S-300PMUs or SA-20B (exported as the S-300PMU2 Favorit; the export variant of the Russian S-400 (or SA-21) is the S-400 Triumf. (Sean O'Conner, "Soviet/Russian SAM Site Configuration, Part 2: S-300P/S-400/SA-10/20/21, S-300V/SA-12, 2Kll/SA-4, 2K12/SA-6, 3K37/317/SA-11/17," January 2010, at <http://www.ausairpower.net/APA-Rus-SAM-Site-Configs-B.html#mozTocId647809>.

FIGURE 7. S-400 BATTERY COMPONENTS*



* Source: Almaz-Antey. A single S-400 battalion could have as many as six batteries. The 40N6 missile is the longer-range of the two, and Almaz-Antet credits it with a range of 400 kilometers (216 nm). The range of the 48N6E3 is advertised as 250 kilometers (135 nm). Almaz-Antey is also developing an S-500 SAM system.

varies with the wavelength of the radar trying to detect the plane, but the aircraft's RCS is larger for long-wavelength search radars compared to its RCS as seen by the shorter, X-band radars typically used by SAMs for fire-control.[57] Radar physics, therefore, argues that VHF and UHF search radars offer greater potential to detect and track stealthy aircraft. Granted, the historically poor resolution

57 Rebecca Grant, *The Radar Game: Understanding Stealth and Aircraft Survivability* (Arlington, VA: IRIS Independent Research, 1998), p. 32. In general, the RCS of an airborne platform relative to a radar attempting to detect the platform is a function of radar's frequency and polarization as well as the azimuth, range and elevation of the vehicle relative to the radar.

in angle and range has prevented traditional long-wavelength radars from providing fire-control-quality data. However, as fully digital versions of these radars incorporating active electronically scanned arrays (AESAs) proliferate, they will present a growing challenge to current and even future stealth aircraft.[58]

The other promising approach to counter LO has been passive systems such as the Czech VERA-E, which uses radar, television, cellular phone and other available signals of opportunity reflected off stealthy aircraft to find and track them.[59] The main limitation of such systems has been the enormous signal-processing power and memory required to analyze all these emissions, differentiate real targets from ghost signals, noise and clutter, and keep the false alarm rate to manageable levels.[60] One potential outcome, however, is that as long-wave radars transition to AESAs (and assuming computational power continues to double every two years or so in accordance with Gordon Moore's "law"), information acquisition will overwhelm the capacity of aerospace engineers to reduce platform signatures.[61] The balance between information acquisition and information denial will swing dramatically in favor of the former. Or, to put the point more bluntly, there will come a time in the not-too-distant future when the SAMs will almost always win against air-breathing penetrating platforms, rendering operations inside denied airspace too costly to bear.

Is this forecast accurate? A definitive answer to this question would obviously require access to data on current and projected capabilities for reducing radar signatures and countering advanced SAMs that are highly classified (and rightly so). Nevertheless, there are substantial reasons to doubt this conclusion. First and foremost, the very same shift to digital AESA radars and continuing growth in computational power that aids the "finders" can also be exploited by stealthy "hiders." For example, the JSF's sensor suite and computational power, which can be easily upgraded over time due to the plane's open avionics architecture,

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58 Russia's Nebo VHF radar is fully digital and incorporates an active electronically scanned array (Carlo Kopp, "Russian VHF Counter Stealth Radars Proliferate," *Defence Today*, December 2008, p. 32; also, Bill Sweetman, "Retro Radars," December 30, 2008, at http://www.aviationweek.com/aw/blogs/defense/index.jsp?plckController=Blog&plckScript=blogscript&plckElementId=blogDest&plckBlogPage=BlogViewPost&plckPostId=Blog%3A27ec4a53-dcc8-42d0-bd3a-01329aef79a7Post%3A95781e5e-6ba1-4037-b302-4278cb55e8aa (accessed December 28, 2010).

59 In February 2006, defense secretary Donald Rumsfeld told the defense minister of the Czech Republic that the Department of Defense had completed a site acceptance test on VERA-E and concluded that the system met its performance specifications (Libor Slezak, "Passive Detection of Low Observable Targets," ERA, 2006, slide 10).

60 Dimitris V. Dranidis, "Airborne Stealth in a Nutshell—Part II: Counter Stealth—Technologies and Tactics," *Waypoint*, December 2003, pp. 119–120.

61 Bill Sweetman, "Worth the Cost?", *Jane's Defence Weekly*, July 19 2006, pp. 63. In 1965, Gordon E. Moore projected that the number of transistors and resistors that could be packed into a single integrated circuit would continue to double each year through 1975 (Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics*, April 19, 1965, pp. 115–116). By 1975 he modified his original observation to a doubling of processing power every two years, and that rate of increase has held from Intel's 4004 processor in 1971 to its most recent, the Itanium processor in 2010.

gives the F-35 an ability to adjust its flight path in real time in response to pop-up threats, something neither the F-117 nor the B-2 have been able to do. Second, the F-35 has an AESA radar that can be used for electronic attack of enemy air defenses as well as digital radio frequency memory (DRFM) capabilities that offer the potential to increase survivability "by delaying, denying, and defeating threat air-to-air and surface-to-air missile systems operating in the radio frequency spectrum."[62] A DRFM countermeasures system can duplicate an incoming signal from enemy radars by converting it from analog to digital and back again. In between, DRFM can modify the digital duplicate so that, when converted back to analog and retransmitted, the manipulated signal will be coherent with the threat radar.[63] DRFM signal manipulation can deceive threat radars by altering the target's apparent RCS, range, velocity, and angle. Third, unlike the F-117 and B-2 that operated singly (and only at night), the F-35, like the F-22, has the survivability for daytime operations and will probably operate in networked groups of four or eight aircraft, thereby greatly multiplying their capacity to overcome enemy air defenses, to include destroying S-300/400/500 class SAMs. There is, then, a lot more to the information competition between hiders and finders than the shift to digital electronics and advances in computational power. Exploiting ongoing technological advances is not limited to SAM "finders," and historically airmen have proven surprisingly adept time and again at finding ways to overcome adversary air defenses.

Finally, there is the issue of the extent to which the U.S. military has actually embraced all-aspect, LO combat aircraft since the Air Force declared a limited initial operational capability (IOC) with the F-117 in October 1983.[64] When the last of the Air Force's 187 F-22s are delivered, all-aspect, LO fighters and bombers will still constitute less than 8 percent of the Service's inventory of combat aircraft. If Navy and Marine combat aircraft are included, the percentage drops to 5.5 percent. It would appear, therefore, that more than a quarter-century after the F-117's IOC, the Air Force, Navy and Marine Corps have yet to embrace stealth as a numerically significant component of their combat air forces. If the 2,443 JSFs now planned are eventually procured, this situation will be reversed and all-aspect, LO aircraft will make up around 70 percent of the U.S. inventory by 2035, when the last of F-35As are produced for the Air Force. The senior DoD decision makers who remain firmly committed to the JSF program are, of course, in

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62 William Balderson, Deputy Assistant Secretary of the Navy (Air Programs), statement before the Airland Subcommittee, Senate Armed Services Committee, April 26, 2007, p. 4, online at <http://www.globalsecurity.org/military/library/congress/2007_hr/070426-balderson.pdf>.

63 This description of DRFM-based electronic countermeasures is based on Richard J. Wiegand, "Electronic Counter Measure System Utilizing a Digital RF Memory," Patent 4,743,905, May 10, 1988, pp. 1–2, online at <http://www.patentstorm.us/patents/4743905/fulltext.html>.

64 David C. Aronstein and Albert C. Piccirillo, *Have Blue and the F-117A: Evolution of the "Stealth Fighter"* (Reston, VA: American Institute of Aeronautics and Astronautics, 1997), p. 165.

positions to evaluate the viability of all-aspect, low observability into the 2040s. Implicitly at least, their continuing commitment to the F-35 suggests that they do not believe that the era of stealth aircraft is about to come to an end.

In the 1950s, after the ceasefire in Korea, budget constraints and the challenge of dealing with nuclear battlefields prompted the U.S. Army to develop divisional structures with fewer troops than those employed during the Korean War.[65] By 1960 the Army had shifted all its division tables of organization and equipment (TO&Es) to pentomic structures to enable them to "fight and survive on nuclear as well as conventional battlefields."[66] The pentomic TO&Es offered two ways of coping with battlefield nuclear weapons. Adding atomic artillery and the nuclear-capable MGR-1 Honest John rocket increased the organic firepower of Army divisions. At the same time, pentomic organizations were more dispersed than traditional triangular division structures, which offered greater survivability against these sorts of tactical nuclear weapons.[67]

Insofar as reconnaissance-strike complexes approach the effectiveness of tactical nuclear weapons against most battlefield targets, they confront traditional ground forces with the same susceptibility to being destroyed from a distance as atomic weapons presented in the 1950s. Not surprisingly, the responses to this vulnerability suggested by early RMA war games were similar to those associated with the Army's pentomic divisions. The RMA war gaming ONA supported in the mid-1990s suggested the need for greater dispersal on the battlefield by smaller, lighter, more agile forces with greater ability to hide while achieving massed

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65 John B. Wilson, *Maneuver and Firepower: The Evolution of Divisions and Separate Brigades* (Washington, DC: Center of Military History, 1998), pp. 266–267. For example, an infantry division structure suggested by the Command and General Staff College at Fort Leavenworth in September 1954 cut nearly 4,000 troops from the 1953 division (ibid., p. 267).

66 Wilson, *Fire and Maneuver*, p. 263.

67 Wilson, *Fire and Maneuver*, p. 271.

effects despite being themselves "de-massed."[68] These lighter, more dispersed units needed stealthy vehicles both for insertion into areas dominated by enemy RUKs and for logistic support; also, RMA ground units needed to be highly networked and supported by unmanned ground vehicles, UAVs, microrobots, and long-range precision fires; and some of the later games even envisioned individual soldiers being equipped with performance-enhancing exoskeletons.[69]

The "Hunter Warrior" experiment conducted by the U.S. Marine Corps in 1996 explored some of these ideas about future ground forces, admittedly in a rudimentary form. The central question Hunter Warrior sought to answer was whether small numbers of dispersed, lightly armed teams could dominate conventional ground forces in relatively large coastal regions. Hunter Warrior's operational concept was to insert six- to eight-man long-range contact patrols (LRCPs) deep into enemy territory by air, use UAVs and advanced and integrated command, control, communications, intelligence (C3I) to achieve shared situational awareness, and then bring extended-range precision fires to bear on the opposition.[70] Conducted over a twelve-day period at the U.S. Marine Corps Air Ground Combat Center at Twentynine Palms in California, Hunter Warrior involved over six thousand marines in a free-play, force-on-force battle ranging across some four thousand square kilometers of battlespace. The Hunter Warrior RMA force was a Special Purpose Marine Air Ground Task Force Experimental (SPMAGTF(X)) made up of about two thousand marines, although its presence ashore typically involved around one hundred troops and a small number of vehicles; the SPMAGTF(X) was opposed by a mechanized opposing force (OPFOR) of nearly four thousand troops and four hundred vehicles.[71]

The results of Hunter Warrior were somewhat mixed, as well as hotly debated within the Marine Corps. Despite losing three hundred of the five hundred vehicles targeted by SPMAGTF(X) teams, the OPFOR achieved most of its objectives, including taking a key port facility and airfield.[72] The broader point, however, is that Hunter Warrior, like many of the land-focused RMA war games and exercises since 1992, explored ground force organizations and equipage substantially different from those that predominate today. One of the possibilities that

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[68] See Commander Jan van Tol, annotated ONA briefing, October 23, 1995, slide 12; William J. Hurley, Dennis J. Gleeson, Jr., Colonel Stephen J. McNamara, Joel B. Resnick, "Summaries of Recent War Games," Joint Advanced Warfighting Program, Institute for Defense Analyses, October 21, 1998, p. 13, which summarizes the Dominating Maneuver Workshop IV in 1996; and James Blackwell, notes provided to Barry Watts in 2006 on the Dominating Maneuver Wargames II and III, both of which took place in 1995.

[69] Michael Vickers and Robert Martinage, "Future Warfare 200XX Wargame Series: Lessons Learned Report," CSBA, December 2001, pp. 11–13, 29, 45–52.

[70] Andrew May, Christine Grafton, and James Lasswell, "The U.S. Marine Corps and Hunter Warrior: A Case Study in Experimentation," SAIC, August 30, 2001," p. i.

[71] May, Grafton, and Lasswell, "The U.S. Marine Corps and Hunter Warrior," p. 26

[72] May, Grafton, and Lasswell, "The U.S. Marine Corps and Hunter Warrior," p. 33.

the Army After Next (AAN) program and RAND's Arroyo Center considered in the late 1990s was a Light Battle Force that could be rapidly inserted and had excellent inter-theater mobility, but leaned heavily on networked sensors and "reach-back" for dispersed, indirect precision fires and the capability to achieve information dominance while denying enemy situational awareness.[73] As originally envisioned in the Army's Future Combat Systems (FCS) program, the next generation of ground combat vehicles would employ signature management and active protection to improve survivability while giving up considerable weight (armor) to achieve rapid deployability by air.[74]

The assumption implicit in all these possibilities remains, as John Schmitt emphasized in his critique of Hunter Warrior, "that anything that moves or masses on the battlefield can be targeted and anything that can be targeted can be destroyed by precise, long-range fires."[75] Even before Hunter Warrior, the vice chairman of the Joint Chiefs of Staff, Admiral William Owens, had advanced a version of this premise, which he labeled Dominant Battlefield Awareness (DBA). DBA was the hypothesis that it would be possible by 2015 or so to provide U.S. war-fighters with near-perfect information on all observable phenomena throughout a volume of battlespace covering an area on the ground some 200-by-200 nm—large enough to encompass North Korea. In 1994 Owens tasked ONA to explore this possibility in a 2015 Korea scenario.[76] Over time, Owens' DBA concept morphed into Dominant Battlespace Knowledge (DBK), the even more visionary conjecture that the emerging U.S. "system-of-systems" would not only enable war-fighters to be aware of all observable phenomena in a volume of battlespace large enough to encompass North Korea, but know what all the phenomena meant.[77]

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73 John Matsumura, Randall Steeb, Thomas Herbert, Scot Eisenhard, John Gordon, Mark Lees and Gail Halverson, "The Army After Next: Exploring New Concepts and Technologies for the Light Battle Force," documented briefing, RAND, 1998, p. 11.

74 Brigadier General Edward T. Buckley, Jr., Lieutenant Colonel Henry G. Franke, III, and A. Fenner Milton, "Army After Next Technology: Forging Possibilities into Reality," *Military Review*, March–April 1998, p. 7.

75 Major John F. Schmitt, "A Critique of the Hunter Warrior Concept," *Marine Corps Gazette*, June 1998, p. 13.

76 The first of the DBA simulations was held in October 1994. ONA assembled a contractor team of SAIC, BDM and Booz Allen to conduct the simulation using BDM's METRIC model with human inputs (Jan van Tol, slides for a briefing of the DBA study program prepared for the Joint Resources Oversight Committee (JROC), undated, slide 6. Commander van Tol was the military assistant on the ONA staff who oversaw the DBA games. Owens' original question was, "What if we could see all the signatures on the battlefield?" (Ibid.). A second DBA simulation was conducted in June 1995 (Maggie Belknap, memorandum to Admiral Owens, "Dominating Maneuver—Game 2, 20–22 June 1995," June 23, 1995).

77 Admiral William A. Owens, "The Emerging U.S. System-of-Systems," *Strategic Forum*, National Defense University, Number 63, February 1996, online at <http://www.ndu.edu/inss/strforum/SF_63/forum63.html>; Admiral William A. Owens with Ed Offley, *Lifting the Fog of War* (New York: Farrar, Straus and Giroux, 2000), p. 203.

These assumptions obviously fly in the face of the view that the fundamental nature of war is essentially an interactive clash—a *Zweikampf* or two-sided "duel," as Carl von Clausewitz characterized it—between independent, hostile, sentient wills dominated by friction, uncertainty, disorder, and highly nonlinear interactions.[78] Can sensory and network technologies eliminate the frictions, uncertainties, disorder, and nonlinearities of interactive clashes between opposing polities? As of this writing, the answer appears to be "No." American combat experiences in Iraq in 1991, in Bosnia in 1999, in Afghanistan from 2001 to the present, and in Iraq since 2003 provide ample grounds for concluding that the frictions, uncertainties, disorder, and nonlinearities of war will persist even in a maturing precision-strike regime.

What does this history suggest for the composition and structure of future ground forces as precision-strike systems proliferate and become increasingly capable of hitting anything they can find and track? On the one hand, if advanced sensors and associated targeting networks one day succeed in rendering ground combat environments more or less transparent—thereby achieving Dominant Battlefield Awareness—then heavy armored and mechanized forces could be destroyed from afar. In that case, one would expect future ground forces to evolve in the direction of the Light Battle Force the Army envisioned in the late 1990s, or possibly even toward Hunter Warrior's LRCP teams. On the other hand, the persistence of friction, uncertainty, disorder and nonlinearity argues that war on the ground—particularly in complex terrain such as urban or mountainous areas—will continue to occur in relatively "cluttered" environments. In cluttered terrain there will be powerful incentives to retain heavy armor if at all possible. As defense secretary Robert Gates stated when he recommended cancelling the vehicle component of the FCS program in April 2009, one of his reasons was concern over whether "lower weight, higher fuel efficiency, and greater information awareness" could compensate adequately for heavy armor in light of "the lessons of counterinsurgency and close quarters combat in Iraq and Afghanistan."[79] Combat experience from those ongoing conflicts has proven time and again that today's battlefields are far from transparent despite enormous U.S. technical and material advantages in state-of-the-art ISR sensors and platforms. So while the proliferation of both long- and short-range PGMs may necessitate smaller, more dispersed ground forces, they do not necessarily support abandoning heavy armor.

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78 Carl von Clausewitz, Peter Paret and Michael Howard (ed. and trans.), *On War* (Princeton, NJ: Princeton University Press, 1976), pp. 75, 139; Werner Hahlweg, *Vom Krieg* (Bonn: Ferd. Dümmlers Verlag, 1980 and 1991), pp. 191, 288.

79 Robert M. Gates, Office of the Assistant Secretary of Defense (Public Affairs), "Budget Press Briefing," as prepared for delivery on April 6, 2009, available online at <http://www.defenselink.mil/speeches/speech.aspx?speechid=1341>.

CHAPTER 9 > **POWER PROJECTION**

Starting in World War II and continuing to the present, one of the core competencies of the U.S. military has been the capability to project conventional military power overseas on a large scale. On August 7, 1942, some 14,000 U.S. marines went ashore on Guadalcanal, Tulagi and Florida in the Solomon Islands. Once the Japanese had finally withdrawn from the Solomons the following February, they were forced onto the strategic defensive in the Pacific and remained on the defensive for the rest of the war. In November 1942, Guadalcanal was followed by Operation Torch, which began with Anglo-American landings in French Morocco and Algeria. These landings involved the coordination of two armadas, one sailing from Britain and the other from the east coast of the United States; altogether they carried more than 100,000 troops to North Africa.[80] By May 1943, Allied forces had occupied Tunisia and, in conjunction with the British 8th Army advancing west from Egypt, had driven the German and Italian forces from Africa. In June 1944, the cross-Channel Allied landings in Normandy were the largest of World War II. On D-Day, June 6, the Allies put almost 133,000 troops ashore at five landing beaches and inserted another 23,000 airborne troops).[81] The naval armada assembled for the initial assault included over 1,200 warships along with 4,100 landing ships and landing craft.[82] On D-Day some 5,400 British and American fighter aircraft and 6,000 other planes supported the landings.[83] By mid-August 1944, the Allies had broken out of the beachhead, forced the German garrison at Cherbourg to capitulate (June 27), taken St. Lo (July 25), and then driven to the western end of the Cotentin Peninsula. By August 21, the Allies had

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80 Rick Atkinson, *An Army at Dawn: The War in North Africa 1942–1943* (New York: Henry Holt, 2002), p. 22.

81 David G. Chandler and James Lawton Collins, Jr., (eds), *The D-Day Encyclopedia* (New York: Simon & Schuster, 1994), pp. 11, 41, 120–121.

82 Chandler and Collins, *The D-Day Encyclopedia*, pp. 380–381.

83 Chandler and Collins, *The D-Day Encyclopedia*, p. 11.

FIGURE 8. U.S. LANDINGS AT NORMANDY AND LEYTE ISLAND, 1944

landed just over two million men in Normandy in addition to vast quantities of vehicles, equipment, ammunition and supplies.

The power-projection capabilities the United States manifested during World War II were later utilized in Korea in 1950, in Vietnam in 1965, in Iraq in 1990–1991 and, most recently, again in Iraq for OIF in 2003. Prior to the official beginning of OIF's major combat phase on March 19, 2003, the United States amassed around 175,000 troops in theater.[84] By mid-April Saddam Hussein's regime had been overthrown and some 92,000 U.S. troops were occupying Iraq.

A common element in all these examples of traditional U.S. power projection has been the buildup in overseas theaters of large, massed air-ground forces, including mechanized and armored units as well as combat and combat-support aircraft concentrated on regional airbases. Another hallmark of the longstanding U.S. approach to power projection has been the ability to gain control of the air, to attack the full range of targets inside enemy airspace, and to utilize combat aircraft to support ground operations while protecting in-theater bases and ports. Emerging anti-access/area-denial capabilities appear to be explicitly designed to mitigate or negate key elements of the U.S. military's traditional, "industrial" approach to overseas power projection.

The PRC is the nation that is developing the most comprehensive A2/AD capabilities. In the long run, though, the proliferation of significant precision-strike capabilities to smaller countries and even terrorist organizations seems

84 Michael R. Gordon and General Bernard E. Trainor, *Cobra II: The Inside Story of the Invasion and Occupation of Iraq* (New York: Pantheon Books, 2006), p. 551. Cobra, of course, had been the code name for the Allies' July 1944 breakout operation from the Normandy beachheads.

FIGURE 9: 3M-14E CLUB-K IN SHIPPING CONTAINERS*

* Sources: Kontsern-Morinformsistema-Agat marketing video, accessed April 29, 2010, at <http://defensetech.org/2010/04/27/containerized-cruise-missile-featured-in-slick-marketing-video/>; Allocer at Wikipedia Commons. The targets in the Russian video are U.S. tanks, helicopters, and C-5 transports without U.S. markings.

inevitable.[85] As a likely harbinger of things to come, the Russian firm Kontsern-Morinformsistema-Agat has begun marketing its Club-K cruise missile concealed inside a 40-foot shipping container that can be deployed on trucks, rail cars, or merchant vessels.[86] The land-attack variant of Club-K is similar to the U.S. Tomahawk Land Attack Missile (TLAM), but has a smaller warhead (400 kilograms) and shorter range (250 kilometers) than TLAM. Kontsern-Morinformsistema-Agat's promotional video appears to be aimed at countries such as Iran and Venezuela. The vulnerability to such systems of surface ships, ports, airfields and fixed installations of all sorts is that U.S. forces attempting to project ground forces and air power into overseas theaters within range of enemy short-range systems could face substantial attrition or even be denied entry—at least until the adversary's ISR and targeting networks have been negated. The question therefore becomes: Will the emergence of long- and short-range precision strike in the hands of various opponents eventually render the costs of traditional power projection too high in blood and treasure for the United States to bear?

At present, the implicit American assumption seems to be that the answer is "No." Early in any conflict against an opponent with precision-strike systems, U.S. forces expect to be able to take down the other side's long-range strike

85 On July 14, 2006, Hezbollah fighters damaged the Israeli corvette *Hanit* with a cruise missile, most likely a Chinese-designed C-802. At the time, the *Hanit* was patrolling ten nautical miles off the coast of Beruit

86 Thomas Harding, "A Cruise Missile in a Shipping Box on Sale to Rogue Bidders," *Telegraph*, April 25, 2010; Reuters, "Deadly New Russian Weapons Hides in Shipping Container," *The New York Times*, April 26, 2010.

capabilities, much as American air forces have done in previous conflicts by rolling back or negating enemy air defenses. With adversary RUKs suppressed or destroyed, U.S. forces could then revert to traditional power-projection practices based on large ground forces supported logistically through major ports, and air forces operating from a small number of regional air bases. Unfortunately, the growing proliferation of relatively inexpensive short-range precision strike capabilities—guided mortars, artillery shells, rockets, etc.—suggests that even if the adversary's long-range precision-strike capabilities could be eliminated at the outset, it still might be difficult and costly to cling to traditional U.S. power-projection practices. Forward bases and massed ground forces would remain highly vulnerable to precision attacks from dispersed enemy forces using shorter-range systems. Thus, alternatives might have to be found to strategic airlift with planes such as the C-17, to depending on surface shipping to deliver the bulk of equipment and supplies to overseas ports, and to the massing of large, mechanized ground forces in forward theaters.

Worse, if enemy long-range RUKs are able to persist past the opening phase of the campaign, then forcible entry into an overseas theater will become more difficult, as will sustaining those forces once they are in theater. Large forward bases and massed forces seem destined to grow increasingly vulnerable to both long-range and short-range precision strike. In the Western Pacific, for example, it is likely that air bases as far forward as Kadena on the island of Okinawa will no longer be able to sustain meaningful sortie rates or avoid the loss of any high-value assets parked there, including ISR assets such as JSTARS and air-refueling tankers. In that case, some rethinking of the U.S. basing structure in that part of the world may be necessary. Further, long-range adversary RUKs that cannot be quickly suppressed will fundamentally diminish the value of short-range systems such as tactical aircraft, whether land-based or operating from aircraft carriers.

Ultimately, these challenges to traditional U.S. power projection could one day render deploying large, heavy forces overseas and sustaining them through ports and fixed bases prohibitively costly in terms of casualties and equipment attrition. One alternative would be to develop a new approach to overseas power projection. Presumably, the platforms used for forcible entry and logistical sustainment of ground forces within the reach of enemy RUKs would have to be quite different from those relied upon today.[87] Also, ground forces would have to be far more dispersed than in the past. Among other things, it might become too difficult to insert or operate heavy armored forces within range of the opponent's

[87] During Operation Desert Storm, more than three-quarters of the 3,150,796 short tons moved into the theater of operations came by sea—Gulf War Air Power Survey, Vol. V, Part I, Lewis D. Hill, Doris Cook, and Aaron Pinker, *A Statistical Compendium* (Washington, DC: U.S. Government Printing Office, 1993), pp. 80, 84, 90. During World War II, half of the total tonnage shipped from the United States was the six billion barrels of oil the country sent overseas—Daniel Yergin, *The Prize: The Epic Quest for Oil, Money and Power* (New York: The Free Press, 1991 & 2009), pp. 361, 364.

precision strike capabilities, which would be a difficult change for the U.S. Army. An even more disturbing possibility is that the United States' capacity to intervene in overseas crises and theaters will become so constrained that the country's role in the world may end up becoming far less active and interventionist than it has been since 1942.

CHAPTER 10 > **CONCLUSIONS**

Today, the U.S. military appears to be in a comparable position to that in which RAND's civilian strategists found themselves during the early 1950s when they began trying to come to grips with the emergence of thermonuclear plenty and ballistic missiles on both sides of the Iron Curtain. A maturing precision-strike regime in which prospective adversaries—states large and small as well as non-state actors—possess advanced sensors and precision weaponry will present challenges fundamentally different from those the U.S. military has had to face since the end of the Cold War. Dealing with these challenges will require innovative thinking, new operational concepts and organizations, and new long-term strategies if the United States is to retain a dominant military position while avoiding imperial overstretch and economic exhaustion in the years ahead.

From ONA's 1992 MTR assessment to the present, the American military has enjoyed a near monopoly on conventional precision strike. While Soviet military theorists did a better job of thinking through the long-term implications of reconnaissance strike and fire complexes for future warfare than their American counterparts, the "operational execution of MTR ideas and massive fielding of MTR weapons was beyond the political, economic, and cultural capacity of the Soviet state."[88] As a result, the need of the U.S. military since the early 1990s to change their traditional approaches to conventional operations has been minimal. However, as precision-strike capabilities proliferate, it will become less and less feasible for the U.S. military Services to continue simply using precision strike to increase the efficiency and effectiveness of traditional ways of projecting conventional military power and fighting. How fundamental are the changes in weaponry, concepts, and organizations likely to be? The growth and proliferation of anti-access/area-denial capabilities, together with short-range guided

[88] Adamsky, *The Culture of Military Innovation*, p. 37.

munitions, have the potential to bring the era of the aircraft carrier to an end, obviate the ability of short-range, tactical U.S. air power to operate from forward bases, and substantially raise the difficulties and costs of moving heavy ground forces into overseas theaters, much less sustaining them once there. A further complication is that if the technologies and capabilities for precision strike at intercontinental distances emerge and proliferate widely, so will the temptation in time of war to attack the adversary's homeland directly. How this prospect may be affected by the continued existence of nuclear arsenals remains to be seen. But a real possibility is that kinetic and non-kinetic capabilities for directly attacking a country's economic, financial, transportation, and information infrastructures could lower nuclear thresholds.

How soon the U.S. military Services will be forced to begin adapting to these new realities is by no means set in stone. The best guess is that responding to them will become unavoidable within fifteen to twenty years. But there is an important caveat that must be appended to this forecast. The new ways of fighting have yet to be tested in a major conflict between capable adversaries. Until such a test occurs, U.S. military institutions may be able to continue clinging to traditional ways of fighting and avoid the fundamental changes implied by the maturation and proliferation of precision strike. As one participant in ONA's 2009 RMA workshops commented after the third event in December, without "some catalytic event, there would appear to be no strategic imperative for rapid investment in radical change, thus forestalling actual achievement of a true RMA force for decades."[89]

What might a relatively mature precision-strike regime look like? John Stillion has suggested that the maturation of precision strike could propel the United States into a period comparable to that between the 1870 Franco-Prussian War and the beginning of World War I in 1914. Starting in the 1860s, the development of steam power for oceanic transport and railway networks fundamentally changed the time and distance factors of war; the telegraph permitted a previously-unheard-of degree of centralization in directing operations; and the development of machine guns and breech-loading, rifled artillery provided new levels of tactical lethality.[90] These were the sinews of industrial warfare based on iron, steam, and mass. Coupled with the German general staff system, they produced a new way of fighting during the wars of German unification, which culminated in May 1871 when Wilhelm I was crowned emperor of the German Empire—the Second Reich.[91] This new way of fighting may have helped create the German state, but against opponents who had yet to master industrial war. That more stringent test came in 1914, and on the Western Front it led to the costly

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[89] James FitzSimonds, "Thoughts from the 11 December 2009 RMA Meeting," p. 2.

[90] General Rupert Smith, *The Utility of Force: The Art of War in the Modern World* (New York: Alfred A. Knopf, 2007), pp. 70–71, 75–78, 81

[91] Smith, *The Utility of Force*, pp. 97, 102.

stalemate of trench warfare. In September 1914, with the Germans bringing up reinforcements to drive through to Paris, General Joseph Gallieni mobilized an armada of Paris taxicabs to move thousands of troops to the front at the critical point, just in time to stymie the German advance in the Battle of the Marne.[92] Thereafter, massive firepower severely constrained movement and maneuver, and the fighting on the Western Front "took on a wholly attritional nature."[93] Stillion's point is that the proliferation of precision fires could lead, once again, to a period in which "firepower dominates movement, and … battles between powerful opponents tend to become costly and inconclusive."[94]

Of course, this vision of future warfare presumes that neither side can eliminate the other's RUKs, particularly their associated sensors and targeting networks. Yet in early 1990s RMA wargaming, with both sides armed with robust precision strike capabilities, eliminating the opponent's ability to see and strike deep tended to surface as *the* overriding operational priority. Moreover, for either side, the ability to win what Krepinevich has termed the "scouting battle" is likely to hinge on the precise relationships between information acquisition and information denial—Vickers' hider-finder competition. Here, even a slight edge could very well prove decisive. That said, sufficient advantage in the hider-finder competition at some future date to enable one side to blind the other would surely depend on tactical details that are impossible to predict with any certainty. If survivable reconnaissance-strike complexes proliferate, and if it proves difficult to hide large military forces even in cluttered environments, then traditional overseas power projection against any competent foe could become too costly to remain viable. Such an outcome might eventually force the American national security establishment to rethink the United States' role in the world. At the same time, should A2/AD capabilities proliferate widely enough, they could also constrain overseas power projection by other countries, including China. But although both outcomes are possible, they are by no means certain. They hinge ultimately on changes in operational realities and the international security environment that are extraordinarily resistant to prediction.

How much and how fundamentally may the conduct of war change by 2040 or 2050? The short but honest answer is: it depends. This paper has explored five of the more obvious and consequential possibilities. Some of them are undoubtedly better understood and more imminent than they were in 1996 when Vickers produced his broad vision of war in a non-nuclear missile age in which guided conventional munitions approach the effectiveness of nuclear warheads. It is also important to keep in mind that others may, for cultural reasons (among others), exploit the maturing precision-strike regime in ways quite different from those

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92 Yergin, *The Prize*, pp. 152–154.

93 Smith, *The Utility of Force*, p. 115.

94 John Stillion, "11 December Workshop on the RMA at CSBA," December 10, 2009, email, p. 2.

embraced by the U.S. military Services.[95] So far at least, the United States has not tried to develop the kind of "keep-out" zones based on A2/AD capabilities that the Chinese are pursuing. Nevertheless, the honest answer to the question about how fundamentally war's conduct will change—and how soon—remains: it depends.

95 For insight into just how different U.S., Russian, and Israeli approaches to the RMA have been, see Adamsky's 2010 *The Culture of Military Innovation*. To a considerable extent these differences in approach are reflected in the specific organizations that led thinking about the RMA in these three countries. In the Soviet Union the lead institution was the General Staff; in the United States it was the Office of Net Assessment, and in Israel it was the Operational Theory Research Institute. To put it mildly, these were vastly different organizations with dramatically different cognitive styles, charters, and positions within their respective defense establishments.

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