CHAPTER THREE

The Value of Military Satellites

THE survey of U.S. and Soviet space programs in the preceding chapter details what each side is doing in space. This chapter examines how those space assets contribute to the national security and military effectiveness of the superpowers on earth. For without a clear picture of the current and future value of military satellites, no decisionmaker can prudently judge what is at stake in the debate over antisatellite weapons. Only by understanding the role that satellites play in preserving the armed peace between the superpowers is it possible to judge how their potential vulnerability could undermine it. Similarly, only by understanding the role of satellites in wartime is it possible to judge whether the reasons advanced for developing ASAT weapons are sound. Finally, only by judging the *relative* value of satellites to the superpowers it is possible to conclude whether one side has any more to lose in the event of hostilities.

Assessing the Importance of Satellites

According to statements by American officials, the United States is now heavily dependent on the services of military satellites. How dependent is a matter of some disagreement. During his tenure as undersecretary of the U.S. Air Force, Edward C. Aldridge, Jr., stated that "US satellites have become essential to national security and must

be safeguarded."[1] Likewise, George Keyworth III, a former science adviser to President Ronald Reagan, has argued that "even in a very limited war, we would have an absolutely critical dependence on space today."[2] A report from the congressional Office of Technology Assessment, however, dissents from this viewpoint: "Space systems are used extensively for military support, but satellites do not now fill a crucial, indispensable, and irreplaceable role. Many functions now carried out in space can be performed by other means."[3]

Similar differences of opinion exist over the relative dependency of the superpowers on space systems. The U.S. Joint Chiefs of Staff in their fiscal 1987 military posture statement reported that "both the United States and the Soviet Union depend on space systems for operational support, the United States more so than the Soviet Union."[4] Yet when asked to comment on this, Secretary of Defense Caspar W. Weinberger replied: "It is not clear that we depend more heavily. We depend on it very heavily. They depend on satellites to a great extent, too."[5]

How can these conflicting appraisals be evaluated? In making judgments about "value" and "dependency," it is essential to draw a distinction between the importance of the mission that a satellite supports and the importance of the satellite to executing that mission. The former depends largely on contextual factors; many satellites have peacetime missions, such as arms control treaty monitoring and early warning of hostile activities, that are critically important yet largely irrelevant once war begins. Similarly, the type of conflict in which the superpowers could become engaged, whether it is a war between third world client states or a full-scale nuclear exchange between themselves, would also determine the usefulness and therefore value of certain satellites. How

1. Quoted in Robert C. Toth, "Military Shuttle in Key Part of Pentagon Plan," *Los Angeles Times*, January 20, 1985.

2. Quoted in Robert A. Kittle, "Space-War Era—It's Already Here," *U.S. News and World Report* (December 17, 1984), p. 30.

3. U.S. Congress, Office of Technology Assessment, *Arms Control in Space: Workshop Proceedings*, OTA-BP-ISC-28 (Government Printing Office, 1984), p. 11.

4. U.S. Joint Chiefs of Staff, *United States Military Posture, FY 1987* (GPO, 1986), p. 81.

5. *Department of Defense Authorization for Appropriations for Fiscal Year 1985*, Hearings before the Senate Committee on Armed Services, 98 Cong. 2 sess. (GPO, 1984), pt. 1, p. 87. For similar assessments see also John Pike, "Anti-Satellite Weapons," *F.A.S. Public Interest Report*, vol. 36 (November 1983), p. 2; and Nicholas L. Johnson, "C^3 in Space: The Soviet Approach," *Signal*, vol. 40 (December 1985), p. 21.

each superpower intends to fight a war is another factor influencing the value of its space assets. The combatants' operational plans may demand different services from their satellites.

The importance of a satellite to the mission is contingent not only on whether alternative means are available but also on how efficiently the auxiliary systems can perform the task. To a large extent, each superpower can decide how dependent it wishes to be on a given space system for a specific mission. Provision can be made for additional backup satellites, either pre-positioned in space or deployed ready for launch. Nonsatellite alternatives can also be procured and maintained to further increase the level of redundancy. Even so, contextual factors can again determine the importance of satellites. In particular, the location of a conflict can increase or decrease the reliance on satellite services. For example, the use of satellites for communication and intelligence gathering is likely to be much higher when the conflict is in a remote part of the world than when it is close to one's national borders. Auxiliary systems such as reconnaissance aircraft that rely on the support of host nations in remote areas are also subject to political factors that could impede operations. Even when alternative means are available, these may be more vulnerable to wartime attrition, thereby raising the value of satellites over the duration of the conflict.

The level of dependency on space systems is not therefore a static condition. Simply stated, not all satellites are important all of the time. The factors identified here that determine the value of space systems become more apparent in the following discussion of the missions of military satellites in peacetime, in a conventional war, and in a nuclear conflict.

Peacetime Missions

The peacetime uses of military satellites can be divided into five principal missions: intelligence gathering, arms control monitoring, war planning, crisis management, and early warning of attack. As will become clear, the same satellites are often used for more than one mission.

—*Intelligence gathering.* Reconnaissance satellites, particularly those that return visual evidence, have become without doubt the most reliable and productive source of military intelligence for both superpowers. Not only is highly detailed imagery available from satellites on a more regular

basis (cloud cover permitting)[6] than from other intelligence sources, but the evidence of military activities that they present is considerably less ambiguous than the product of other national technical means and especially human intelligence sources. The information supplied by photoreconnaissance and signals intelligence (SIGINT) satellites has become invaluable for defense planning in general and weapon procurement in particular. For example, defense planners can evaluate the strengths and weaknesses of opposing weapon systems and design their countermeasures accordingly. Theoretically at least, this prevents wasteful expenditures on unnecessary or outmoded weaponry.

—*Arms control monitoring.* The process of monitoring compliance with arms control agreements is virtually identical to that of intelligence gathering. The only real difference is that the reconnaissance assets may be tasked to concentrate on specific areas or events to meet the verification requirements of a particular accord. Thus, if a violation is suspected, coverage by photoreconnaissance satellites is likely to increase to collect more evidence. SIGINT satellites have also proved to be particularly useful aids to verification. For example, the collection and analysis of telemetry signals from flight tests of ballistic missiles can indicate the likely range, payload, throw weight, accuracy, and number of warheads carried by a new system.[7]

Although the Soviet Union does not appear to have an equivalent system, the United States uses the nuclear explosion detection sensors aboard its Defense Support Program (DSP) satellites (and, in the future, will use those aboard its Navstar GPS satellites) for monitoring compliance with the Limited Test Ban Treaty and the Nuclear Non-Proliferation Treaty.

—*War planning.* Photoreconnaissance satellites are the principal source of intelligence for the strategic targeting plans of the superpowers.[8] Without precise information on the location of potential aimpoints

6. Meteorological satellites are useful for planning photoreconnaissance missions to forestall taking pictures of clouded areas. See Desmond Ball, "The Defense Meteorological Satellite Program (DMSP)," *Journal of the British Interplanetary Society*, vol. 39 (1986), p. 45.

7. See Desmond Ball, "The Rhyolite Programme," Reference Paper 86 (Canberra: Australian National University, Strategic and Defence Studies Centre, November 1981), pp. 19–22; and Farooq Hussain, *The Future of Arms Control—Part IV: The Impact of Weapons Test Restrictions,* Adelphi Papers 165 (London: International Institute for Strategic Studies, 1981), p. 42.

8. Jeffrey Richelson, "The Keyhole Satellite Program," *Journal of Strategic Studies*, vol. 7 (June 1984), p. 144.

such as missile silos and command centers, counterforce targeting options simply would not be available.[9] Satellites also contribute directly to the accuracy of strategic nuclear delivery systems. The accurate mapping of the earth's surface carried out by geodetic satellites is invaluable for targeting intercontinental ballistic missiles (ICBMs) and submarine-launched ballistic missiles (SLBMs).[10] One estimate is that the accuracy of the Trident II SLBM will increase as much as 10 percent for certain potential launch areas through the use of the U.S. Navy's Geosat satellite.[11] Similarly, the U.S. strategic cruise missiles now entering service rely on guidance information originally derived from satellite imagery that has been converted into digital format for storage in the on-board computer. Once launched and over land, the cruise missile will be able to correlate radar altimeter readings with the stored data.[12]

Both superpowers also use SIGINT satellites to draw up the "electronic order of battle" of their adversary. Besides acquiring information on the whereabouts of radar systems (particularly the mobile variety) for direct targeting in wartime, the characteristics of radar signals—their frequency, strength, pulse length, and pulse rate—are plotted for electronic countermeasures (ECM) such as jamming and "spoofing."[13] This allows bomber and strategic reconnaissance aircraft to plan their penetration routes into enemy airspace and suppress the defenses they encounter.[14]

9. Thomas Karas, *The New High Ground: Systems and Weapons of Space Age War* (Simon and Schuster, 1983), p. 109.

10. Desmond Ball, "Geodetic Satellites," Reference Paper 125 (Canberra: Australian National University, Strategic and Defence Studies Centre, October 1984).

11. "Geosat Data to Aid Trident 2 Accuracy," *Aviation Week and Space Technology*, vol. 117 (July 19, 1982), p. 26.

12. "Mapping Agency to Expand Digital Use," *Aviation Week and Space Technology*, vol. 121 (July 16, 1984), p. 52; James B. Schultz, "Cruise Missile Deployment Marked by System Upgrades and Operational Tests," *Defense Electronics*, vol. 16 (May 1984), p. 52; and John C. Toomay, "Technical Characteristics," in Richard K. Betts, ed., *Cruise Missiles: Technology, Strategy, Politics* (Brookings, 1981), p. 39.

13. Ball, "Rhyolite Programme," pp. 16–18.

14. It was for this mission that the Soviet Union accused the United States of using signals intelligence (SIGINT) satellites in coordination with the incursion of the Korean airliner KAL 007 into Soviet airspace in September 1983. Serge Schmemann, "Soviet Cites Role of U.S. Satellite," *New York Times*, September 20, 1983. See also P. Q. Mann, "Reassessing the Sakhalin Incident," *Defense Attaché*, no. 3 (1984), pp. 41–56; and "Soviet Union Offers Proof KAL 007 Was on Spy Mission," *Defense Electronics*, vol. 16 (March 1984), pp. 20–21.

—*Crisis management*. Reconnaissance satellites are especially useful for monitoring events or conflicts that threaten superpower stability. Certainly they are invaluable when alternative surveillance methods—principally aircraft—are difficult to use for geographical or logistical reasons, or if they are likely to be politically inflammatory or militarily hazardous. The Soviets in particular have come to rely on these satellites for observing third world conflicts, as evidenced by the frequency of launches during specific crises and the manipulation of satellite ground tracks to increase the coverage of key areas of interest.[15]

With their advantages for long-distance communication, satellite links have become important aids to international crisis management. Admiral James D. Watkins has recalled that while acting as chairman of the Joint Chiefs of Staff during the U.S. peacekeeping operations in Lebanon, "I communicated from my quarters, in the middle of the night, with our Marine peacekeepers on the ground in their foxholes near the Beirut airport. This proved to me the incredible value of our capabilities in space for immediate command and control, linkages so vital to the decisionmaking process."[16] Another recent illustration is the Gulf of Sidra incident of October 1981, when U.S. Navy aircraft destroyed two Libyan fighters. Information on the incident was back to the White House in less than a minute and subsequent events were monitored virtually as they occurred.[17]

The U.S. Diplomatic Telecommunications Service relies heavily on Defense Satellite Communications System (DSCS) spacecraft for connecting the State Department with its embassies and consulates abroad. At a higher level, NATO has developed its own satellite communication system linking alliance capitals and military command centers to permit multilateral consultations in a serious crisis.[18] Similarly, satellite communication was the obvious choice for modernizing the U.S.-Soviet hot line that is known officially as the Direct Communications Link.[19]

15. Recent examples have been the Iran-Iraq war, the Libyan withdrawal from Chad, and the U.S. invasion of Grenada.

16. Quoted in L. Edgar Prina, "Signal Flags to Satellites," *Sea Power*, vol. 26 (December 1983), p. 45.

17. Ibid., p. 45.

18. See Sir John Anderson, "The Evolution of NATO's New Integrated Communications System," *NATO's Fifteen Nations* (Special issue 2, 1980), pp. 26–30; Larry K. Wentz and Gope D. Hingorani, "Outlook for NATO Communications," *Signal*, vol. 37 (December 1982), pp. 53–59; and I. Mason-Smith, "NATO SATCOM—A Synopsis of Its Technological Evolution," *NATO's Fifteen Nations*, vol. 26 (October–November 1981), pp. 28–32.

19. This now consists of a leased circuit through an Intelsat IV satellite with ground

—*Early warning*. Among the first and still most critical tasks carried out by satellites is to provide strategic and tactical early warning of attack. Strategic warning refers to indications that an attack is being prepared, while tactical warning refers to evidence that one is either imminent or under way.

In a serious crisis involving the United States and the Soviet Union, reconnaissance satellites are likely to provide the earliest indications that military operations are being planned. The dispersal of bombers and theater nuclear forces from their peacetime bases, the "flushing" of ballistic missile submarines from port, and the general mobilization of conventional forces are classic strategic warning indicators. SIGINT satellites complement their photoreconnaissance cousins in warning of heightened or unusual military activity. An increase in signals traffic to a sensitive area, the formation of new tactical communication nets, the call signs of new military units, changes in the radio frequencies used by frontline troops, and, of course, the interception of attack orders can all indicate preparations for war.[20] Signals intelligence may in some cases provide the only source of strategic warning, as photographic evidence may be unavailable for climatic or other reasons.

The principal function of the ballistic missile early warning satellites is to provide positive evidence that an attack has started—in other words, tactical warning. In the case of an ICBM attack, these satellites may give as much as twenty-five minutes' warning time before the missiles reach their targets, while with submarine-launched and intermediate-range ballistic missiles, the time may be considerably less depending on the location of the launch. The role and value of ballistic missile early warning satellites will be discussed more fully in the section dealing with nuclear operations.

In addition to these five principal missions, satellites provide general support for peacetime military operations. This includes weather forecasting, navigation, and communications. For example, a frequently cited statistic is that more than 70 percent of all long-haul U.S. military

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stations in Etam, West Virginia, and Moscow, and another circuit through a Soviet Stationar satellite with its ground stations at Vladimir in central Russia and Fort Detrick, Maryland. See Desmond Ball, *Can Nuclear War Be Controlled?* Adelphi Papers 169 (London: International Institute for Strategic Studies, 1981), p. 22; and "Text of the 1963 Hot Line Agreement with 1971 and 1984 Amendments," in Barry M. Blechman, ed., *Preventing Nuclear War: A Realistic Approach* (Bloomington: Indiana University Press, 1985), pp. 189–91.

20. William J. Broad, "Experts Say Satellite Can Detect Soviet War Steps," *New York Times*, January 25, 1985.

communication goes via satellite.[21] While in peacetime a great deal of this traffic is made up of such routine, nonurgent messages as inventory stock requests and personnel information, a major proportion is for the U.S. intelligence community, which takes advantage of high-capacity communication satellites, especially those using the superhigh-frequency (SHF) band such as the DSCS II and III systems, to shift large amounts of raw data from points all over the globe to the United States for processing.[22]

Several general conclusions emerge about the relative superpower dependency on satellites in peacetime. Given the closed nature of Soviet society, the United States is plainly more dependent on reconnaissance satellites for intelligence gathering and arms control verification. No comparable alternatives are available for penetrating the veil of secrecy that envelops the Eastern bloc. This asymmetry should not be exaggerated, however. The Soviets also need photoreconnaissance satellites for observing activities in China, for strategic targeting purposes, and for corroborating intelligence obtained from other sources. They may be able to collect vast quantities of information from the U.S. press and from congressional hearings, but there are still highly classified U.S. military installations and research facilities that can be inspected only from space. Moreover, the Soviets have on balance a greater dependence on photoreconnaissance satellites for monitoring activities in remote parts of the world. American forces, in comparison, have more alternative means at their disposal, such as SR-71 and TR-1 reconnaissance aircraft, that can operate far from the continental United States with in-flight refueling or from numerous bases around the world.[23] Although

21. Quoted in Richard Halloran, "U.S. Plans Big Spending Increase for Military Operations in Space," *New York Times,* October 17, 1982.

22. The CIA is reported to operate its own covert satellite system for communicating with agents or emplaced sensors abroad. See Desmond Ball, "CIA Covert Communications Satellites," Reference Paper 100 (Canberra: Australian National University, Strategic and Defence Studies Centre, October 1981); and Dusko Doder, "Soviet Jailed as Alleged Spy for CIA," *Washington Post,* August 23, 1983. The KGB uses communication satellites for the same purpose. See *Soviet Space Programs: 1976–80,* pt. 3: *Unmanned Space Activities,* Committee Print, Senate Committee on Commerce, Science, and Transportation, 99 Cong. 1 sess. (GPO, 1985), p. 1088.

23. The SR-71 has an unrefueled range of more than 3,000 miles and can reportedly photograph an area of 100,000 square miles at an altitude of 80,000 feet in one hour. For more information on the SR-71, see Jay Miller, *Lockheed SR-71* (A-12/YF-12/D-21) (Arlington, Tex.: Aerofax Inc., 1985), pp. 4–5; and Robert R. Ropelewski, "SR-71 Impressive in High-Speed Regime," *Aviation Week and Space Technology,* vol. 114

the Soviets also have long-range reconnaissance aircraft, these planes are generally considered inferior to their U.S. counterparts, and they do not have access to as many foreign bases. This is true of U.S. and Soviet SIGINT systems as well.[24]

Conventional War Missions

Support of conventional force operations is the area where military space systems have had the most impact in recent years. It is also the area that shows the greatest promise for expansion in the future. Though modern warfare can no longer be neatly separated into ground, air, and maritime operations, it is useful for analytical purposes to discuss the growing contribution of satellite services to conventional warfare in these three areas.

Ground Operations

Ground forces have probably been the last of the armed services to benefit from satellite support. This is now changing as reconnaissance, communication, and navigation satellites begin to play a larger role in aiding land operations.

In wartime, the contribution of reconnaissance satellites has always been limited by the unavoidable delay in repeating the overflight of a specific area (due to the rotation of the earth under a satellite's orbit)

(May 18, 1981), pp. 47–56. The TR-1 reportedly can cover 263,014 square miles an hour from an altitude of 65,000 feet. See Col. William V. Kennedy and others, *Intelligence Warfare* (New York: Crescent Books, 1983), p. 142; and "TR-1s Provide High-Altitude Reconnaissance and Surveillance," *Aviation Week and Space Technology,* vol. 123 (August 5, 1985), pp. 59–62. Both the SR-71 and TR-1 use synthetic aperture radars that permit stand-off reconnaissance at night and in any weather. See speech by Donald C. Latham, *Signal,* vol. 39 (August 1985), p. 40. One advantage of the TR-1 over the SR-71 is that it can downlink information almost instantaneously, while the SR-71 has to return to base. See *Department of Defense Appropriations for 1986,* Hearings before a Subcommittee of the House Committee on Appropriations, 99 Cong. 1 sess. (GPO, 1985), pt. 2, p. 377.

24. For more information on alternative U.S. and Soviet SIGINT systems, see Kennedy and others, *Intelligence Warfare,* pp. 152–65; and more specifically Martin Streetly, "US Airborne ELINT Systems—Part 3: The Boeing RC-135 Family," *Jane's Defence Weekly,* vol. 3 (March 16, 1985), pp. 460–65; and Martin Streetly, "US Airborne ELINT Systems—Part 4: The Lockheed SR-71A," *Jane's Defence Weekly,* vol. 3 (April 13, 1985), pp. 634–35.

and the time needed to process and transmit tactically relevant intelligence to field commanders. As Admiral Wesley McDonald, the commander of U.S. forces during the Grenada invasion, pointed out after the operation, "We have designed and are continuing to design systems which collect intelligence in great volume and in near-real time, but I am concerned as to whether we are designing into these systems the communications capability to get that data to the tactical commander in a usable fashion and in a timely manner." The admiral went on to lament: "What good is sophisticated satellite imagery sitting in Washington, D.C., or Norfolk, Va., when the field commander who needs it is on the ground in Grenada, on a ship off Lebanon, or in some even more remote corner of the world?"[25]

At least one of the superpowers is endeavoring to change this situation. As the former director of the U.S. Defense Advanced Research Projects Agency (DARPA), Robert S. Cooper, has stated: "A key goal of DoD programs in the past seven or eight years has been to make intelligence information from satellites also available to field commanders in real-time."[26] The most important of these programs is known as TENCAP, for Tactical Exploitation of National Capabilities.[27] Each service including the Marine Corps is procuring special receiver and processing equipment, sometimes called "fusion centers," to receive satellite imagery and signals intelligence. Satellite photos were apparently used to direct the U.S. naval bombardment of Lebanon in 1983. According to one report:

> New Marine Corps target acquisition radars were able to backtrack incoming artillery rounds and locate enemy gun positions to within about 30 meters. When those data were correlated with satellite imagery, the positions were quickly targeted to within about 13 meters accuracy—well within the lethal radius of the battleship *New Jersey*'s 16-in guns.[28]

25. "McDonald Reviews C3I during Grenada Operation," *Aerospace Daily,* December 16, 1983.

26. Robert S. Cooper, "No Sanctuary: A Defense Perspective on Space," *Issues in Science and Technology,* vol. 11 (Spring 1986), p. 43.

27. "Army, Intel Officials Note TENCAP Uses," *Military Space* (October 29, 1984), p. 1. See also "Eye in the Sky for the Grunts on the Ground," *Defense Week,* vol. 6 (November 4, 1985), p. 11; and *Department of Defense Appropriations for 1987,* Hearings before a Subcommittee of the House Committee on Appropriations, 99 Cong. 2 sess. (GPO, 1986), pt. 3, pp. 680–81.

28. Deborah G. Meyer, "DoD Likely to Spend $250 Billion on C³I through 1990," *Armed Forces Journal International,* vol. 122 (February 1985), p. 75. Unfortunately, the accuracy of the *New Jersey*'s guns did not match up to the targeting data it had received.

The new generation of U.S. photoreconnaissance satellites due to become operational by the end of the 1980s will probably be able to downlink imagery directly to senior field commanders without today's time delays. As a result, satellites will make a larger contribution to battlefield intelligence gathering and, with it, the targeting of enemy forces. However, although local commanders will receive intermittent "snapshots" of the battlefield, *constant* real-time surveillance of events, for reasons discussed in chapter 2, will not be available for the foreseeable future.

It is difficult to judge how fast the Soviets are moving in the same direction. Although they have developed a space-based ocean reconnaissance system as a naval tactical targeting aid (see below), their use of digital transmission links to hasten the flow of imagery from photoreconnaissance satellites is relatively new. It seems fair to assume, therefore, that while the Soviets can be expected to make greater use of reconnaissance satellites for tactical purposes, they still lag behind the United States in this regard.

The advent of small transportable satellite communication terminals and even man-pack-sized radio transceivers has permitted an unprecedented degree of control over military operations. This is particularly true for operations in areas not well served by alternative means. To quote again from Admiral Wesley McDonald's report of the 1983 U.S. invasion of Grenada: "Satellite communications were used in most cases all the way from the company level to the JCS. . . . We had several satellite channels assigned, so we made extensive use of man-pack satellite terminals. . . . I don't think I will surprise anyone when I say that in this type of operation, satellite connectivity is absolutely essential."[29]

While the tactical use of communication satellites by U.S. forces is becoming quite common, the adoption of small portable or easily transportable terminals by Soviet ground forces does not seem so widespread, no doubt reflecting technical inferiorities and to some extent Soviet command style.[30] Nevertheless, the Soviets obviously recognize the benefits of satellite communication as indicated by the effort they

29. "McDonald Reviews C3I during Grenada Operation," *Aerospace Daily*, December 16, 1983.

30. Stephen M. Meyer, "Space and Soviet Military Planning," in William J. Durch, ed., *National Interests and the Military Use of Space* (Cambridge, Mass.: Ballinger, 1984), p. 72.

expend maintaining their various constellations in orbit for this purpose.[31] As a consequence, the use of communication satellites by Soviet forces is becoming more evident, with terminals present at army group and divisional headquarters.[32]

When the Navstar Global Positioning System (GPS) becomes fully operational, U.S. ground troops will for the first time make use of navigation satellites that have hitherto been used almost exclusively by naval forces. Besides allowing ground forces to navigate better, particularly in desert and jungle areas, it should also significantly improve the accuracy and coordination of artillery barrages, air-to-ground attacks, and parachute supply drops. Since each of the relevant users will be operating from common time and position data supplied by Navstar, the chances of error should diminish dramatically.[33]

Air Operations

For the same reasons that apply to the land battle, the added intelligence input from reconnaissance satellites will be particularly useful for planning ground attack and long-range interdiction strikes from the air. Meteorological satellites have already proved their worth in operations like these. The receipt of timely and accurate weather information is critical for air operations. It enables military commanders to decide whether to postpone a mission, what route to take, when and where to strike a particular target, from what altitude, and sometimes even what type of ordnance to use.[34] During the war in Southeast Asia, weather satellites proved their worth for the first time.[35] As Air Force General William Momyer stated:

31. The store-dump low-altitude communication satellites are often identified as tactical-theater communication systems.

32. Charles Dick, "Soviet C^3 Philosophy: The Challenge of Contemporary Warfare," *Signal*, vol. 39 (December 1984), p. 49; and James C. Bussert, "Soviet Military Communications in the 1980's," *Defense Electronics*, vol. 15 (October 1983), p. 139. The Soviets have reportedly deployed satellite terminals in Bagran, Afghanistan, and close to the SA-5 air defense missile batteries that they control in Syria. See Jon L. Boyes, "Scanning Soviet C^3," *Signal*, vol. 39 (December 1984), pp. 15–16; and Meyer, "Space and Soviet Military Planning," p. 71.

33. Richard W. Blank, "The NAVSTAR Global Positioning System," *Signal*, vol. 41 (November 1986), p. 78.

34. Maj. Thomas L. Sack, USAF, "Air Weather Service as a Force Intensifier," *Air Force Magazine*, vol. 63 (November 1980), p. 110.

35. See Henry W. Brandli, "The Use of Meteorological Satellites in Southeast Asia

> As far as I am concerned, this weather picture is probably the greatest innovation of the war. I depend on it in conjunction with the traditional forecast as a basic means of making my decisions as to whether to launch or not to launch a strike. . . . The [DMSP] satellite is something no commander has ever had before in a war.[36]

The U.S. Air Force and Marines are procuring new transportable and rapidly deployable terminals to make Defense Meteorological Satellite Program (DMSP) weather data available wherever American forces are sent in sizable numbers. The Harris MK IV terminal, which can be airlifted by C-130 transport planes, then off-loaded, assembled, and made operational by a three-man crew in less than six hours, receives both hard and soft copy data and allows retransmission of soft copy over battlefield telephone lines to other tactical commanders.[37] The Soviets no doubt find meteorological satellites equally useful for the same reasons.

The latest, and arguably most valuable, contribution of satellites to U.S. air operations will come with the full deployment of the Navstar GPS system. Since 1977 the U.S. Air Force at its Yuma Proving Ground in Arizona has been exploring the applications of the Navstar system, with impressive results. Using six satellites simulating the full constellation, helicopters have made blind landings within several feet of the designated spot, jet fighters have rendezvoused with tanker aircraft for refueling without the help of other navigational aids, cargo aircraft have parachuted supplies within thirty to forty feet of a ground marker, and fighter-bombers have delivered conventional "iron bombs" to their target with the precision of "smart" munitions.[38] In wartime, the impact of Navstar GPS is expected to be dramatic. The efficiency of bombing operations in terms of the quantity of munitions and the number of sorties required to perform a given mission is likely to improve signifi-

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Operations," *Aerospace Historian*, vol. 29 (September 1982), pp. 172–75. Britain reportedly also relied on U.S. meteorological satellites to pick the optimum time to conduct its amphibious assault on the Falkland Islands. See Defense Marketing Services Inc., "NOAA," *DMS Market Intelligence Report* (Greenwich, Conn., 1984).

36. Quoted in Desmond Ball, "Code 417, The Defense Meteorological Satellite Program (DMSP)," draft of paper prepared at the Strategic and Defence Studies Centre, Australian National University, Canberra, Australia, December 1984.

37. James B. Schultz, "Air Force Budget Emphasizes Research and Development," *Defense Electronics*, vol. 16 (September 1984), p. 74.

38. *Department of Defense Authorization for Appropriations for Fiscal Year 1981*, Hearings before the Senate Committee on Armed Services, 96 Cong. 2 sess. (GPO, 1980), pt. 5, p. 2674. See also Karas, *New High Ground*, chap. 5.

cantly. For example, some predict that for close air support operations and long-range interdiction of ground targets, the "kill probabilities" could improve by several orders of magnitude.[39] Navstar receivers are already being fitted to F-111 long-range bombers, F-16 fighters, and tanker aircraft.

Scant information is available on how the Soviet Union intends to use its Glonass navigation system in wartime, but given the similarities with Navstar, one can expect many of the same applications.

The majority of the present applications of satellites for air operations relate to ground attack missions. In the future it is conceivable that spacecraft will be used to support air defense operations. Just as AWACS aircraft today warn of attacks and coordinate interceptor aircraft, so spacecraft could become the ultimate battle management platform for air defense. As discussed in the preceding chapter, the use of space-based radars and infrared sensors for this purpose is already being investigated in the United States. General Lawrence A. Skantze, commander of Air Force Systems Command, has graphically depicted the benefits of such a system: "Information [from the space sensors] could be passed through AWACS to our fighters. We could then more selectively scramble our fighters to splash incoming targets."[40] Though attractive, space-based air defense sensors are unlikely to be available before the late 1990s. Major questions of cost effectiveness and vulnerability still need to be resolved.

Naval Operations

Arguably, naval forces have been the greatest beneficiaries of military satellite support. Ocean reconnaissance, communication, navigation, and meteorological satellites all contribute in important ways to maritime operations.

For well over a decade the United States and the Soviet Union have employed satellites for ocean reconnaissance. The United States appears

39. K. D. McDonald, "Navigation Satellite Systems: Their Characteristics, Potential and Military Applications," in Bhupendra Jasani, ed., *Outer Space—A New Dimension of the Arms Race* (London: Taylor and Francis for the Stockholm International Peace Research Institute, 1982), p. 178. For other examples, see David A. Boutacoff, "Navstar Forecast: Cloudy Now, Clearing Later," *Defense Electronics*, vol. 18 (May 1986), p. 99.

40. Quoted in Edgar Ulsamer, "What's Up in Space," *Air Force Magazine*, vol. 69 (February 1986), p. 48.

to use its space-based ocean reconnaissance system for general intelligence gathering on the worldwide deployment of naval forces. In contrast, the Soviet ocean reconnaissance system appears specifically designed to support the primary mission of the Soviet navy in wartime, which is to prevent U.S. naval forces, especially carrier battle groups and attack submarines, from coming within striking range of the Soviet homeland and in particular the bastions for its ballistic-missile-carrying submarines in the Barents Sea and the Sea of Okhotsk.[41] The Soviet RORSAT and EORSAT satellites would provide early warning of the movement of U.S. naval forces in the principal avenues of approach to the Soviet submarine bastions, information that could then be used to target those surface ships.

Despite the operational shortcomings of both the EORSATs and RORSATs (discussed in chapter 2), the Soviets clearly believe that these satellites will play an active role in wartime. As the director of U.S. naval intelligence, Rear Admiral John Butts, reported to Congress: "The new generation of ships and submarines entering the Soviet fleet are equipped to receive surveillance and targeting data directly from satellites and we believe their navy will rely increasingly on such data in the years ahead."[42] Long-range attacks by *Backfire* bombers armed with stand-off cruise missiles are another option that the Soviets have apparently exercised.[43] Furthermore, attacks on U.S. carrier battle groups by land-based intermediate-range ballistic missiles cannot be ruled out, certainly in nuclear contingencies.[44]

41. On the wartime missions of the Soviet navy, see U.S. Department of Defense, *Soviet Military Power, 1985* (GPO), pp. 91–92; Michael MccGwire, "Naval Power and Soviet Global Strategy," *International Security*, vol. 3 (Spring 1979), pp. 134–89; and Louise Hodgden, "Satellites at Sea: Space and Naval Warfare," *Naval War College Review*, vol. 32 (July–August 1984), pp. 31–45.

42. *Department of Defense Authorization for Appropriations for Fiscal Year 1986*, Hearings before the Senate Committee on Armed Services, 99 Cong. 1 sess. (GPO, 1986), pt. 8, p. 4366.

43. Hodgden, "Satellites at Sea," p. 40; Paul Bracken, *The Command and Control of Nuclear Forces* (Yale University Press, 1983), p. 153.

44. See Robert P. Berman and John C. Baker, *Soviet Strategic Forces: Requirements and Responses* (Brookings, 1982), p. 55. Berman and Baker state that "within ninety minutes of detection, enemy combat vessels or high-value convoys on the open seas could be struck by ballistic missiles fired from either sea or land." Ibid., p. 163. Such attacks, however, would not be easy to execute given the inevitable delays in processing the intelligence, changing the missile's guidance system, and reaching the target. The potential for midcourse targeting updates could make this more feasible in the future, however.

Although ocean reconnaissance satellites do not appear to play such an active role in U.S. naval operations, communication satellites, by contrast, have become virtually indispensable. According to one report the U.S. Navy now relies on satellites for relaying 95 percent of all its messages.[45] Terminals for using the FLTSATCOM and Leasat spacecraft are fitted to all of the navy's major surface ships, submarines, P-3C Orion aircraft, and shore stations around the world.[46] These are interconnected through the fleet's Naval Tactical Data System (NTDS), which encompasses a variety of information exchange subsystems designed to support specific naval missions.[47]

One critical area that has benefited enormously from satellite communication is antisubmarine warfare. The rapid collection, collation, and dissemination of ASW-relevant information from sensors around the world has immensely facilitated the task of tracking Soviet submarines. Information obtained from such diverse sources as reconnaissance satellites, the Sound Surveillance System (SOSUS), P-3C Orion aircraft, and other sensors is integrated and processed by regional shore-based U.S. ASW Operations Centers (see figure 3-1) and then distributed to naval forces via the FLTSATCOM network.[48] The U.S. Navy's new mobile version of SOSUS, the Surface Towed-Array Sensor System (SURTASS) deployed from T-AGOS ships, makes use of the higher capacity DSCS system to transmit the data it collects.[49]

45. Prina, "Signal Flags to Satellites," p. 47. An estimate of 85 percent is cited by Vice Admiral Gordon Nagler in "Space: Air Force and Navy Outlook," *Signal,* vol. 38 (January 1984), p. 24.

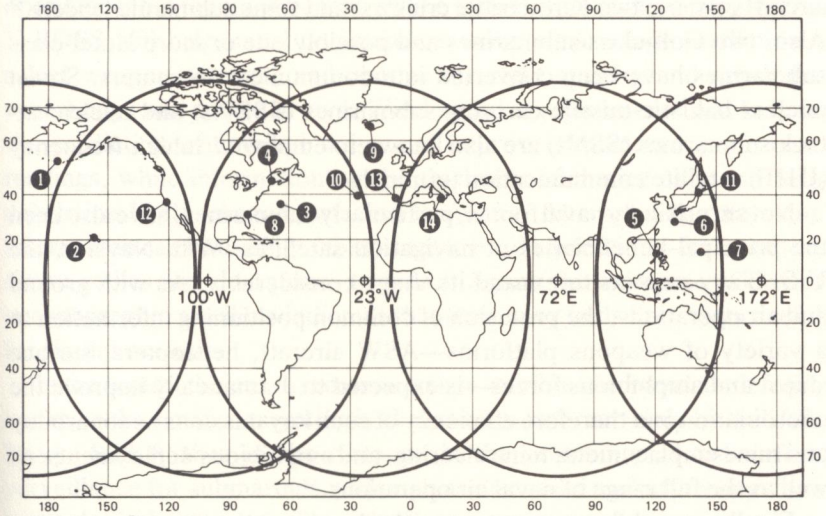
46. "Navy Space Expansion Requires Dedicated Satellites," *Defense Electronics*, vol. 13 (July 1981), p. 81.

47. They include the Common User Digital Information Exchange System (CUDIXS), which handles all the hard copy fleet broadcast messages, the Submarine Satellite Information Exchange System (SSIXS), the Antisubmarine Warfare Information Exchange System (ASWIXS), now subsumed within the Officer in Tactical Command Information Exchange System (OTCIXS), and the Tactical Intelligence System (TACINTEL). See "U.S. Navy Strategic and Tactical C^3I for the 80s," *Signal*, vol. 37 (September 1982), p. 17.

48. This system is apparently part of the Classic Wizard program. See Louise Hodgden, "Satellites at Sea: Space and Naval Warfare," in Durch, ed., *National Interests and the Military Use of Space*, p. 123. See also Joel S. Wit, "Advances in Antisubmarine Warfare," *Scientific American*, vol. 224 (February 1981), p. 35.

49. See U.S. Department of the Navy, *Justification of Estimates for Fiscal Year 1985: Operation and Maintenance* (Dept. of the Navy, February 1984), p. 3-11. The T-AGOS ships will send their data to ground terminals in Northwest, Virginia; Fort Detrick, Maryland; and Clark Air Base, the Philippines. From here the data are passed

Figure 3-1. *Earth Coverage of U.S. Fleet Satellite Communications System, with Sites of U.S. Navy Antisubmarine Operations Centers*



1. Adak, Alaska
2. Barber's Point
3. Bermuda
4. Brunswick, Maine
5. Cub Pt., Philippines
6. Kadena, Okinawa
7. Agana, Guam
8. Jacksonville, Florida
9. Keflavik, Iceland
10. Lajes, Azores
11. Misawa, Japan
12. Moffett, California
13. Rota, Spain
14. Sigonella, Sicily

Source: Based on "Navy Expansion Requires Dedicated Satellites," *Defense Electronics*, vol. 13 (July 1981), p. 79.

To deliver up-to-date intelligence for surface operations, the U.S. Navy is setting up its own fusion centers, known as Tactical Flag Command Centers, aboard aircraft carriers, which will receive targeting data via satellite. As part of the TENCAP program mentioned earlier, other major naval ships will also be fitted with Fleet Imagery Support Terminals (FISTs) to receive processed imagery from ashore.[50]

For many of the same reasons, the Soviet navy also has exploited the advantages of satellites for maritime communication. Although the extent to which satellite user equipment has been deployed throughout the Soviet fleet is unclear from the public record, it is known that certain warships and auxiliaries have been fitted with "Big Ball" and "Punch Bowl" satellite communication antennas to serve as command centers

to the navy's ocean processing facilities at either Dam Neck, Virginia, or Ford Island, Hawaii.

50. Ted W. Jensen, ed., *Space, The Next Ten Years*, A Symposium Report by the United States Space Foundation (Colorado Springs, Colo.: The Foundation, 1985), p. 61.

afloat. These include two converted Sverdlov-class cruisers, the *Zhdanov* (Black Sea Fleet) and *Admiral Senyavin* (Pacific Fleet); four Kiev-class aircraft carriers; two Kirov battle cruisers; and some submarine tenders.[51] Also, two Golf-class submarines and possibly one or more Hotel-class submarines have been converted into communication centers. Soviet nuclear ballistic-missile-carrying submarines (SSBNs) and nuclear attack submarines (SSNs) are also known to employ ultrahigh-frequency (UHF) satellite communication terminals.[52]

Not surprisingly naval forces, particularly submarines, have also been the principal beneficiaries of navigation satellites. With Navstar, the U.S. Navy expects to expand its usage considerably. As with ground and air operations, the provision of common positioning information to a variety of weapons platforms—ASW aircraft, helicopters, surface ships, and amphibious forces—is expected to dramatically improve the coordination and therefore efficiency of such key missions as sonarbuoy and mine emplacement, mine clearing, and amphibious deployments, as well as the full range of naval air operations.[53]

Finally, naval forces are among the largest subscribers to satellite-derived meteorological reports. Timely and precise forecasts, particularly when they relate to adverse weather, are absolutely essential for naval operations. For U.S. forces, the majority of weather reports will continue to be transmitted by communication satellites from the Fleet Numerical Weather Central in Monterey, California, although the navy is also fitting DMSP terminals aboard its major aircraft carriers to receive weather data directly. Presumably, the Soviet navy derives similar benefits from the Meteor satellites, though the extent to which surface ships can receive data directly from these spacecraft is unclear.

Of equal importance to naval operations is the data supplied by oceanographic satellites. As noted in chapter 2, the U.S. Navy is developing its own space system specifically for this purpose: the Navy–

51. Jim Bussert, "Wartime Needs Give Direction to Soviet C³I Technology," *Defense Electronics*, vol. 17 (May 1985), pp. 154–55; and Norman Polmar, "Soviet C³: An Overview," *Signal*, vol. 39 (December 1984), p. 29. See also Norman Friedman, "Soviet Naval Command and Control," *Signal*, vol. 39 (December 1984), p. 58. Admiral Sergey G. Gorshkov is reported to have directed the Soviet navy's worldwide exercise *Okean 75* from one of these command ships.

52. See Capt. W. J. Ruhe, USN (ret.), "Soviet Submarine C³," *Signal*, vol. 39 (December 1984), p. 65.

53. See L. Edgar Prina, "A Constellation of Capabilities," *Seapower*, vol. 30 (February 1987), pp. 8, 10.

Remote Ocean Sensing System. Though N-ROSS will be useful for a multitude of naval missions, it is in the area of ASW and counter-ASW operations that the most benefit will be gained. Information supplied by N-ROSS will help naval commanders make sonar range predictions, select weapon settings, and choose the right spacing and depth for sonarbuoys and towed arrays. Wind speed measurements will help in the prediction of ambient noise and improve the accuracy of sonar readings, while information on the thickness of the ice caps can help determine likely enemy surfacing locations. Alternatively, the same information can be used by submarines to evade detection—for instance, ocean eddies are ideal places to hide.[54] Again, the existence of Soviet oceanographic satellites indicates that their navy finds these data useful for similar reasons.

In the future, the use of reconnaissance satellites for naval air defense and over-the-horizon targeting is likely to increase, certainly by the U.S. Navy. Still further in the distance is the possibility of subsurface surveillance for submarines, although as discussed earlier, tremendous technological obstacles still need to be overcome.

Regardless of the prospects for space-based detection of submarines, satellites will increasingly be used to collect data from terrestrial-based ASW sensors for processing and dissemination. A glimpse of the shape of things to come was given in 1985, when DARPA sponsored the launch of an experimental satellite, known as GLOMR (for global low-orbiting message relay), to test the ability of small communication satellites to collect raw data from passive sensors such as sonarbuoys and relay the information to ground stations or ships for processing.[55] Thus, whether or not the oceans become "transparent" from space, the importance of satellites for ASW operations will grow.

Judgments about the relative superpower dependency on satellite services in a conventional war are, for the reasons discussed at the beginning of this chapter, difficult to make. While none of the services provided by satellites in wartime are unique, satellites can in certain cases provide significant additional capabilities to the non-space-based alternatives at the disposal of the United States or the Soviet Union. These additional means may also be more vulnerable and, depending on the location of the conflict, not readily available.

54. Ibid., p. 13.

55. Craig Covault, "Spacelab 3 Mission to Launch University, Defense Spacecraft," *Aviation Week and Space Technology*, vol. 122 (April 15, 1985), pp. 14–16.

In a NATO–Warsaw Pact conflict in central Europe, the level of redundancy for both superpowers would be high. The battlefield commanders of both sides would probably rely more on the intelligence-gathering assets under their direct control—ground-based SIGINT systems, reconnaissance aircraft, and, increasingly, remotely piloted vehicles—than on satellites.[56] Beyond the immediate zone of engagement, however, reconnaissance satellites would be particularly useful for identifying the movement of men and materiel to the front, information that would be valuable for planning long-range attacks. For NATO, with its new strategy of targeting successive echelons of advancing Soviet forces, known as Follow-on Forces Attack (FOFA), satellites would become even more important, especially as the transmission of imagery to local commanders is speeded up. Long-range reconnaissance aircraft could also perform this mission, but with the likelihood of high attrition. Over a prolonged conflict, the reliance on reconnaissance satellites could increase as ground and aerial systems were lost to enemy action.

For communication, navigation, and weather forecasting, NATO and the Warsaw Pact are again not totally reliant on space systems. Given the geographic separation of the United States from its allies, however, NATO is, on balance, more dependent on satellite communication. The Navstar GPS is also likely to be employed by a larger community of users for more military missions than its Soviet counterpart.[57] Furthermore, as one analyst has argued:

> Soviet military capabilities would not suffer for the lack of space-based navigation. In the context of the air-land battle in the [European] theater, the Soviet Air Force has provided for a wide range of ground control points on the battlefield and in the rear areas, and radio locator beacons are also deployed.[58]

In conflicts away from the European theater, the level of dependency is likely to increase for both sides as the availability of alternative assets declines. The relative position, however, will still depend on where the war is being fought. In areas that are close to the Soviet homeland such as Southwest Asia, the United States is likely to be more reliant on

56. Meyer, "Space and Soviet Military Planning," p. 68. See also Kennedy and others, *Intelligence Warfare,* pp. 141–65.

57. Twenty thousand receiver sets are being provided for U.S. forces, in addition to those for NATO. See U.S. General Accounting Office, *Issues Concerning the Department of Defense's Global Positioning System as It Enters Production,* GAO/MASAD-83-9 (GAO, 1983), p. 14.

58. Meyer, "Space and Soviet Military Planning," pp. 76–77.

satellite services, particularly for communication, navigation, and weather forecasting. But when both superpowers are fighting at a distance from their homelands, the relative dependency is likely to reverse itself. This is especially true for intelligence gathering systems, as noted in a leaked but still classified General Accounting Office (GAO) report: "As the Soviet Union projects its forces further from its borders, or into a denied area, such as China, it becomes increasingly dependent on this type of [reconnaissance satellite]."[59] In contrast, for the same reasons that apply in peacetime crisis monitoring, the United States will probably have more alternative reconnaissance assets at its disposal in remote parts of the world than will the Soviet Union.

For maritime operations, the U.S. Navy is clearly more dependent on space systems. As noted earlier, communication satellites are responsible for relaying virtually all the U.S. fleet's messages. Not only has the alternative high-frequency (HF) network contracted, so that certain areas of the globe such as parts of the South Pacific, the South Atlantic, and the Indian Ocean reportedly cannot be covered satisfactorily, but also the level of experience in operating HF systems has diminished.[60] Similarly, the United States is likely to become increasingly dependent on space-based navigation aids. For one thing, since Navstar will provide worldwide service, it will create a dependency on satellite systems in those areas not now served by other radio navigation aids, such as Omega and LORAN-C.[61] For another, these alternative systems are scheduled to be phased out of service in the 1990s, after which reliance on Navstar will inevitably grow.[62]

The Soviet navy—certainly the surface fleet—is likely to be deployed in home waters during a major conflict, which should lower its reliance on satellite support. For example, while ocean reconnaissance satellites

59. Jack Anderson, "Space 'Peeping Toms' Are a Danger," *Washington Post,* February 12, 1985.

60. Jensen, ed., *Space, The Next Ten Years,* p. 59. Also, according to Vice Admiral Gordon Nagler, "We have become so dependent on satellites for our day-to-day communications to the fleet that we really don't have as much expertise as I would like . . . in keeping a high-frequency circuit in [operation]." Prina, "Signal Flags to Satellites," p. 47.

61. For information on the coverage of existing systems, see table 2-2 above; and John Bell, "A Dozen Ways to Keep on the Straight and Narrow," *New Scientist,* vol. 104 (October 11, 1984), p. 47.

62. *Hearings on Military Posture and Department of Defense Authorization for Appropriations for Fiscal Year 1983,* Hearings before the House Committee on Armed Services, 97 Cong. 2 sess. (GPO, 1982), pt. 5, p. 593.

appear to be valued highly by the Soviet navy, it is by no means dependent on them. The Soviet ocean surveillance system is made up of an extensive network of sensors including trawlers fitted with eavesdropping equipment, special auxiliary general intelligence ships (AGIs), submarines, long-range aircraft, and high-frequency/direction-finding (HF/DF) stations based on land.[63] These are likely to be more readily available in maritime areas close to the Soviet land mass. The same applies to navigation and communication support.

Nuclear Operations

One way to assess the value of satellites in a nuclear war is to examine their probable roles in a preemptive first strike, a retaliatory second strike, and a protracted conflict. They can also aid tactical nuclear operations.

—*In a first strike.* Photoreconnaissance and signals intelligence satellites would provide a great deal of information for planning a coordinated first strike against an opponent's strategic forces. The most susceptible to being detected and thus targeted from space are ICBM silos, bombers, SSBNs in port, and fixed command and control (C^2) centers. Even mobile C^2 centers could be located and targeted by SIGINT satellites.[64] Planners would rely on meteorological satellites to provide up-to-date information on the weather over the target area. Since the accuracy of ballistic missile warheads can be adversely affected by wind and precipitation, timely information would be critical for modifying their guidance systems.[65] Bomber crews would also need to take into account the weather en route to their targets.

Similarly, navigation satellites would indirectly contribute to the accuracy of the attacks. If ballistic-missile-carrying submarines were

63. Norman Polmar and Norman Friedman, "Their Missions and Tactics," *Proceedings*, vol. 108 (October, 1982), pp. 42–44. For more information on U.S. and allied ocean surveillance systems, see Kennedy and others, *Intelligence Warfare*, pp. 166–91; and more specifically Martin Streetly, "US Airborne ELINT Systems—Part 1: The US Navy," *Jane's Defence Weekly*, vol. 3 (January 12, 1985), pp. 69–70.

64. Daniel Ford, *The Button: The Pentagon's Strategic Command and Control System* (Simon and Schuster, 1985), p. 164; and Bruce G. Blair, *Strategic Command and Control: Redefining the Nuclear Threat* (Brookings, 1985), p. 159.

65. Ball, *Can Nuclear War Be Controlled?* p. 19. The targeting data on the Minuteman missiles are changed every twenty-four hours to accommodate weather conditions over the target areas.

engaged, they would obtain last-minute position fixes from satellites to update their inertial navigation systems. Such fixes provide the reference points to adjust the guidance systems of the SLBMs. The accuracy of the new generation of U.S. sea-based strategic forces, however, is unlikely to improve markedly from the presence of Navstar GPS. The Trident D-5 missile, for example, has a star-tracking system for mid-course guidance, while the submarine-launched cruise missiles use terrain-matching radar. Although the United States has considered fitting Navstar GPS receivers to its strategic missiles, the idea has so far been rejected for fear that the satellites could be rendered inoperable or that the radio links could be subjected to jamming and disruption by nuclear blasts.[66] However, receivers have been added to B-52, FB-111, and B-1 bomber and tanker aircraft, which should improve their performance in wartime.[67]

Valuable though satellites would be in supporting a damage-limiting first strike (that is, one that limited the enemy's capacity to retaliate), they would not make it possible to execute a fully disabling attack. Deployed submarines remain undetectable from space and dispersed mobile ICBMs will be extremely difficult to find. Although the United States and almost certainly the Soviet Union are investigating ways to locate and continuously track, in real time, land-based mobile strategic targets, success is still long way off. How far off is a matter of some debate. Secretary of the Air Force Edward C. Aldridge, Jr., believes that the U.S. effort will yield "positive results within 8 to 10 years," but other experts, including the Defense Science Board and Air Force Science Advisory Board, are reportedly skeptical of this timetable.[68] Besides increasing satellite constellation size requirements (see the

66. James B. Schultz, "Navstar GPS Offers Mid-Course Guidance Improvements to Cruise Missiles," *Defense Electronics*, vol. 16 (May 1984), p. 68; and Clarence A. Robinson, Jr., "Parallel Programs Advance Small ICBM," *Aviation Week and Space Technology*, vol. 120 (March 5, 1984), p. 17. In 1979 and again in 1980, Navstar GPS receivers were fitted on Minuteman II missiles and launched from Vandenberg AFB to assess Navstar's potential use for ballistic missile guidance. The results indicated that significant improvements in accuracy could be achieved. Similar experiments were carried out with cruise missiles. See Schultz, p. 70; and Walter Andrews, "New Satellite System Found Right on Target," *Washington Times*, April 25, 1983.

67. *Department of Defense Appropriations for 1984*, Hearings before a Subcommittee of the House Committee on Appropriations, 98 Cong. 1 sess. (GPO, 1983), pt. 8, pp. 394–95; and Karas, *New High Ground*, p. 135.

68. R. Jeffrey Smith, "Proposal to Ban Mobile Missiles Favors Targeting over Arms Control," *Science*, vol. 233 (August 22, 1986), p. 831.

discussion of "Strategic and Tactical Surveillance" in chapter 2), the imaging and data-processing demands would also be immense; targets must be discriminated from the background "clutter" virtually instantaneously, a difficult task even without Soviet active and passive deception measures. In short, the prospects for constant real-time surveillance of mobile strategic targets before the twenty-first century do not look promising.

—*In a second strike.* Satellites improve the chances that either superpower could retaliate effectively after suffering a first strike. The earliest confirmation of such an attack would, as noted earlier, be supplied by each side's early warning satellites.[69] This warning would provide the option to launch a retaliatory strike before the arrival of the attacking warheads. At the very least, vulnerable strategic forces like bombers, tankers, and airborne command posts could be sent aloft to avoid immediate destruction. The early warning satellites—at least the DSP system—would also be able to determine the general size of the attack and detect the approximate launch sites, which would in turn provide clues as to the types of missiles used.[70] This knowledge could be useful for helping decisionmakers discern the purpose of the attack, especially if it is a relatively limited strike, and for deciding on the most prudent response.[71] Locating the source of the attack would also give the national command authorities information to target the adversary's remaining ICBM forces.[72]

The space-based U.S. Nuclear Detection System (NDS) would complement the data supplied by the DSP early warning satellites in important ways. Though the decision time would be slim, the NDS sensors could,

69. The Soviet over-the-horizon (OTH) radar systems can actually provide warning almost simultaneously with the satellites, although they are not considered to be so precise. See Department of Defense, *Soviet Military Power, 1985,* p. 45. For more information on current and planned U.S. and Soviet early warning radars, see Thomas K. Longstreth, John E. Pike, and John B. Rhinelander, *The Impact of U.S. and Soviet Ballistic Missile Defense Programs on the ABM Treaty,* 3d ed. (Washington, D.C.: National Campaign to Save the ABM Treaty, 1985).

70. Ford, *The Button,* p. 62. The current DSP satellites are not able to pinpoint the exact silos or the likely aimpoints of the attacking missiles. Blair, *Strategic Command and Control,* p. 223.

71. See Ford, *The Button,* p. 62; and Ashton B. Carter, "The Command and Control of Nuclear War," *Scientific American,* vol. 252 (January 1985), p. 35.

72. The ability to rapidly reprogram the guidance systems of ICBMs and other strategic forces is obviously critical to this kind of retargeting. This is reportedly being improved in the U.S. case. See "Fast Targeting for Minuteman," *Defense Week,* vol. 6 (March 18, 1985), p. 5.

for example, "record the detonation of Soviet SLBMs on U.S. territory some 10 to 20 minutes before the expected arrival of the more accurate 'silo killing' Soviet ICBMs. The U.S. leadership would have additional information to use in making the dangerous decision of whether to save the threatened ICBMs by launching them promptly."[73] It would "also aid commanders in identifying areas that have escaped destruction so that they could direct bombers, tankers, and command post aircraft to them."[74]

Finally, communication satellites would be used to set the second strike in motion. In the U.S. case, there are AFSATCOM terminals to receive launch orders (the Emergency Action Message) aboard all the airborne command posts (EC-135, E-4B, and the navy's TACAMO aircraft), on B-52, FB-111, and B-1 bombers, on KC-10 tankers, and at all SAC command posts and missile launch control centers (LCCs).[75] In the future, the Milstar system will bear the burden of strategic command and control both during and after the attack. Soviet strategic forces are presumably connected in a similar way.

—*In a protracted conflict.* For obvious reasons, assessing the role of satellites over the course of an intercontinental nuclear war becomes increasingly hypothetical. Conceivably, many of the same functions described above would be repeated for successive nuclear exchanges. Thus early warning satellites would detect follow-on strikes for as long as there were means to receive and process their data. Communication satellites would be used to control surviving strategic forces and relay damage assessment reports and targeting information from photoreconnaissance satellites. The United States is in fact deploying a fleet of trucks equipped with satellite terminals to operate as mobile command posts in a protracted nuclear war.[76] These and other command posts will also receive data from the NDS sensors, which would make it easier to plan subsequent strikes against the Soviet Union. As General Bernard P. Randolph, director of the U.S. Air Force's space systems and command, control, and communication research, testified: "When we

73. Carter, "Command and Control," p. 35.

74. Blair, *Strategic Command and Control*, p. 273.

75. Under the ICBM superhigh-frequency satellite terminal (ISST) program, Minuteman silos will also be fitted with receive-only SHF terminals. See Gen. Larry D. Welch, USAF, "Strategic C^3: The Tie That Binds," *Signal*, vol. 40 (March 1986), p. 28.

76. See Richard Whitmire, "U.S. Builds Command Post Juggernauts," *San Bernardino Sun*, April 1, 1985.

try to destroy hard targets in the Soviet Union, we are able [with NDS] to demonstrate or to understand our success in destroying those hard targets, and therefore, [we do] not have to go back and restrike those targets, and we can retarget in near real time.[77] Furthermore, according to air force budget documents, NDS data could be a "major information component during negotiations to terminate a nuclear conflict."[78] Communication satellites might also conceivably play a role in the war termination discussions.

—*Tactical nuclear operations.* For the conduct of tactical nuclear operations, satellites would also play a useful role. Information from the nuclear explosion detection sensors in space would be able to confirm the use of tactical nuclear weapons outside U.S. territory and perhaps prevent hasty decisions based on erroneous information. Weather forecasts from meteorological satellites would also help gauge the likely pattern of fallout from the use of battlefield nuclear weapons. Furthermore, communication satellites are the most direct and reliable means of authorizing the release of such weapons. This is reflected in the fact that all the U.S. nuclear weapon storage sites worldwide are linked by the AFSATCOM system.[79] A special satellite communications net known as Flaming Arrow is also being deployed for U.S. forces in the European theater.[80]

Important though satellites have become to the conduct of nuclear operations, neither superpower is dependent on their services for basic retaliation. In particular, since both sides possess invulnerable ballistic-missile-carrying submarines, neither side is dependent on satellite-derived tactical warning to carry out a second strike. And both have deemed it prudent to deploy a variety of systems that duplicate the main functions of the most important satellites. For example, the United States and the Soviet Union have ground-based radars that would detect

77. *Department of Defense Authorization for Appropriations for Fiscal Year 1983*, Hearings before the Senate Committee on Appropriations, 97 Cong. 2 sess. (GPO, 1982), pt. 7, p. 4625. See also Colin S. Gray, *American Military Space Policy: Information Systems, Weapon Systems and Arms Control* (Cambridge, Mass.: Abt Books, 1982), p. 28; and Desmond Ball, *Targeting for Strategic Deterrence*, Adelphi Papers 185, (London: International Institute for Strategic Studies, 1982), pp. 34–36.

78. U.S. Department of the Air Force, *Supporting Data for Fiscal Year 1985, Budget Estimates, Descriptive Summaries: Research, Development, Test and Evaluation* (Dept. of the Air Force, February 1984), p. 393.

79. *Department of Defense Appropriations for 1984*, Hearings, pt. 8, pp. 383–84.

80. Jack Cushman, "New Arms and Archaic C^3 Units," *Defense Week*, vol. 4 (December 19, 1983), pp. 4–5. This is in addition to the HF-based Regency Net system.

the launch of a ballistic missile roughly five minutes after the early warning satellites had reported the event. Each side also has numerous other ways for communicating with strategic forces. Nevertheless, satellites give each side additional confidence that it could retaliate effectively after a surprise attack. For the Soviet Union, with a higher proportion of its strategic arsenal made up of fixed land-based ICBMs, the extra warning time a satellite could supply might be highly valuable, especially if, as some Western analysts believe, it has adopted a launch-on-warning posture to compensate for this vulnerability.[81] Although the United States does not rely so heavily as the USSR on land-based missiles to ensure retaliation, its strategic bomber force and particularly its airborne command posts, which are vital to the wartime control of U.S. nuclear forces, would profit considerably from tactical warning to escape attack.[82]

Compared with the Soviet Union, the United States also appears more interested in the use of satellites for postattack assessments and retargeting, as evidenced by its proliferation of spaceborne nuclear explosion detection sensors. The advent of land-based mobile theater and strategic forces will encourage the further use of reconnaissance satellites for this purpose.[83] In contrast, some Western analysts contend, there is no evidence of a Soviet inclination to use satellites in this way.[84]

81. See Raymond L. Garthoff, "Mutual Deterrence and Strategic Arms Limitation in Soviet Policy," *International Security*, vol. 3 (Summer 1978), pp. 129–31; and Stephen M. Meyer, "Soviet Perspectives on the Paths to Nuclear War," in Graham T. Allison, Albert Carnesale, and Joseph S. Nye, Jr., eds., *Hawks, Doves, and Owls: An Agenda for Avoiding Nuclear War* (W.W. Norton, 1985), pp. 173-74. Some have also argued that the United States is operationally geared to launch on warning. Officially this is denied, but there is some circumstantial evidence as well as statements by responsible officials to support the contention. See R. J. Smith, "A Worrisome Shift in Nuclear Strategy," *Science*, vol. 232 (June 6, 1986), p. 1187.

82. See Blair, *Strategic Command and Control*, pp. 180, 188. Indeed, Blair argues that "reliance on tactical and strategic warning has grown so that both are essential to the control of retaliatory forces." Ibid., p. 210. The Soviet bomber forces and airborne command posts would presumably benefit in the same way.

83. As Lt. Gen. Richard Saxer, director of the U.S. Defense Nuclear Agency, testified to Congress: "With the advent of Soviet and Warsaw Pact mobile systems, an area of overriding concern is having the ability for U.S. planners to perform near-real-time targeting of these mobile assets." Quoted in "Fast Targeting for Minuteman," p. 5.

84. Meyer, "Space and Soviet Military Planning," p. 68. Soviet references—albeit fragmentary—to "withholding" nuclear forces and maintaining a strategic reserve, whether ballistic-missile-carrying submarines or mobile ICBMs, suggest that postattack assessment may be more important to the Soviets than is often credited. For a brief

Conclusion

In peacetime satellites perform many stabilizing and benign functions. They reduce the likelihood of misunderstandings between the superpowers, provide a crucial tool for monitoring arms control agreements, and help guard against surprise attack. Although satellites also make it possible for both sides to target strategic forces with great precision, a completely successful first strike is still not feasible. Satellites are not, therefore, a threat to strategic stability nor are they likely to become one in the near future. The deployment of new, more extensive and intrusive forms of surveillance that could undermine the security of each side's deterrent forces is not likely to occur before the twenty-first century at the earliest.

Benign though satellites may be in peacetime, their role can change dramatically in wartime. Many have become force multipliers in that they directly enhance the effectiveness of the weapon systems and combatants. For this reason they are valued by one's own forces and feared in the hands of an adversary. How much they are valued and how much of a threat they pose is, as discussed earlier, largely determined by a range of contextual factors—particularly the level and locale of the conflict. Although both superpowers would benefit considerably from their military satellites during a conflict, in the places where U.S. and Soviet forces are most likely to clash, such as central Europe or Southwest Asia, it is the United States that on balance would benefit most from satellite support. It has more to lose, therefore, if denied that support. How such attacks on satellites might be carried out and also thwarted are the subjects of the following chapter.

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discussion of this topic, see Ball, *Can Nuclear War Be Controlled?* pp. 32–34; and Jan S. Breemer, "The Soviet Navy's SSBN Bastions: Evidence, Inference, and Alternative Scenarios," *RUSI Journal*, vol. 130 (March 1985), pp. 19–21.