Chapter 17

Missile Warning Systems

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This chapter addresses the missile warning systems controlled by US Strategic Command (USSTRATCOM) in support of the North American Aerospace Defense Command (NORAD) agreement to protect the continental United States and Canada from ballistic missile attack.[1] Also covered are systems developed for theater-level missile defense in accordance with the Missile Defense Act of 1991, as amended by Congress in 1992, for the protection of forward-deployed US forces and allies.[2]

Space-Based Warning Sensors

The earliest space-based missile warning system was the Missile Defense Alarm System (MIDAS) satellite, which was part of the Air Force missile warning program in the late 1950s.[3] It was designed to detect and track hot exhaust gases from intercontinental ballistic missiles (ICBM) during the boost phase. In 1963, MIDAS became the first space-based system to accurately detect a missile launch when it reported on both Minuteman and Polaris ICBM test launches, which were deliberately scheduled to coincide with the MIDAS orbit.[4] MIDAS was eventually phased out in the late 1960s in favor of the Defense Support Program (DSP), which has a more advanced sensor design and a more robust spacecraft platform. DSP has been the stalwart of missile warning since the 1970s, with a total of 23 satellites launched in the program. The early single-string, mainframe processors at the ground stations were replaced by the newer and more robust Space-Based Infrared System (SBIRS) in 2002, although that system will continue to incorporate DSP satellites until the launch of the first SBIRS geosynchronous satellites in 2010.

Space-Based Infrared System

The primary mission of SBIRS is to provide space-based surveillance for missile warning, missile defense, battlespace characterization, and technical intelligence. SBIRS contributes to missile warning by providing timely and accurate data to the president, geographic and functional combatant commanders (CCDR), and other users within the space community regarding detection, identification, and predicted impact-point location of ballistic missile launches. The missile defense mission is supported by SBIRS via the timely, accurate, and reliable transmission of ballistic missile launch and in-flight data to missile defense assets in-theater in order to allow those systems to respond to an enemy attack. The SBIRS technical intelligence mission is performed through the expeditious relaying of infrared target signatures and threat performance data to the intelligence community for analysis. The SBIRS battlespace characterization mission refers to the provision of data used to enhance the overall situational awareness of decision makers, support battle damage assessments, and aid in intelligence preparation of the operational environment.[5]

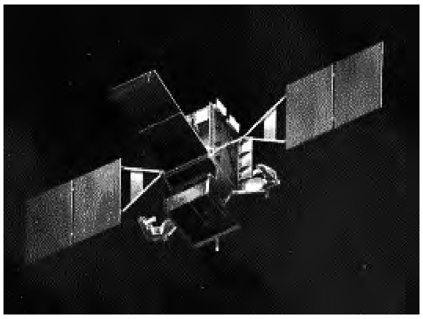

Figure 17-1. SBIRS artwork. (*Reprinted from* Lockheed Martin, "SBIRS Artwork," http://www.lockheedmartin.com/data/assets/8207.gif [accessed 7 April 2008]).

Figure 17-2. DSP satellite. (USAF image)

SBIRS is an integrated "system of systems" consisting of space and ground components.[6] The space component currently consists of a constellation of geosynchronous DSP satellites, a key part of North America's early warning system. The space component will eventually include SBIRS-High (fig. 17-1), originally designed to consist of four geosynchronous Earth orbit (GEO) and two highly elliptical orbit (HEO) satellites. However, due to massive cost overruns and schedule delays, only two or three GEO satellites are actually scheduled to be deployed.[7] The ground component consists of control stations such as the Mission Control Station located at Buckley AFB, Colorado, which is responsible for consolidating event data from dispersed legacy DSP ground systems.[8]

In geosynchronous orbits, DSP satellites (fig. 17-2) serve as the continent's first line of defense against ballistic missile attack and are normally the first systems to detect space and missile launches. In addition to launch detections, DSP satellites also have numerous sensors on board to detect nuclear detonations (NUDET).[9]

Remote ground stations receive missile warning data from the satellites and feed the data via secure communications links to ground stations for processing. These ground stations include both the fixed mission control station and mobile/deployable ground stations.[10] The ground stations assess system reliability, attempt to identify the type of launch occurring, and generate a launch report. Crews send these reports to the NORAD operations centers at Cheyenne Mountain AFS, Colorado; the Alternate Missile Warning Center at Offutt AFB, Nebraska; and other command centers.

Defense Support Program

The Defense Support Program, comprised of both ground and satellite segments, began with the first DSP satellite launch in the early 1970s. Since that time, DSP satellites have provided uninterrupted early-warning capability. In 2001, the DSP ground system was replaced by the SBIRS ground system, though the DSP satellites continue to operate as part of the newer SBIRS architecture.[11]

DSP Satellite Evolution. Over the years, the DSP satellites have seen many improvements. Initially, there were phase-one and phase-two (first and second generation) satellites weighing approximately 2,000 pounds with solar panels generating about 400 watts of power. The third-generation satellite was called Multiple Orbit Satellite/Program Improvement Module (MOS/PIM). The MOS/PIM variant was designed to address emerging threats such as antisatellite systems and ground-based lasers.[12] Despite the multiple-orbit option available on this generation of satellites, it was never exercised. However, this generation of satellites did introduce an antijam command capability.

The major improvement in the fourth generation of satellites, known as Sensor Evolutionary Development (SED) satellites, was the increase in infrared detection cells from 2,000 to 6,000 cells, which enhanced the satellites' ability to discriminate between launch events.[13] Along with the increased cell count was the experimental medium-wave infrared (MWIR) package, also known as the second-color experiment.[14] This package was a proof of concept for implementation on the fifth and final generation of DSP satellites, DSP-1. We refer to this fifth generation as the final generation of DSP satellites because of the development of a new family of satellites as part of the SBIRS.

DSP satellites have routinely exceeded their design life by many years.[15] The design life of DSP-1–era birds was three to five years; however, many satellites have reached 10 to 15 years of service. By 2006, there were as many as 10 DSP satellites still operating.[16] In fact, "DSP satellites have exceeded their specified design life by some 30 percent through five upgrade programs."[17]

Current DSP Satellites. As the capabilities of DSP satellites have grown, so have their weight and power. Unlike the old lightweight, low-power satellites, the newest generation of DSP satellites weighs over 5,000 pounds, and the solar arrays generate 1,285 watts of power. The current DSP satellite is approximately 33 feet long and 22 feet in diameter.[18] The system is comprised of the satellite vehicle, also referred to as the bus, and the sensor (fig. 17-3). The satellites are placed in geosynchronous orbit. Global coverage can be efficiently achieved with three satellites. Additional satellites can provide dual or triple coverage, providing for more accurate and timely event reporting.

The DSP satellite spins around its Earth-pointing axis, which allows the infrared (IR) sensor to sweep across each point on the earth. While full-time global coverage by a sensor that stares at the entire earth is preferable, this method reduces the size of the IR sensor and limits the amount of data needing to be downlinked and processed.

DSP-1 Sensor Overview. The sensor (fig. 17-4) detects sources of IR radiation. A telescope/optical system and a photoelectric cell (PEC) detector array, comprised primarily of lead sulfide detectors and some Mercad-Telluride cells for the MWIR detection capability, are used to detect IR sources. IR energy enters the opening in the IR sunshade, passes through the corrector lens, travels past the PEC array, reflects off the mirror, and is focused onto the PEC array.

The PEC array contains more than 6,000 detector cells.[19] The cells are sensitive to energy in the infrared spectrum. As the satellite rotates, the earth's surface is scanned by this array. With the PEC array scanning the field of view, a cell passing across an IR source will develop a signal with an amplitude proportional to the source's intensity. The signal is then amplified, passed through an analog-to-digital converter, and placed on the downlink for transmission to the ground station.[20]

Theater Missile Warning

To meet the war fighter's growing demand for situational awareness of theater-class ballistic missiles, the theater event system (TES) was created.[21]

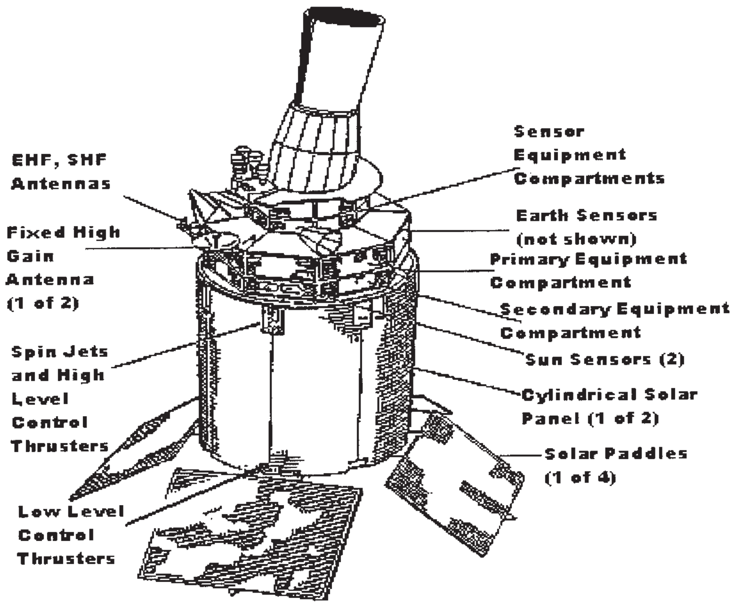

Figure 17-3. Defense Support Program satellite. (*Reprinted from* Air University, *Space Primer*, unpublished book, 2003, 15-3.)

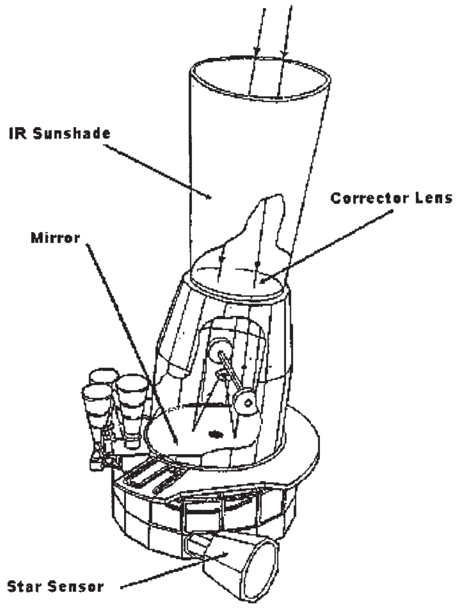

Figure 17-4. DSP sensor schematic. (*Reprinted from* Air University, *Space Primer*, unpublished book, 2003, 15-4.)

Theater Event System

The TES provides highly accurate tactical threat data through the use of stereo processing (or better) of the DSP satellite data. The TES is composed of three elements: SBIRS, the joint tactical ground station (JTAGS), and tactical detection and reporting (TACDAR). All three legs rely on IR detection for characterization and profiling of theater ballistic missile launches. An example of the TES architecture is shown in figure 17-5.

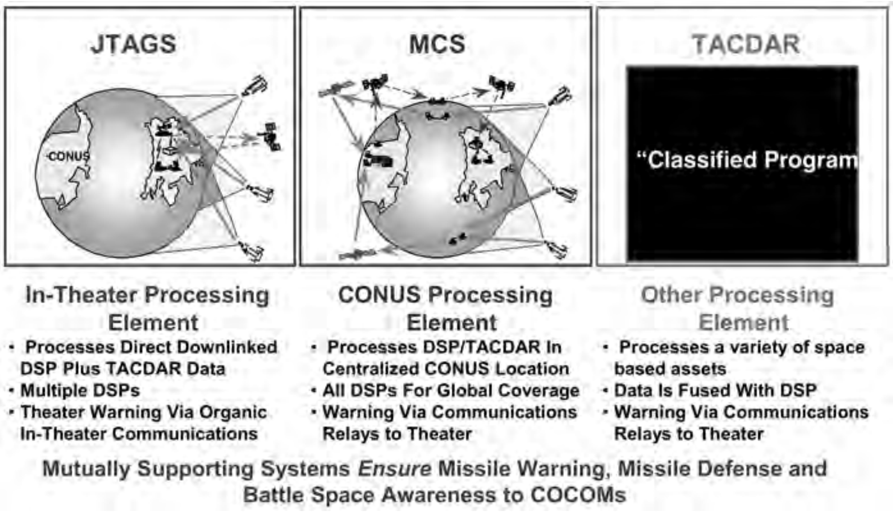

Figure 17-5. TES example. (*Reprinted from* Mike Nadler, Space and Missile Defense Future Warfare Center, "Early Warning," briefing, 21 August 2007.)

As discussed above, SBIRS accomplishes both the strategic and tactical missile warning function. JTAGS is the mobile, in-theater element of TES; it provides to the theater CCDR a direct downlink of DSP data for in-theater processing. The Army Space Command has operational control of the JTAGS.[22]

TACDAR is an additional sensor that can provide missile launch reports. The TACDAR sensor rides on a classified host satellite and therefore will not be discussed in this reference.[23] Inquiries on TACDAR may be forwarded through USSTRATCOM Global Operations (J3).

How Do I Get TES Data?

The TES has the primary mission of reporting theater/tactical threats. For theater warning, the TES (SBIRS, JTAGS, or TACDAR) reports the launch (voice and data) in-theater over two types of satellite broadcast networks: the Integrated Broadcast Service-Simplex (IBS-S), formerly the tactical related applications (TRAP) data dissemination system (TDDS), and/or the Integrated Broadcast Service-Interactive (IBS-I), formerly the tactical information broadcast service (TIBS). IBS-S transmits real-time data via the Secret Internet Protocol Router Network or tactical terminal to the Global Command and Control System.[24] IBS-I can provide timely intelligence information directly from collectors and associated ground processing facilities to the theater commanders for targeting, battle management, and overall situational awareness.[25] Theoretically, one event could be reported by all three TES elements, but the "first detect—first report" procedures help control and deconflict multiple reports of the same event. Regardless, tactical display processors in the field have coding that helps correlate missile tracks received over both networks to ensure that duplicate tracks from the same event do not appear as two separate launches in theater.

Warning data goes out over the theater satellite broadcast networks and can be incorporated in battle-management systems such as the Air Defense Systems Integrator (ADSI), the Constant Source Terminal, the Combat Intelligence Correlator (CIC), and the Airborne Warning and Control System (AWACS). See figure 17-6 for details.

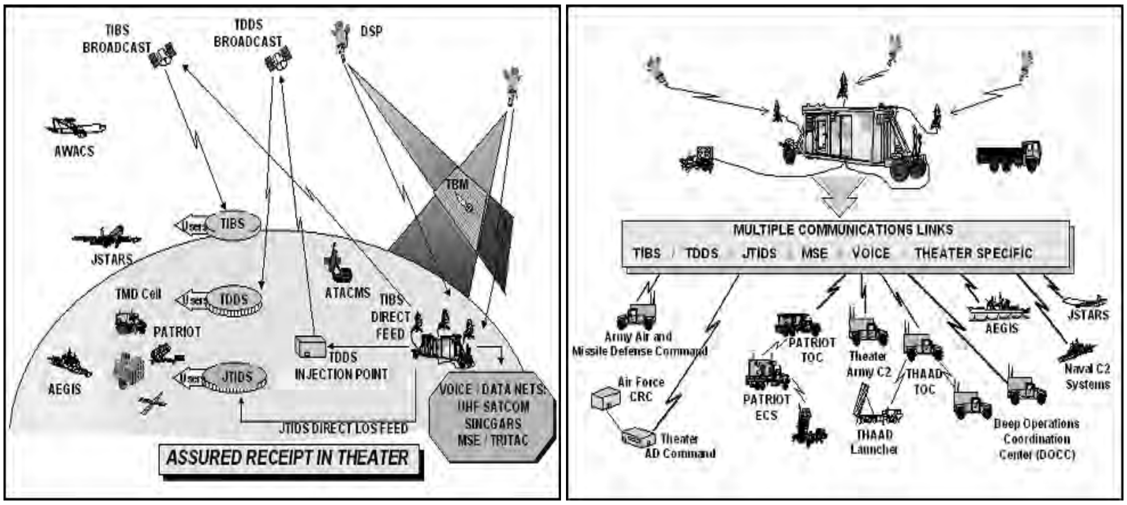

Figure 17-6. JTAGS communications and interoperability. (*Reprinted from* Army Field Manual 40-1, *Joint Tactical Ground Station Operations*, 9 September 1999.)

Ground-Based Warning Sensors

The ground-based warning sensors consist of three separate types of systems: Ballistic Missile Early Warning System (BMEWS), Perimeter Acquisition Vehicle Entry Phased-Array Weapons System (PAVE PAWS), and Perimeter Acquisition Radar Attack Characterization System (PARCS). The BMEWS sensor sites include Site I at Thule AB, Greenland; Site II at Royal Air Force Fylingdales, United Kingdom; and Site III at Clear AFS, Alaska. The PAVE PAWS sensor sites are located at Cape Cod AFS, Massachusetts, and Beale AFB, California. The PARCS sensor is located at Cavalier AFS, North Dakota.[26] A more detailed description of these sensor sites is provided in chapter 19.

Summary

Space-based infrared sensors and missile warning radar sites around the globe provide the world's most sophisticated missile warning system for the president, secretary of defense, geographic and functional CCDRs, and the entire joint military community. The robustness of the US missile warning systems and their inherent redundancy ensure that the United States will be able to promptly react and respond to any attack on its sovereignty or national interests. The US missile warning posture will continue to be enhanced as additional components of SBIRS and other missile warning follow-on systems attain full operational capability.

Notes

1. "Agreement between the Government of Canada and the Government of the United States of America on the North American Aerospace Defense Command," 28 April 2006, http://www.treaty-accord.gc.ca/ViewTreaty.asp?Treaty_ID=105060&bPrint=True&Language=0 (accessed 8 April 2008).
2. H. F. Cooper, *Summary of SDI Programs and Plans for Theater and National Ballistic Missile Defenses* (Washington, DC: Strategic Defense Initiative Organization, 4 January 1993).

3. Smithsonian National Air and Space Museum, "Sensor, Infrared, Series III, Missile Defense Alarm System," http://collections.nasm.si.edu/code/emuseum.asp?profile=objects&newstyle=single&quicksearch=A19700253000 (accessed 26 May 2009).
4. Jeffrey Richelson, "Space-Based Early Warning: From MIDAS to DSP to SBIRS," http://www.gwu.edu/~nsarchiv/nsaebb/nsaebb235/index.htm (accessed on 26 May 2009).
5. Maj Jay A. Moody, *Achieving Affordable Operational Requirements on the Space Based Infrared System (SBIRS) Program: A Model for Warfighter and Acquisition Success?* (Maxwell AFB, AL: Air Command and Staff College, 1997), 5.
6. Lori Reichert, "Lockheed Martin Team Passes SBIRS High System Critical Design Review," Lockheed Martin Press Release, http://www.lockheedmartin.com/news/press_releases/2001/LockheedMartinTeamPassesSBIRSHighSy.html (accessed 7 April 2008).
7. Marcia S. Smith, *Military Space Programs: Issues Concerning DOD's SBIRS and STSS Programs, Congressional Research Service Report for Congress* (Washington, DC: Library of Congress, January 2006).
8. Air Force Space Command (AFSPC), "Space Based Infrared Systems," Fact Sheet, http://www.afspc.af.mil/library/factsheets/factsheet.asp?id=3675 (accessed 7 April 2008); and Desmond Ball, *A Base for Debate: The US Satellite Station at Nurrungar* (North Sydney, Australia: Allen & Unwin, 1987), 36–65.
9. AFSPC, "Space Based Infrared Systems."
10. Ball, *A Base for Debate*, 49–51.
11. AFSPC, "Space Based Infrared Systems."
12. Maj James J. Rosolanka, *Defense Support Program (DSP): A Pictorial Chronology, 1970–1998* (Los Angeles AFB, CA: SBIRS System Program Office, 1998).
13. Paul B. Stares, *Space and National Security* (Washington, DC: Brookings Institution Press, 1987), 26.
14. Rosolanka, *Defense Support Program*, 17.
15. Northrop Grumman, "Defense Support Program," http://www.st.northropgrumman.com/capabilities/missile_defense/defense_support.html (accessed 7 April 2008).
16. Austronautix, "DSP," http://www.astronautix.com/craft/dsp.htm (accessed 8 April 2008).
17. "Defense Support Program," Federation of American Scientists, http://www.fas.org/spp/military/program/warning/dsp.htm (accessed 8 April 2008).
18. Tamar A. Mehuron, ed., *2002 Space Almanac*, *Air Force Magazine*, August 2002, 40.
19. Mohamed M. Abid, *Spacecraft Sensors* (Hoboken, NJ: John Wiley & Sons, 2005), 135–203.
20. NASA, "Space Shuttle STS-44 Press Kit," http://science.ksc.nasa.gov/shuttle/missions/sts-44/sts-44-press-kit.txt (accessed 7 April 2008).
21. USSTRATCOM, "Theater Ballistic Missile Warning," http://www.stratcom.mil/fact_sheets/fact_tbmw.html (accessed 8 April 2008).
22. Mike Nadler, Space and Missile Defense Future Warfare Center, "Early Warning," briefing, 21 August 2007.
23. Ibid.
24. Joint Interoperability Test Command, "Tactical Data Dissemination System (TDDS)," http://jitc.fhu.disa.mil/gccsiop/interfaces/tdds.pdf (accessed 7 April 2008).
25. Col James W. McClendon, "Information Warfare: Impacts and Concerns," in *Battlefield of the Future: 21st Century Warfare Issues*, ed. Barry R. Schneider and Lawrence E. Grinter (Maxwell AFB, AL: Air University Press, 1995).
26. AFSPC, *Space Surveillance Network (SSN) Site Information Handbook* (24 October 2007), 70–90.