Chapter 21

SPACE SURVEILLANCE THEORY AND NETWORK

The Space Surveillance Network (SSN) is a combination of optical and radar sensors used to support the Space Control Center (SCC) and its mission, which is to detect, track, identify and catalog all *man-made* objects in earth orbit. This chapter looks at the various components of the SSN, its sites and how they combine to support the space surveillance mission. This chapter also contains a description of the radar and optical sensors, which are the two primary technologies used by the SSN.

SPACE SURVEILLANCE THEORY

Although referred to as a network, the SSN was not originally envisioned as such. As various sensors became available, their particular capabilities were used to support the space surveillance mission.

The current sensors use numerous technologies. Each sensor in the SSN and the methods by which the SCC uses (tasks) the SSN to sustain the space surveillance mission are also described in this chapter.

A description of the space surveillance principles includes their associated technologies. A review of the Space Object Identification (SOI), a specific application of optical and radar sensors, will also be provided.

Doppler Effect

When a source of sound moves toward or away from a listener, the pitch (frequency) of the sound is higher or lower than when the source is at rest with reference to the listener. A common example is the rise and fall of the pitch of a locomotive's whistle as it approaches and recedes from the listener. Similar results are obtained when the listener approaches or withdraws from a stationary source of sound. This phenomenon is referred to as the Doppler effect, named after the Australian scientist, Christopher Johann Doppler, who predicted in 1842 that the color of a luminous body would change in a similar manner, due to the relative motion of the body and the observer.

Simply stated, the Doppler effect applies to all types of waves and can further be described by the following sequence. When a source of sound approaches the listener, the waves in front of the source are crowded together so the listener receives a larger number of waves in the same time than would have been received from a stationary source. This process raises the pitch the listener hears. Similarly, when the source moves away from the listener, the waves spread farther apart and the observer receives fewer waves per unit of time, resulting in a lower pitch.

The Doppler effect is significant in optics. Due to the velocity of light, pronounced effects can only be observed for astronomical or atomic bodies possessing velocities exceeding normal values. The effect is seen in the perceived shift in the wavelengths of light emitted by moving astronomical bodies. The perceived shift to longer wavelengths of light emitted from distant galaxies indicates they are receding and hence, supports the concept of an expanding universe. Radiation from hot gases shows a spread of wavelengths (Doppler broadening), because the emitting atoms or molecules move at varying speeds in different directions as measured by the observing instrument.

The Doppler effect has many uses in science as well as a variety of practical applications. For example, measurements of shifts of radio waves from orbiting satellites were used in maritime navigation; the effect is also utilized in radar surveillance.

Radar

Radar is actually an acronym for Radio Detection and Ranging, a name given to an electronic system utilized during World War II, whereby radio waves were reflected off an aircraft to detect its presence and location. Numerous researchers have aided in the development of devices and techniques of radar. The earliest practical radar system is usually credited to Sir Robert Watson-Watt.

Operation

A radio transmitter generates radio waves which radiate from an antenna that "illuminates" the air or space with radio waves. A target, such as an aircraft, which enters this space scatters a small portion of this radio energy back to a receiving antenna. This weak signal is amplified by an electronic amplifier and displayed on a Cathode-Ray Tube (CRT), where it is examined by a radar operator. Once detected, the object's position, distance (range) and bearing can be measured. As radio waves travel at a known constant velocity -- the speed of light (300,000 km/sec or 186,000 mi/sec) -- the range may be found by measuring the time it takes for a radio wave to travel from transmitter to the object and back to the receiver. For example, if the range was 186 miles, the time for the round trip would be (2 x 186)/186,000 = two-thousandths of a second, or 2,000 microseconds. In pulse radar, the radiation is not continuous, but is emitted as a succession of short bursts, each lasting a few microseconds. This radio-frequency pulse is emitted on receipt of a firing signal from a trigger unit that simultaneously initiates the time-base sweep on the CRT. The electronic clock is started and when the echo signal is seen on the tube, the time delay can be measured to calculate the range. The pulses are emitted at the rate of a few hundred per second so that the operator sees a steady signal.

Modern radar also provides excellent moving-target indication by use of the Doppler shift in a frequency similar to a radio wave when it is reflected from a moving target. Target detection is hindered by "clutter" echoes rising from backscatter from the ground or raindrops. Today's radars have higher transmitter powers and more sensitive receivers, which cause pronounced clutter so that even flocks of birds may show up on the screen. Antenna design can reduce these effects and the use of circularly polarized waves reduces rain echoes.

The WWII wartime radar operator interpreted the mass of data displayed. Simultaneously tracing the histories of many targets, which is essential to modern systems, requires the incoming radar data to be electronically processed to make information more accessible to the operator/controller. Progress towards satisfying this need had to await the arrival of large-scale integrated circuits, charge-coupled devices and the development of the technology for processing digital signals. Another important advance has been the development of computerized handling of video data, as in automatic plot extraction and track formation.

SSN Radar Sensor Systems

Radar sensors used by the SSN are divided into three categories: tracking, detection and phased array.

<u>Tracking Radars (TR)</u> **(Fig. 21-1**), or mechanical trackers, are the oldest type used by the SSN and are employed to follow or track a target throughout the radar's coverage. Basic radar technology is used to transmit a single beam of radar energy out toward the target. The energy is then reflected off the target and returned to the radar receiver for measurement. The transmitter sends out another beam of radar energy and the cycle repeats itself as the radar follows the target throughout its coverage. The TR is a good system for tracking near earth ob-

jects because it can acquire a large number of data points on a target. It is very precise in predicting the trajectory of that target. The main limitation of the TR is its inability to track more than one object at a time. It cannot "search" for targets very efficiently because it sends out only a single beam of radar at a time.

Fig. 21-1. Kwajalein Tracking Radar

Detection Radars (DR) send out radar energy to form a fan out in space. This fan literally "blankets" an area with radar energy. The radar simply waits for a target to break this fan. Unlike the TR, a DR gives only a single data point at the location where the object breaks the radar's fan. The DRs used to support the SSN usually transmit two separate fans of energy. This allows for two data points to be collected on an object, which limits the accuracy. DRs are always collocated with at least one TR. When an object is detected by the DR, the TR is then used to lock onto the object, giving more accurate positional data.

Phased Array Radar (PAR) is the newest radar technology used within the Space Surveillance Network. Rather than move the antenna mechanically, the radar energy is steered electronically. In a PAR there are many thousands of small Transmit/Receive (T/R) antennas placed on the side or face of a large wedge-shaped structure. If the signals from the separate T/R are released at the same time and in phase, they form a radar beam whose direction of travel is perpendicular to the array face.

To detect objects that do not lie directly in front of the array face, time delay units, or phase shifters, are used. This phase-lag steering is a computer procedure where the radiating elements are delayed sequentially across the array, causing the wave front to be at an angle to the perpendicular. This controls the direction of the beam. Since these radars have several thousand T/R antenna elements, multiple beams can be formed at the same time. A PAR is capable of simultaneously tracking several hundred targets, since a computer calculates the proper time delays of these beams. There are several advantages of this type of radar: it can track many different objects at the same time and it can put up search patterns, by volume, or detection fans similar to DRs. However, there are two disadvantages of a PAR: the high cost of building it and complex maintenance.

Optical Sensor Systems

Optical sensors are very basic. They simply gather light waves reflected off an object to form an image. This image can then be measured, reproduced and analyzed. However, these sensors are limited due to their reliance on light; they cannot track during the day or under overcast sky conditions. The objects tracked must also be in sunlight and have some reflective qualities. *Electro-optical* sensors are the only optical sensors used operationally today to support the space surveillance mission.

Electro-optical refers to the way the sensor records the optical image. Instead of being imprinted on film, the image is changed into electrical impulses and recorded onto magnetic tape. This is similar to the process used by video recorders. The image can also be analyzed in real-time.

The primary electro-optical sensors used in the SSN are part of the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) System. These telescopes are extremely powerful.

Space Object Identification (SOI)

SOI analyzes signature data, both optical and radar, to determine satellite characteristics. More specifically, the size, shape, motion and orientation of the satellite. With optical sensors, the SOI information depends on the clarity of the satellite pictures. There are two types of radar SOI: wideband and narrowband. Two sensors (Haystack and the Advanced Research Projects Agency (ARPA) Lincoln C-Band Observable Radar (ALCOR)) have the capability of providing wideband SOI. Wideband SOI provides a detailed radar picture of the satellite. Most other radar sensors can provide narrowband SOI, which is a depiction of the radar energy charted as an amplitude versus time. SOI information is used to determine the operational status of various payloads and may forecast maneuvers or deorbits. The process of using SOI data, in conjunction with other intelligence resources to determine the nature of unidentified payloads, is called mission payload assessment.

THE SPACE SURVEILLANCE NETWORK (SSN)

All sensors in the SSN are responsible for providing space surveillance and SOI to the SCC located at Cheyenne Mountain AS (CMAS), Colorado. The sensors in the network are categorized primarily by their availability for support to the SCC. There are three active sensor categories (dedicated, collateral and contributing) plus the passive sensors which collectively comprise the SSN.

Dedicated Sensors

A dedicated sensor is a U.S. Space Command (USSPACECOM) operationally controlled sensor with a primary mission of space surveillance support. Dedicated sensors include: GEODSS, Naval Space Surveillance (NAVSPASUR), and the AN/FPS 85 Phased Array Radar (PAR).

GEODSS

GEODSS has the mission to detect, track and collect SOI on deep space satellites in support of the SCC. Each GEODSS site **(Fig. 21-2**) is controlled and operated by the 21st Space Wing and the 18th Space Surveillance Squadron (SPSS). There are currently three detachments operating GEODSS sensors: Det. 1, Socorro, New Mexico, Det. 2, Diego Garcia, British Indian Ocean Territories, and Det. 3, Maui, Hawaii. The GEODSS sites provide near real-time deep space surveillance capability.

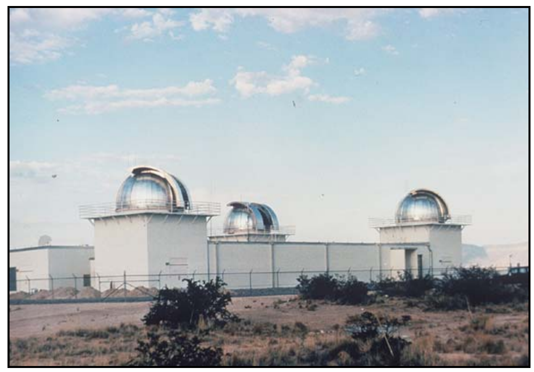

Fig. 21-2. GEODSS Site

To perform its mission, GEODSS brings together three proven technologies: the telescope, low-light television, and computers. Each site has three telescopes: two main and one auxiliary (with the exception of Diego Garcia, which has three main telescopes). The main telescopes have a 40-inch aperture and a two-degree field of view. The system only operates at night, when the telescopes are able to detect objects 10,000 times dimmer than the human eye can detect. Since it is an optical system, cloud cover and local weather conditions influence its effectiveness.

The telescopes move across the sky at the same rate as the stars appear to move. This keeps the distant stars in the same positions in the field of view. As the telescopes slowly move, the GEODSS cameras take very rapid electronic snapshots of the field of view. Four computers then take these snapshots and overlay them on each other.

Star images, which remain fixed, are electronically erased. However, man-made space objects do not remain fixed and their movements show up as tiny streaks which can be viewed on a console screen. Computers measure these streaks and use the data to calculate the positions of objects, such as satellites in orbits from 3,000 to 22,000 miles. This information is used to update the list of orbiting objects and is sent nearly instantaneously from the sites to CMAS. The GEODSS system can track objects as small as a basketball more than 20,000 miles in space.

MOSS

The Moron Optical Space Surveillance (MOSS) system was fielded at Moron AB, Spain during the first quarter of Fiscal Year (FY) 1998. MOSS will operate in conjunction with the existing GEODSS network. The GEODSS network called for an additional site in the Mediterranean to provide contiguous geosynchronous coverage. Air Force Space Command (AFSPC) is fielding MOSS to provide this critical geosynchronous belt metric and Space Object Identification (SOI) coverage.

MOSS consists of one high resolution electro-optical telescope and the MOSS Space Operations Center (MOSC) van. The telescope has a nominal aperture of 22 inches and a focal length of 51 inches (f 2.3). The camera houses a 1024 x 1024 MIT/LL charge-coupled device (CCD) focal plane array. The telescope is housed in a dome structure and is positioned by an Uninterruptible Power Supply (UPS) and backed up by a diesel generator.

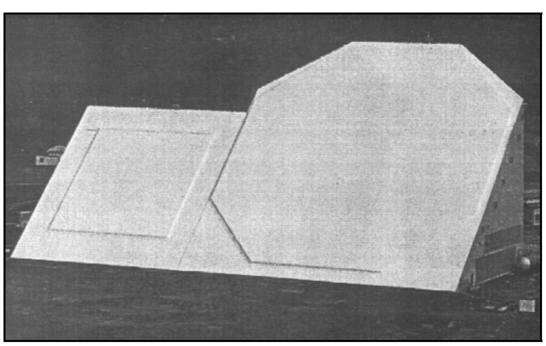

Fig. 21-3. AN/FPS-85 PAR at Eglin AFB

NAVSPASUR

Naval Space Command (NAVSPACE) has the oldest sensor system in the SSN: NAVSPASUR, whose mission is to maintain a constant surveillance of space and to provide satellite data as directed by the Chief of Naval Operations and higher authorities to fulfill Navy, USSPACECOM and national requirements. NAVSPASUR uses three transmit antennas and six receive antennas, all geographically located along the 33rd parallel of the U.S. The transmitters send out a continuous wave of energy into space, forming a "detection fence" which covers 10 percent of the Earth's circumference and extends 15,000 miles into space.

When a satellite passes through the fence, the energy from the transmitter sites "illuminates" it and a portion of the energy is reflected back to a receive station. When the reflected energy is acquired by at least two receive sites, an accurate position of the satellite can be determined through triangulation.

NAVSPACE has the additional mission of being the Alternate Space Defense Operations Center (ASPADOC) and the Alternate Space Control Center (ASCC).

AN/FPS 85 PAR

Located at Eglin AFB, Florida, the AN/FPS-85 PAR is operated by Air Force Space Command (AFSPC), 21st Space Wing, 20th Space Surveillance Squadron (SPSS). The 20 SPSS operates and maintains the only phased array space surveillance system dedicated to tracking space objects. It is one of the earliest PARs, built in the mid-1960s, and became operational in December 1968.

The radar is housed in a wedge-shaped building **(Fig. 21-3)**, 318 feet long and 192 feet high (receiver side), and 126 feet high (transmitter side). Unlike other PARs, Eglin has separate transmitter and receiver arrays (antennas). The transmitter array has about 5,200 transmitter elements, while the receiver array has roughly 4,600 receiver elements. The transmitter and receivers are set in their respective antenna faces on the south side of the building, which is inclined at a 45 degree angle. It has the capability to track both near-earth and deep-space objects simultaneously. The previous primary mission at Eglin was Submarine- Launched Ballistic Missile (SLBM) warning. Once the southeast radar at Robins AFB, GA, known as PAVE PAWS (Phased Array Warning System) became operational, the SLBM warning coverage was redundant and Eglin's mission changed in 1988 to dedicated space surveillance. The PAR at Eglin tracks over 95 percent of all earth satellites daily.

Collateral Sensors

A collateral sensor is a USSPACECOM operationally controlled sensor with a primary mission other than space surveillance (usually, the site's secondary mission is to provide surveillance support). Collateral sensors include the Maui Optical Tracking and Identification Facility (MOTIF), Maui Space Surveillance System (MSSS), Ballistic Missile Early Warning System (BMEWS), PAVE PAWS, the Perimeter Acquisition Radar Attack Characterization System (PARCS), Antigua, Ascension and Kaena Point. MSSS was once part of 18th SPSS Det 3 but AFSPC transitioned it to AFRL on 1 Oct 00.

MOTIF

MOTIF performs near-earth/deep space surveillance and SOI. It uses photometric, visual imaging, and also a Long Wave Infra-red (LWIR) data generation system. It is an optical sensor very similar to the GEODSS sites, in addition to its LWIR capability.

MOTIF consists of a dual telescope system on a single mount **(Fig. 21-4)**. One telescope is used primarily for infrared and photometric (light intensity) measurements. The other is used for low-light-level tracking and imagery. Both use video cameras to record data. MOTIF has identified objects as small as 8 cm in geosynchronous orbit.

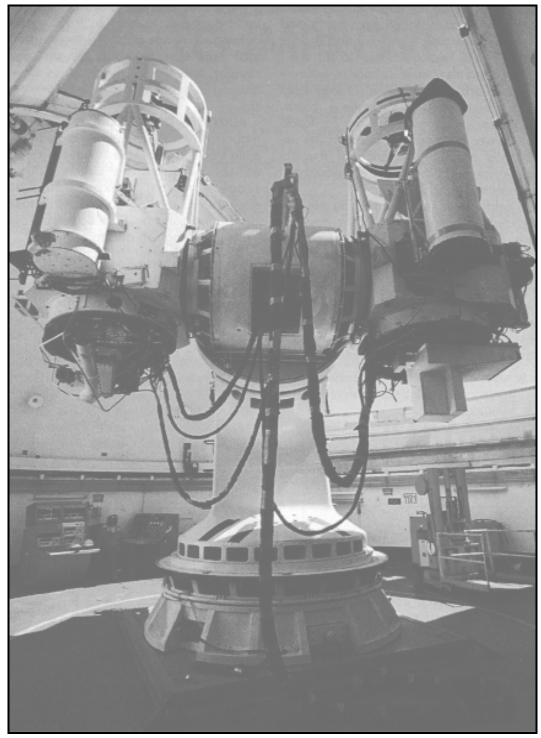

Fig. 21-4. MOTIF

BMEWS

BMEWS is a key radar system developed to provide warning and attack assessment of an Intercontinental Ballistic Missile (ICBM) attack on the CONUS and southern Canada from the Sino-Soviet land mass. BMEWS III also provides warning and attack assessment of a SLBM/ICBM attack against the United Kingdom and Europe. BMEWS' tertiary mission is to conduct satellite tracking as collateral sensors in the space surveillance network. BMEWS consists of three sites: Site I is located at Thule AFB, Greenland; Site II is at Clear AFB, Alaska; and Site III is at Royal Air Force Station Fylingdales, United Kingdom.

Site I, Thule **(Fig. 21-5**), is operated by the 12th Space Warning Squadron (SWS), a unit of AFSPACECOM's 21st Space Wing. Site I's initial operations began in October 1960. Its original equipment consisted of four Detection Radars (DRs) and a single Tracking Radar (TR). After more than 26 years of continuous operation, the DRs and TR were replaced with a phased array radar. The upgraded radar became operational in June 1988.

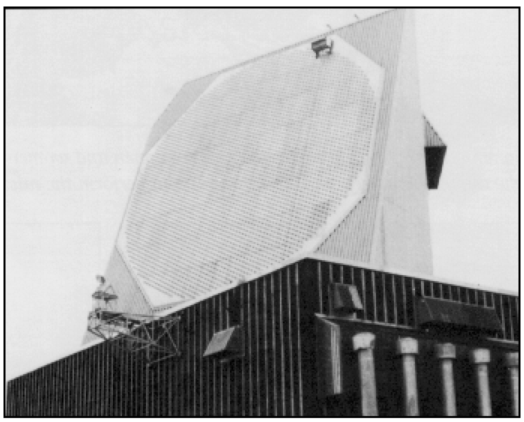

Fig. 21-5. PAR at Thule AB

The 13 SWS at Clear AFB, Alaska began operations in 1961 with three DRs (AN/FPS-50s), each 400 ft long and 165 ft high, and a TR (AN/FPS-92) that is 84 ft in diameter and weighs 100 tons. **(Fig. 21-6)** The DRs provide most of the data by surveying a fixed volume of space and providing the basic measurements to estimate the trajectory of any missile or satellite detected. Clear has been upgraded with a dual faced phased array radar similar to Thule and the PAVE PAWS sites.

The Royal Air Force at Fylingdales operates a three-faced phased array radar. Fylingdales' original configuration consisted of three tracking radars that have since been dismantled. It searches the sky for possible missile threats with a full 360^0 coverage.

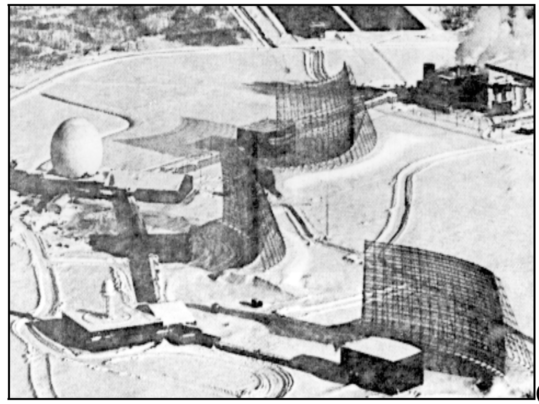

Fig. 21-6. Clear AFB, AK Prior to Phased Array Radar Upgrade

PAVE PAWS

Increasing technology provided the former Soviet Union the capability to launch ballistic missiles from submarines.

Studies indicated the need for early warning facilities to detect such an attack. The PAVE PAWS mission is to provide warning and attack assessment of a SLBM attack against the CONUS and southern Canada. PAVE PAWS also provides warning and attack assessment of an ICBM attack against North America from the Sino-Soviet land mass. The final tertiary mission, like BMEWS, is to provide satellite tracking data as collateral sensors in the space surveillance network.

The first two sensors came on line in 1980, while the other two (located at Robins AFB, Georgia and Eldorado AFS,

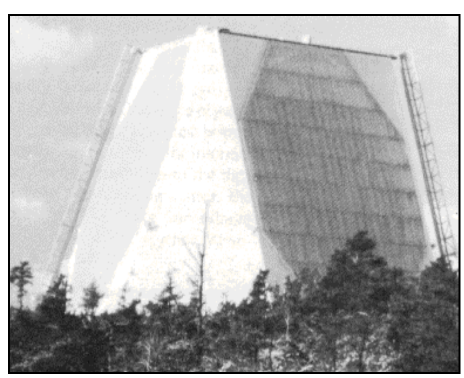

Fig. 21-7. PAVE PAWS Site

Texas) followed seven years later. The latter two sites were closed in mid-1995.

PAVE PAWS currently consists of the initial two sites: Site I **(Fig. 21-7**) is located at Cape Cod AFS, Massachusetts and run by the 6 SWS; Site II is at Beale AFB, California and operated by the 7 SWS. Both sites operate a dual-faced, phased array radar (AN/FPS-115). The computer hardware and software was upgraded in the mid-1980s, when the other two sites were built.

The PAVE PAWS phased array antenna, as with any other directional antenna, will receive signals from space only in the direction in which the beam is aimed. The maximum practical deflection on either side of antenna center of the phased array beam is 60 degrees. This limits the coverage from a single antenna face to 120 degrees. To provide surveillance across the horizon, the building housing the entire system and supporting antenna arrays is constructed in the shape of a triangle. The two building faces supporting the arrays, each 120 degrees, will monitor 240 degrees of azimuth. The array faces are also tilted back 20 degrees to allow for an elevation deflection from three to 85 degrees above the horizon. The lower limit provides receiver isolation from signals returned from ground clutter and for environmental microwave radiation hazard protection of the local area.

The PAVE PAWS system is capable of detecting and monitoring a great number of targets that would be consistent with a massive SLBM attack. The system must rapidly discriminate between vehicle types, calculating their launch and impact points in addition to the scheduling, data processing and communications requirements. The operation is entirely automatic, requiring people for system monitoring, maintenance, and as a final check on the validity of warnings. Three different computers communicating with each other form the heart of the system which relays the information to CMAS.

PARCS Sensor

PARCS is operated by the 10 SWS, located just 15 miles south of the Canadian border at Cavalier AS, North Dakota **(Fig. 21-8**). The PARCS sensor was originally built as part of the Army's Safeguard Anti-Ballistic Missile (ABM) system. It was operational for one day (1 October 1975). The ABM system was shut down in 1975 by Congress. It later was modified by the Air Force in 1977 for use as a missile warning/space surveillance sensor, a role it continues to do extremely well.

PARCS' mission is to provide warning and attack characterization of an SLBM and ICBM attack against the CONUS and southern Canada. It is one of the workhorses, along with Eglin, providing surveillance, tracking, reporting and SOI data. PARCS uses a single-faced phased array radar (AN/FPQ-16). The radar, computer, communications equipment and operations room are housed in a reinforced concrete building, originally designed to ride out a missile attack as part of the Safeguard ABM system. The single-faced radar looks due North and slopes from the side of the building at a 25^0 angle. This site is considered a "CONUS remote."

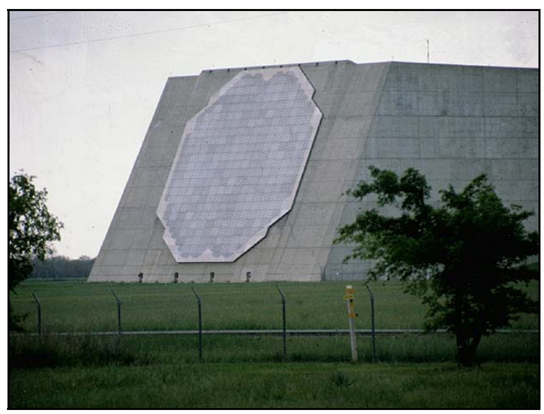

Fig. 21-8. PARCS, Cavalier AS, ND

Antigua and Ascension

The radars located on Antigua and Ascension Islands in the Atlantic Ocean are tracking radars. They are part of the Eastern Range, playing a secondary role in supporting the SCC.

Contributing Sensors

The contributing sensors are those owned and operated by other agencies, but provide space surveillance upon request from the SCC. They are: Millstone/Haystack, the ARPA Long-Range Tracking and Identification Radar (ALTAIR), ALCOR and AMOS.

Millstone/Haystack

The Millstone/Haystack Complex is owned and operated by Lincoln Laboratories of the Massachusetts Institute of Technology (MIT). Millstone Hill Radar **(Fig. 21-9)** and Haystack Long Range Imaging Radar are both located in Tyngsboro, Massachusetts.

Fig. 21-9. Haystack Radar

Millstone is a deep space radar that contributes 80 hours per week to the SCC. Haystack is a deep space imaging radar that provides wideband SOI tracks to the SCC. Haystack provides this data one week of every six of Millstone operations. USSPACECOM may recall Haystack off schedule twice in a fiscal year.

ALTAIR and ALCOR

ALTAIR and ALCOR are located in the Kwajalein Atoll in the western Pacific Ocean. Operated by the Army, they are primarily used for ABM testing in support of the Western Range and support the space surveillance mission when possible. ALTAIR is a near-earth and deep-space tracking radar. Due to its proximity to the equator, ALTAIR alone can track one-third of the geosynchronous belt. ALCOR is a near-earth tracking radar, and is the only other radar besides Haystack that can provide wideband SOI.

Kaena Point

Kaena Point is a tracking radar **(Fig. 21-10)** located on Oahu, Hawaii. It is part of the Western Range and supports the SCC with satellite tracking data.

Fig. 21-10. Kaena Point Tracking Radar

AMOS

The last contributing sensor is AMOS, which is a GEODSS-type optical sensor collocated with the GEODSS and MOTIF sensors on Maui. The research and development facility uses a 1.6-meter telescope owned by Air Force Materiel Command.

Both the AMOS and MOTIF systems at the MSSS will be upgraded in the near future.

Passive Space Surveillance System

The U.S. passive space surveillance system locates and tracks man-made objects in space via a new generation of radio frequency technology. Passive space surveillance units include the Deep Space Tracking System (DSTS).

Deep space tracking involves tracking objects with orbits that take more than 225 minutes to rotate the earth (geosynchronous). DSTS antennas are at the 3rd

Space Surveillance Squadron (3 SPSS), Misawa AB, Japan, and the 5 SPSS, RAF Feltwell, U.K.

The 4 SPSS, Holloman AFB, New Mexico **(Fig. 21-11)** performs mobile space surveillance communications and space data relay.

This passive system supports USSPACECOM and theater warfighters' requirements through continuous all-weather, day-night surveillance of on-orbit satellites.

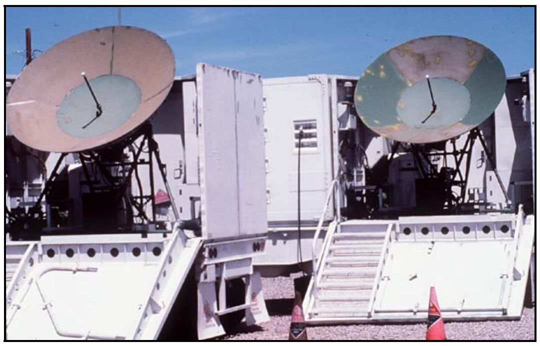

Fig. 21-11. Holloman Mobile Communications Antennas

SPACE SURVEILLANCE SENSOR TASKING

Because of the limits of the SSN which include number of sensors, geographic distribution **(Fig. 21-12)**, capability and availability, every satellite cannot be continuously tracked. To maintain a data base of where all man-made objects in earth orbit are, the SCC uses a tracking cycle which starts with a prediction. The SCC makes an assumption as to where a newly launched object will be, then sends out this postulation in the form of an element set (ELSET) to the sensors. Subsequently, the sensor uses this ELSET to search for the object. If the assumption is close, the sensor will detect-and-track the object. The sensor then collects observations from the track, which are sent back for processing and analysis.

The SCC uses this information to compute a new ELSET, or prediction, which is then sent to the next sensor to track it. This cycle repeats 24 hours a day, seven days a week.

Another tool used by SCC to efficiently distribute the limited tracking capabilities of the SSN, is prioritized sensor tracking. A NORAD/USPACECOM regulation defines categories of priority and specific data collection instructions (categories and suffixes); assigned according to each satellite's type and orbit. Generally, satellites with high interest missions or unstable orbits (objects about to decay) will have higher priority and data collection requirements than other satellites.

SUMMARY

We have covered the different sensor technologies used to track satellites and identify them, and then looked at the Space Surveillance Network (SSN) and all the sensors that make up the SSN. Finally, we looked at how the SCC processes sensor information to maintain its database for over 9,000 objects.

A listing of acronyms used in this chapter is included on the next page.

A listing of space surveillance sites is detailed on the two pages following the acronym listing (Table 21-1).

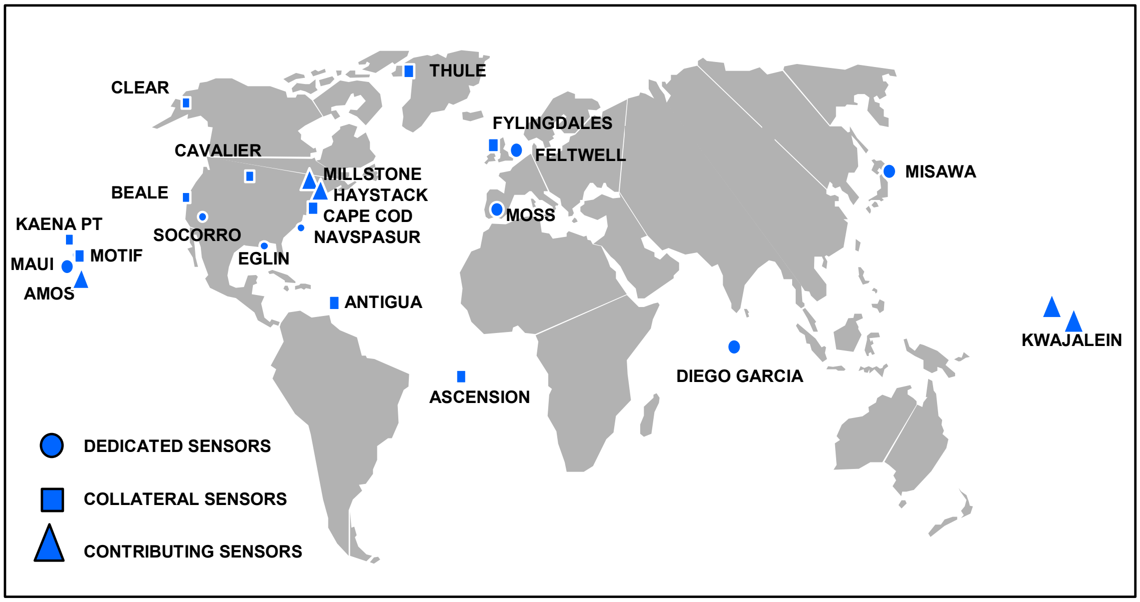

Fig. 21-12. Space Surveillance Network

SSN ACRONYMS

ABM – Anti-Ballistic Missile

ALCOR – ARPA Lincoln C-band Observable Radar (Wideband)

ALTAIR – ARPA Long-range Tracking and Identification Radar

AMOS – ARPA Maui Optical Station (Imaging)

ARPA – Advanced Research Projects Agency

ASPADOC – Alternate Space Defense Operations Center (at NAVSPACE)

ASCC – Alternate Space Control Center (Dahlgren, VA)

BMEWS – Ballistic Missile Early Warning System

CRT – Cathode Ray Tube

DSTS – Deep Space Tracking System

ELSET – Element Set (SOI positioning tool format)

GEODSS – Ground-based Electro-Optical Deep Space Surveillance

Haystack – Wideband (X-band) deep space tracking radar at Tyngsboro, MA

LWIR – Long Wave Infra-red (data generation system)

Millstone – Lincoln Lab L-band deep space tracking radar at Tyngsboro, MA

MOSS - Moron Optical Space Surveillance

MOTIF – Maui Optical Tracking and Identification Facility

NAVSPASUR – Naval Space Surveillance (system)

PAR – Phased Array Radar (also known as the AN/FPS-85)

PARCS – Perimeter Acquisition Radar Attack Characterization System (AN/FPQ-16)

PAVE – Major command nickname for project acquisition

PAWS – Phased Array Warning System (AN/FPS-115)

SOI – Space Object Identification

SSN – Space Surveillance Network

SCC – Space Control Center in Cheyenne Mountain Air Station, Colorado

Table 21-1. Space Surveillance Sites

SITE NAME	TYPE	TRACK	INTEL	LOCATION	FREQ	CATEGORY	REMARKS
ALCOR	TR	NE	WB/C	Kwajalein Atoll, Pacific	C-band	Contributing	WB imaging
ALTAIR	TR	NE/DS	NB/C	Kwajalein Atoll, Pacific	UHF/VHF	Contributing	
AMOS	PHOTO	NE/DS	PHOTO	Mt. Haleakala, HI	LWIR	Contributing	AF Maui Optical Site-Imaging
Antigua	TR	NE	NB/NC	British West Indies	C-band	Collateral	
Ascension	TR(2)	NE	NC/NC	Ascension Island, South Atlantic	X-band	Collateral	
Beale AFB	PHASED ARRAY	NE	NB/NC	California	UHF	Collateral	PAVE PAWS
Cape Cod AS	PHASED ARRAY	NE	NB/NC	Massachusetts	UHF	Collateral	PAVE PAWS
Cavalier AS	PHASED ARRAY	NE	NB/NC	North Dakota	UHF	Collateral	PARCS
Clear AS	PHASED ARRAY	NE	NB/NC	Alaska	UHF	Collateral	BMEWS II
Diego Garcia	GEODSS	DS	PHOTO-METRIC	British Indian Ocean Territory	Optical	Dedicated	
Eglin AFB	PHASED ARRAY	NE/DS	NB/NC	Florida	UHF	Dedicated	

C – Coherent DS – Deep Space NB – Narrow Band NC – Non-Coherent NE – Near Earth RF – Radio Frequency TR – Tracking Radar WB – Wideband

SITE NAME	TYPE	TRACK	INTEL	LOCATION	FREQ	CATEGORY	REMARKS
Feltwell	PASSIVE	DS	RF	Feltwell, England	0.5 - 18 GHz	Dedicated	Primary - Space Intel
RAF Fylingdales	PHASED ARRAY	NE	NB/NC	United Kingdom	UHF	Collateral	BMEWS III SSPAR
Haystack Auxiliary	TR	NE/DS	- - -	Tyngsboro, MA	X-band	Contributing	
Haystack	TR	DS	WB/C	Tyngsboro, MA	X-band	Contributing	
Kaena Point	TR	NE	NB/NC	Oahu, HI	C-band	Collateral	
Maui	GEODSS	DS	PHOTO	Mt. Haleakala, HI	Optical	Dedicated	
Millstone	TR	DS	NB/C	Tyngsboro, MA	L-band	Contributing	
Misawa AB	PASSIVE	DS	RF	Misawa, Japan	0.5 - 18 GHz	Dedicated	Primary - Space Intel
MOTIF	PHOTO/ LWIR	NE/DS	PHOTO	Mt. Haleakala, HI	LWIR	Collateral	
NAVSPASUR	CW FENCE	NE	- - -	Dahlgren, VA (HQ)	UHF	Dedicated	3 Transmitters 6 Receivers
Socorro	GEODSS	DS	PHOTO	New Mexico	Optical	Dedicated	
Thule, AB	PHASED ARRAY	NE	NB/NC	Greenland	UHF	Collateral	BMEWS I - SSPAR

C – Coherent DS – Deep Space NB – Narrow Band NC – Non-Coherent NE – Near Earth RF – Radio Frequency TR – Tracking Radar WB – Wideband

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4th Space Surveillance Sq, Holloman AFB, NM, nd,
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