BEALE AIR FORCE BASE, PERIMETER ACQUISITION VEHICLE ENTRY PHASED-ARRAY WARNING SYSTEM, TECHINICAL EQUIPMENT BUILDING
(Building No. 5760)
(PAVE PAWS)
End of Spencer Paul Road, north of Warren Shingle Road (14th Street)
Marysville vicinity
Yuba County
California

HAER CA-319-A
CA-319-A

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
PACIFIC GREAT BASIN SUPPORT OFFICE
National Park Service
U.S. Department of the Interior
600 Harrison Street
San Francisco, CA 94103

HISTORIC AMERICAN ENGINEERING RECORD

BEALE AIR FORCE BASE, PERIMETER ACQUISITION VEHICLE ENTRY PHASED-ARRAY WARNING SYSTEM, TECHNICAL EQUIPMENT BUILDING (Beale Air Force Base, Building No. 5760) (Beale Air Force Base, PAVE PAWS)

HAER No. CA-319-A

Location: Centrally sited within a fenced compound at the end of Spencer Paul Road, north of Warren Shingle Road (14th Street). On Beale Air Force Base, Yuba County, California.

USGS Smartville Quadrangle (7.5'), Universal Transverse Mercator Coordinates: 10 642677E 4332989N

Present Owner: United States Air Force

Present Occupant: Air Force Space Command

Present Use: Building 5760 houses the Perimeter Acquisition Vehicle Entry Phased-Array Warning System (PAVE PAWS) radar equipment. Air Force personnel track potential launches of sea-launched ballistic missiles (SLBMs) and intercontinental ballistic missiles (ICBMs) from a command post inside the structure. A secondary mission also exists, tracking space objects. Building 5760 is operational 24 hours a day, seven days a week, 52 weeks a year.

Significance: The PAVE PAWS at Beale Air Force Base is one of four large phased-array radars designed and built by Raytheon. PAVE PAWS was the first solid-state, phase-phase steered array radar operational in the world. The PAVE PAWS at Beale and that at Otis Air Force Base (today, Otis Air Force Station) on Cape Cod, Massachusetts, were the first two radars completed in the system. The original mission of PAVE PAWS was to monitor potential Soviet SLBM launches and to serve as early warning of an attack on the United States. A second pair of PAVE PAWS radars followed in the middle 1980s, sited in Texas and Georgia. The PAVE PAWS in Texas and Georgia are no longer operational. In 2002, Air Force Space Command initiated a major upgrade of the PAVE PAWS at Beale Air Force Base. The ballistic missile defense shield currently proposes to use PAVE PAWS as a platform for enhanced early warning radar, and to combine the system with missile interceptors.

Building 5760 is the primary structure at the PAVE PAWS compound on Beale Air Force Base.

Description: Building 5760 is alternately known as the Technical Equipment Building. Housing a large phased-array radar, the steel-frame structure is trapezoidal in footprint and rises to a fascia height of 105'11". The flat roof is configured as an equilateral triangle, with an elevation of just under 105'. Each of the three main facades of the radar are configured as squares, 105' by 105', tilted back from the

vertical at an angle of 20 degrees on each of the two radar array faces. The rear and front façades rise at a 90-degree angle from the ground. The facades containing the radar arrays are 120 degrees apart, measured from each array's boresight. The interior is divided as 10 floors, including five main working levels with mezzanine platforms 1A through 5A bracketing each of these and providing access to the rear of the arrays. Floor and platform height is 10'1" at each level, with the exception of the first floor and platform 5A, which are both 11'11" in height. Interior floor plans are isosceles triangles, with flattened apexes, rising through the structure in a transition from the ground floor trapezoid to the rooftop triangle. Steel paneling encases the steel framing as a primary component of an electromagnetic-pulse (EMP) shield. Corrugated foam-filled aluminum panels finish the exterior of the structure. The technical equipment building is windowless, with a single louvered vent on its rear façade. The foundation is a reinforced concrete slab.

A 102'-diameter circular pattern of antenna slots defines each of the two arrays, Face A and Face B, set within a planar octagonal frame. The crossed 8"-high dipoles angle downward to prevent adjacent dipoles from interacting electromagnetically at certain steering angles. Metal stubs sit between the dipole elements. These units help to create a circularly polarized radar beam, a beam type that increases the radar's sensitivity (Brookner 1988, 176). Antennas are set in rectangular aluminum panels designed to hold 32 units each and physically configured as four columns of eight antenna slots in staggered two-unit rows, per panel. Panels contain an irregular number of antennas, per 32-unit slot configuration. Each array face supports 56 subarrays, each in a concentric pattern of irregularly sized and arranged areas, and each containing 32 antennas. (The 32-unit design of the rectangular panels and that of the subarrays are not coincident with one another as the panels are not completely filled with antennas.) Each subarray is capable of forming a radar beam independently of the host array face. The arrays are operated as thinned arrays, with 1,792 active elements and 885 dummy elements set within a 72' smaller circle on each array face. Dummy elements are electrically terminated and do not have transmit-receive modules emplaced. The array is at its most dense in the center, thinning outward in a ratio of 1:2. Each array face is built for expansion to 5,354 transmit-receive modules per face, a configuration that would fill the 102' arrays. The outer periphery of the arrays, roughly the area between the inner 72' circle and the 102' encompassing circle, contain 2,677 antenna slots to support a possible future upgrade in the power of the radar. A small horizontally-configured, linear array of dipole elements was originally configured at level 4A on Face C as an interference monitor array. During the PAVE PAWS upgrade in 1990, the Air Force removed the interference monitor array from Face C, replacing it with an interference analysis system on all three faces. The interference analysis system antennas are located on Face C, and at levels 1 and 5A of Faces A and B. In about 1997, the Air Force disconnected the antennas, abandoning them in place (National Research Council 1979, 7, 12; Raytheon 1990, 7-8; 84-89; Stein 1979, 60; White 1980).

The five main floors have maintained their basic uses since the Beale PAVE PAWS began operation in 1980, although individual interior room and hallway modifications have occurred (Emich 1998).

> The first floor primarily serves as maintenance and storage space, with an office, day room, and lounge in the original plans. By the field-check drawings of 1985, office use had increased, extending into the day room and lounge. The most significant change occurred in 1982-1983, with the conversion of a storage area to additional computer facilities for military programmers whose available time on the backup mainframe on the third floor was compromised. From its operational status through the opening of the PAVE PAWS at Robins Air Force Base in 1986, the Beale PAVE PAWS hosted a group of military programmers who analyzed, developed, and maintained all software for the PAVE PAWS system. Between 1983 and 1986, the programmers worked on the first floor of Building 5760, operating a Cyber 170-720 (1020th Computer Services Squadron 1983).
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> The second floor serves as the key administrative and office space for the facility, augmented by a cafeteria and kitchen. Although minor changes in room use were in place by 1985, the floor plan remained substantially unaltered.
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> The third floor houses the computer and radar electronics equipment, with the computer room hosting the two Cyber 170-865s that replaced the original Cyber 170-174s in the upgrade of 1989-1991. The computer room, formally designated the Computer Maintenance Operations Center, is a secure room, and as such parallels the importance of the secure, 24-hour command and control room, the Missile Warning Operations Center, on the fourth floor. The third floor is relatively unchanged in plan.
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> The fourth floor focuses on the Missile Warning Operations Center, bracketed by message and communications centers. In mid-1988 the Missile Warning Operations Center underwent renovation, with new equipment replacing that of 1979, although the basic functional configuration remains unchanged.
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> The fifth floor houses air conditioning equipment, and is unchanged in plan.

Several significant *upgrades*, as well as *major maintenance activities*, have occurred during the 20-year life of the technical equipment building. As a highly technical, militarily secure structure, Building 5760 can be anticipated to support continuous change to sustain its radar and computer systems. With the exception

of the modification of the first floor to accommodate the Cyber 170-720 in 1982-1983, change to the structure first occurred between 1986 and 1988. Beginning in that year, the security system sustained an upgrade, with initial work undertaken by Carissimi Rohrer Associates, Sacramento. Several smaller maintenance and improvement projects followed, with mechanical and electrical modifications. In mid-1987, Koenigshofer Engineers, Sacramento, relocated and replaced selected EMP filters for the PAVE PAWS facility, inclusive of the technical equipment building. In 1990-1991, the PAVE PAWS facility underwent a major equipment and EMP shield check through the Idaho National Engineering Laboratory, the Department of Energy's installation built in the early years of the Cold War near Arco and Atomic City, Idaho. The Idaho National Engineering Laboratory had first served as a Naval proving ground for nuclear-powered submarine research. At this same time, Black & Veatch Engineers-Architects, Kansas City, provided the master design for an improved security and surveillance system surrounding the PAVE PAWS. Upgrading included new cameras, with selected new locations inside and outside the perimeter fencing; wire sensors; infrared equipment; partial new fence placement; alarm systems changes; a new copper buried lightening protection grid; and, exterior area lights. Other modifications to the Beale PAVE PAWS have been of maintenance type. The Air Force augmented the fire sprinkler system for the third floor computer room, and overlaid splicing for selected EMP paneling and aluminum siding.

Attached to Building 5760 is a small ancillary utility structure, abutting the power plant on one of its faces and the passageway connecting Building 5760 and the power plant (Building 5761) on a second face. Planned in 1977 as a part of the original construction, the one-story utility building measures 26'2" by 44' and is centered behind the technical equipment portion of Building 5760. Resting on a footed, reinforced concrete slab foundation, the structure stands just over 11' high, with a slightly sloped metal roof. Wall construction and sheathing continues that of Building 5760 and of the power plant (Building 5761). A ramped entrance and louvered 6' by 6' vent articulate the unobstructed façade paralleling the connecting passageway between Buildings 5760 and 5761. A center-opening door and two louvered vents, 3' by 3' and 5' by 8', articulate the remaining unobstructed façade. Hooded exhaust vents accent the roof. The structure houses equipment, historically including a diesel fire pump, an electric fire pump, an emergency diesel generator, two boilers, two hot water pumps, and a steam generator. The flooring is augmented through concrete pads of varying thickness to support the equipment. The Air Force planned to replace the roofs of Building 5760 and the utility structure as of late 1997, an action still pending in 1999.

Not mapped as a part of the original construction and still not present in 1984, a civil engineering shop and uninterrupted power source are assumed to be an expansion of the passageway between Building 5760 and the power plant (Building 5761) undertaken during 1985. The space is one-story. The Air Force

provided this area with EMP protection during 1986-1987. In addition to the room containing the uninterrupted power source, the space houses a battery room.

Several unnumbered ancillary structures are also associated with Building 5760. These structures include:

Near-Field Horns

Originally the Air Force sited two near-field horns 150' in front of the array faces of Building 5760, one for each array. The original near-field horns were mounted on telephone poles. As a part of the PAVE PAWS upgrade of 1990, the Air Force replaced the original near-field horns with new near-field horns, physically locating these units on concrete foundations 45' in front of each array. The new near-field horns are mounted low to the ground, with an angled presentation to their arrays. The horns each contain two dipole elements. The original near-field horns are abandoned in place, with no existing connection to the radar. Those installed in 1990 are linked via conduit below grade to the Building 5760.

Cooling Towers

Two freestanding cooling towers, sited to the north rear of Building 5760, were a part of original construction. Harry A. Yee & Associates, Inc., electrical engineers, added EMP protection specific to the towers in 1986-1987. Winzler & Kelly, consulting engineers, Santa Rosa, demolished, removed, and replaced these towers with a new unit in 1997-1998. The Air Force had planned the replacement project as of late 1996.

Ice Storage Building and Air Conditioning Units

A small rectangular structure immediately abutted the north rear corner of Building 5760 by 1990. Not mapped on site plans of original construction, or on site plans as late as 1985-1986, the unit is assumed to have gone in place during the middle-to-late 1980s. Harry A. Yee & Associates provided EMP protection for both the ice storage structure and the cooling towers in 1986-1987. The Air Force removed the ice storage structure at the time it replaced the cooling towers in 1996, leaving the two air conditioning units.

Fuel and Lubrication Oil Tanks

Originally the PAVE PAWS facility had four underground, bunkered fuel tanks of 40,000-gallon capacity each, sited between the power plant (Building 5761) and the supply warehouse (Building 5768). The largess of the fuel supply reflected the policy of Strategic Air Command in the early 1980s, providing for a 30-day supply of fuel on the immediate premises (Wood 1998). During 1998,

the Air Force removed the four fuel tanks. The agency placed two 40,000-gallon tanks in the same location as the original tanks.

Hazardous Chemical and Flammable Storage

In addition to the primary underground fuel tanks, the original PAVE PAWS site also sustained a small underground chemical tank at the north rear corner of Building 5760 and a small underground fuel oil tank near the southeast corner of the utility room. A 500,000-gallon water tank and pump station extension, both original construction, are located outside the fenced PAVE PAWS site along the access road to the facility. By 1990, site maps denote miscellaneous underground tanks and aboveground storage units on the property, including an acid waste tank and an acid neutralizing holding tank near the original cooling towers; a oil / water separator and hazardous chemical storage pad near the north security fence line; two flammable storage units at the electrical substation (Building 5770); a 200-gallon fuel tank at the rear of the supply warehouse (Building 5768); an acid neutralizing tank at the rear of the SATCOM terminal (Building 5771); and, a row of equipment at the immediate rear of the power plant (Building 5761). Included among the equipment were a dirty lubricant oil tank, an underground fuel oil drainage tank, an oil interceptor, and four fuel oil day tanks. Four radiators also stood nearby.

The information presented here is derived from a field inventory of June 1998. Subsequent physical changes to Building 5760 are undetermined.

Historical Context: The PAVE PAWS radar installation at Beale Air Force Base was in planning and construction during 1976-1980. The architectural-engineering firm responsible for the design of the PAVE PAWS was Raytheon, of Boston. Raytheon's Equipment Division worked with United Engineers & Construction and Jackson & Moreland International, Inc., also both of Boston. The design of PAVE PAWS dates to January 1977. The regional architectural-engineering firm adapting Raytheon's master drawings to site-specific conditions at Beale was Tudor Braccia Bentley Architects & Engineers of San Francisco. The Tudor Braccia Bentley drawings are dated March to September 1977. Sverdrup & Parcel, of St. Louis, field-checked the as-builts for the Beale PAVE PAWS in June 1985, and created the set of drawings that exists today. During 1989-1991, Black & Veatch of Kansas City designed security and surveillance systems for the PAVE PAWS compound at Beale Air Force Base.

The historical context for the PAVE PAWS at Beale is complex and multi-faceted. Beale supported major missions throughout the cold war. During the late 1950s, Strategic Air Command placed a bomber alert facility on the base, while simultaneously Air Defense Command constructed a command post for the Semi-Automatic Ground Environment (SAGE). The SAGE post at Beale was one of 23 in the nation. Its air defense jurisdiction monitored a radar network spread across northern California. Strategic Air Command added a second

important mission at Beale in the early 1960s: Titan I ICBM silos ringed the base, emplaced at Lincoln, Chico, and Sutter Buttes. After 1965, Beale complemented its strategic and air defense roles by becoming a pivotal installation for reconnaissance aircraft, including the SR-71, U-2, and TR-1. The PAVE PAWS radar installation was the final major mission to arrive at Beale, in 1980.

The PAVE PAWS at Beale is one of 10 large, phased-array radars built for the American long-range search-and-track mission, and one of four constructed specifically for the monitoring possible SLBM or ICBM attacks against the continental United States. These radars represent multi-decade technological improvements, in radar and computer hardware, and in supporting software programs. The precursors to the four PAVE PAWS included radars at Eglin Air Force Base, Florida, of the 1960s (built for high-inclination space tracking); in the Aleutians, of the early 1970s (built for monitoring Soviet missile launches); and, in North Dakota, of the middle 1970s (built for the American antiballistic missile [ABM] program). The four PAVE PAWS of 1980-1987 were the middle group of large, phased-array radars, constructed on the east coast (at Cape Cod), west coast (at Beale), and Gulf coast/southeast (in Texas and Georgia). The PAVE PAWS were part of an increasingly sophisticated radar fence erected to provide early warning for the United States. The accuracy and power of the large, phased-array radar made it a viable replacement for the long-range search radars of the Ballistic Missile Early Warning (BMEWS) network of the early 1960s. During the 1990s, the Air Force built the final three radars similar to PAVE PAWS—those at the three BMEWS sites in Greenland, England, and Alaska.

The PAVE PAWS radars and the other large, phased-array radars in its contextual group, have remained controversial throughout their existence. The politics of the cold war, in particular the fears raised by advanced ICBMs and their complementary ABM defense scenarios, were intimately tied to the PAVE PAWS. The ABM Treaty of 1972 called out the large, phased-array radar (what was allowed, what was not). During the final decade of the war, the United States and Soviet Union each constructed large, phased-array radars interpreted as violating the ABM Treaty: the two PAVE PAWS in Texas and Georgia, and several radars in the Soviet Union. One issue was the potential conversion of a large, phased-array radar to a battle-management radar. The upgrading of the PAVE PAWS at Beale in the late 1990s accommodated the requirements of a ballistic missile defense shield, as did the installation of the final American large, phased-array radar in Clear, Alaska, at the end of the decade.

Sources:

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Project Information: During 1998 and 1999, Air Combat Command assessed the National Register of Historic Places (NRHP) significance of the PAVE PAWS radar at Beale Air Force Base in compliance with Sections 106 and 110 of the National Historic Preservation Act (NHPA). In consultation with the California Office of Historic Preservation, the Air Force decided that the Beale PAVE PAWS was eligible for the NRHP under criteria A and C at the national level of significance. In conjunction with the NRHP evaluation, Air Combat Command also contracted for a historic context for the Beale PAVE PAWS.

While this process went forward during 1998, Air Force Space Command entered into a four-state Programmatic Agreement (PA) covering the PAVE PAWS in Massachusetts, California, Georgia, and Texas. The PA referenced a prior agreement between the SHPOs and the Air Force to conduct a Level II Historic American Buildings Survey (HABS) / HAER documentation for the first PAVE PAWS at Cape Cod, with Level III HABS/HAER documentation at each of the other three radar installations. To complete the PA requirements, Air Combat Command contracted with the Fort Worth District, United States Army Corps of Engineers, to complete a HAER documentation of the PAVE PAWS at Beale.

A team of individuals collaborated on the Beale PAVE PAWS HAER. The primary researcher and author of the HAER narrative document and architectural data forms is Dr. Karen J. Weitze of Weitze Research. The HAER photographer is Joseph Murphey, Fort Worth District, United States Army Corps of Engineers. Personnel at KEA (EDAW), San Diego, collaborated on the draft HAER during 2000-2002. Geo-Marine, Inc., Plano, Texas, handled oversight of the final HAER in 2006.