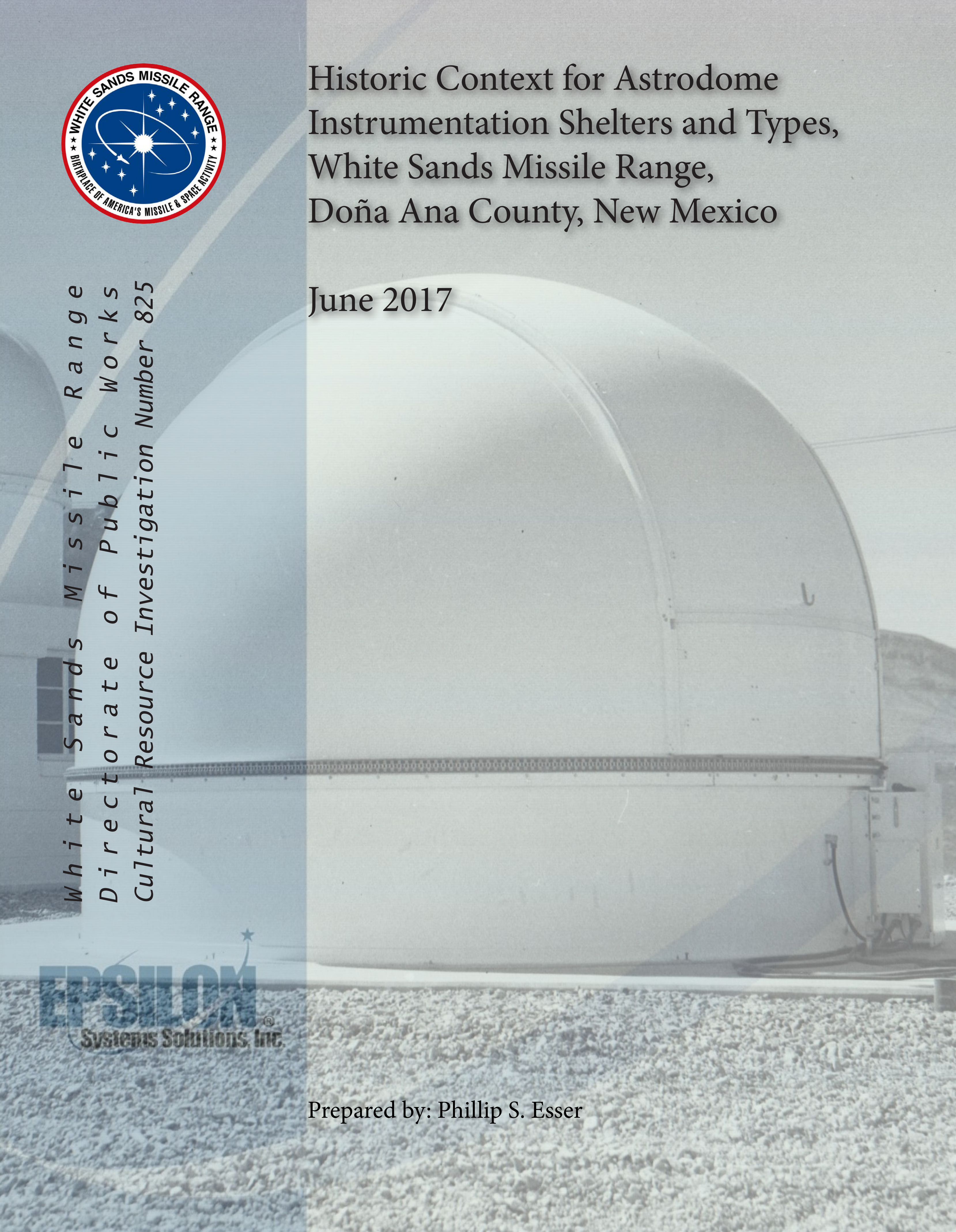

White Sands Missile Range
Directorate of Public Works
Cultural Resource Investigation Number 825

Historic Context for Astrodome Instrumentation Shelters and Types, White Sands Missile Range, Doña Ana County, New Mexico

June 2017

EPSILON® Systems Solutions, Inc.

Prepared by: Phillip S. Esser

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14. ABSTRACT
The attached document is a historic context for evaluating buildings and structures under National Register of Historic Places (NRHP) for the multitude of fixed astrodomes at White Sands Missile Range, Dona Ana County, New Mexico. The National Historic Preservation Act, Section 106, requires federal agencies to review the effects of it undertakings upon historic structures. This review includes an overview study in anticipation of evaluations of the structures for their eligibility to the National Register. Documents such as this are also highly important in preserving the history of the range and its activities and will become part of the public record. Presently this document will be included as a supporting document as the US Army initiates consultation with the New Mexico Historic Preservation Division regarding the proposed demolition of historic structures at WSMR.

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The author would especially like to acknowledge Jim Sommer, the key figure in the development of the Parabam astrodome, for taking the time to be interviewed and provide access to his archival records at MSG West in Adelanto, California.

Jim Sommer, June 2, 2015

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1. Introduction

During the Cold war, commonly held as the period between 1946 and 1990, the US Army at White Sands Missile Range (WSMR) in southern New Mexico was involved with the testing of numerous rocket and missile programs in an effort by the United States to remain technologically superior to the Soviet Union in military defense. Originally conceived as a temporary effort to test captured German V2 rockets at the end of WWII, the facility became a permanent installation as immediate post-war tensions rose between the new superpowers. From the beginning, the scientists and engineers knew that all types of data would need to be collected to analyze a multitude of performance and flight characteristic information. Located in the Tularosa Basin in southwestern New Mexico, the 40-mile wide by 100-mile long site was chosen for its ideal characteristics such as remoteness, climate, and flat and open ground bounded by mountain ranges (Starkweather 1989: 6) (Figure 1). Over the next thirty-five years, hundreds of buildings and structures were constructed throughout the 4,000 square-mile land mass to house an array of instrumentation devices designed to capture that data.

Protecting sensitive optical devices from the elements has posed a challenge since the development of large-scale telescopes in the nineteenth century. The astrodome, a miniaturized adaptation of a telescope observatory protective shell, came into being at the end of the WWII and early Cold War through pure necessity. It served an almost exclusive military role with likely over 1,000 being produced over a 30-year period. Its origins lie in the development of optical tracking equipment at rocket and missile test stations which are often subject to harsh climatic environments. While many remain abandoned in place since the turn of the twenty-first century, astrodomes have been largely ignored as a subject of study. Considered by the military as equipment, they are not typically recorded as facilities.

This analysis was borne of a desire to inventory and classify the dozens of retired astrodome shelters found at WSMR used for optical tracking devices. These ubiquitous domed structures, most of which are no longer in use, dot the landscape of WSMR. Not an exhaustive survey, this document provides a historic context for the hundreds of such type astrodome installations at WSMR with data gathered from archival and primary sources. The limitations to this study are that no systematic range-wide inventory was undertaken to comprehensively capture both the extant types and their condition. It explores the origins of the astrodome, its development, physical and mechanical characteristics, and specific types found on the ranges at WSMR.

This document was also prepared in anticipation of ongoing inventory and evaluations under Sections 106 and 110 of the National Historic Preservation Act (NHPA). Section 106 of the NHPA requires federal agencies to “take into account” the impact of their undertakings on historic properties, whereas Section 110 directs federal agencies to inventory historic properties under their care and management, beyond considerations related to specific projects. Historic properties are buildings, structures, sites, districts, and objects that meet the criteria for listing in the National Register of Historic Places (NRHP or National Register; 36 Code of Federal Regulations [CFR] 60). How astrodomes fit into the NRHP evaluation process is discussed in Chapter 8.

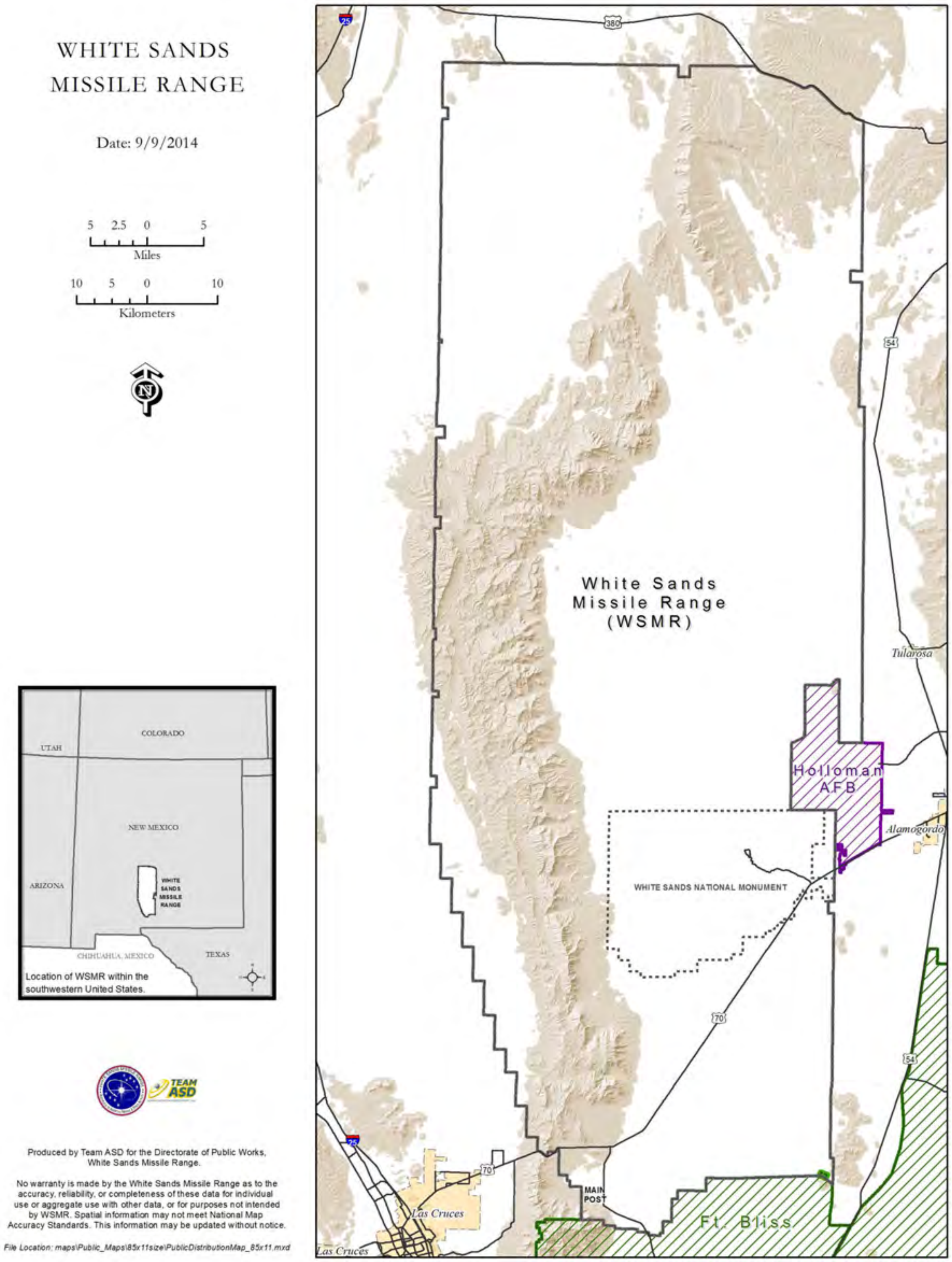

Figure 1. White Sands Missile Range

2. Origin of Instrumentation Shelters

As the Allies moved deep into the German heartland in WWII, the US mined a treasure trove of captured rocket and missile technology, including the deadly V1 and V2 rockets that wreaked havoc on London and its environs. Included in the spoils were the German-made Askania cinetheodolite, a highly sensitive projectile tracking and recording optical device. This particular instrument would be the driving force behind the conception and development of the astrodome. Since the development of the astrodome was a direct result of the cinetheodolite, it is best to start by describing the instrument's function.

A theodolite is a surveyor's tool which has its origins in the combination of a sextant (to measure elevation; vertical) with an alidade (to measure azimuth; horizontal). The addition of a motion picture camera to a theodolite created a cinetheodolite, a photographic instrument for the collection of trajectory data (Figure 2). The Germans worked to improve the device in the early twentieth century, which ultimately led to its use in training antiaircraft gunners and to determine projectile trajectories up to the end of WWII (Test Department 1953: 2). The cinetheodolite served as a critical tool on American missile test ranges and was continually improved through the second half of the twentieth century (Figure 2).[1]

The immediate needs of the test ranges prompted the military to forgo considerations for sheltering the instrumentation other than rudimentary covers to protect the delicate instruments when not in use, a practice that continued up to the 1960s in select areas of WSPG. Interestingly, the only structures erected were for electronics and human shelter (Figure 4). At NOTS, a rigid cylindrical casing nicknamed the "peanut shell" was used (Jack Godett, personal communication 2012) and electronics were typically transported to the site. As missile and rocket testing activities increased dramatically in the late 1940s, a number of factors, primarily environmental (climatic), would drive range engineers to conceive of and implement gradual improvements.

Askania cinetheodolite units (manufactured by Askania Werke A.G. in Germany, also used at the Peenemünde rocket research center), were salvaged from Germany and brought to the United States for use at the newly emerging military test ranges (Figure 3). Along with their counterparts in the Navy and Army Air Force, technicians at the Army's White Sands Proving Ground (WSPG) restored and modified captured Askania cinetheodolites for use on

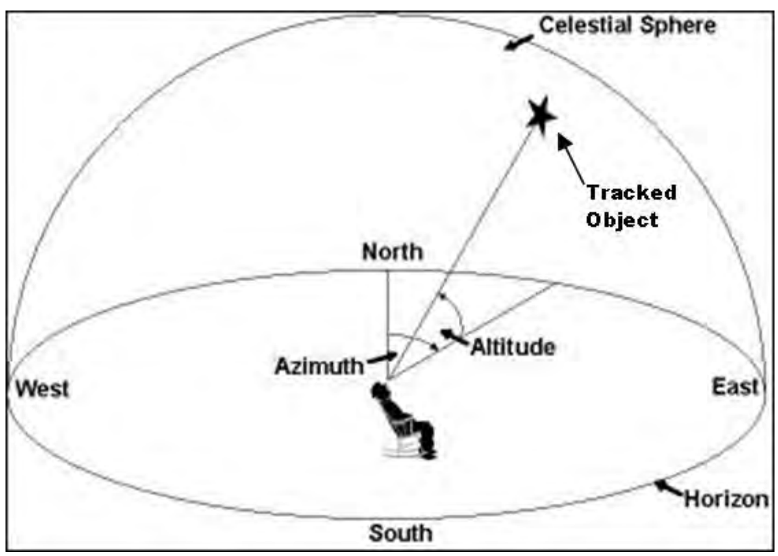

Figure 2. Schematic of how a theodolite tracks azimuth and elevation.

1 In some early period missile range literature, the term *theodolite* is used interchangeably with *photo-theodolite* and *cinetheodolite*.

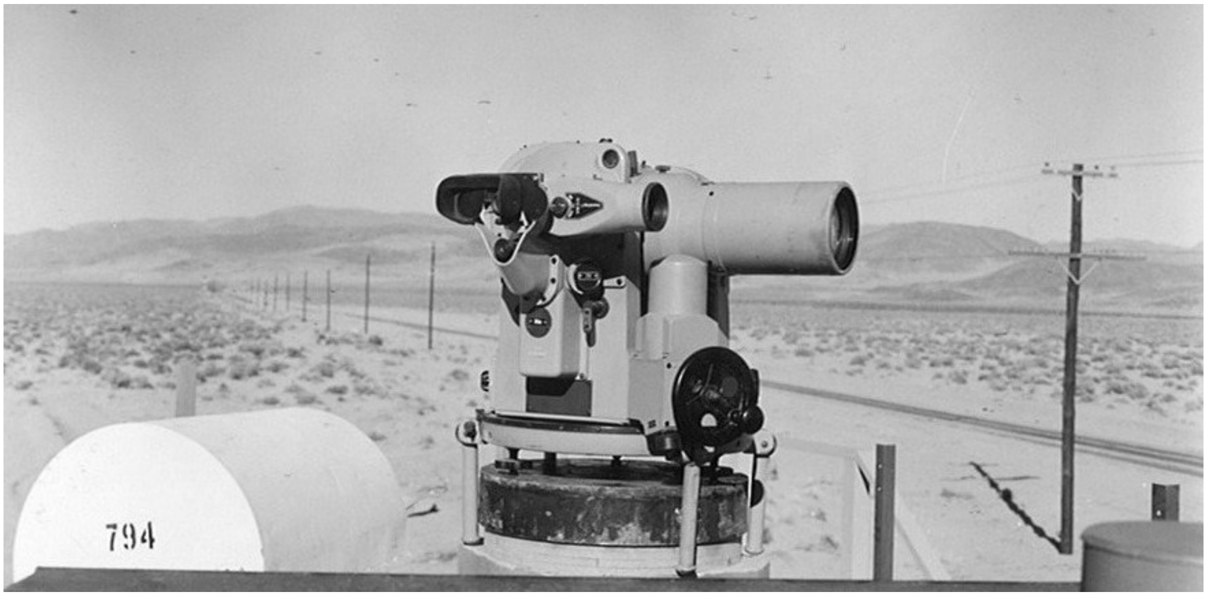

Figure 3. Captured Kth 41 NOTS-modified Askania Cinetheodolite, Naval Ordnance Test Station (*NOTS)* Inyokern, California, ca. 1946 (*NAWS TID 307905)*.

their ranges as early as 1946.[2] The units that went to WSPG were apparently dumped in the Baltic Sea by German scientists to prevent their capture (Kammer 1997).

The competition for procurement of these captured cinetheodolites was fierce but each branch of the military received (and modified) a number of the prized instruments for use on their respective ranges. The immediate needs for testing precluded any sophisticated facilities or shelters for the instruments but unforeseen factors led to a variety of solutions culminating in the astrodome shelter. The simple but clever device would house other optical instrumentation in time and become a mainstay of missile tracking for more than a half century.

The earliest known shelter specifically created to house optical instrumentation was a "ra-dome", designed for use at Fort Bliss, Texas (Figure 4). Drawings dating from 1945 illustrates that the concept significantly predates the development of the astrodome-type shelter some years later. Two domes were built in support of the Doña Ana Antiaircraft Artillery Range; only the concrete pedestals survive. While the drawings reference housing a "theodolite", it is not clear what type. Given the dimensions of the dome and the substantial reinforced concrete pedestal on which it rested, it seems likely that it housed a cinetheodolite. The only types available at the time were the American-made Mitchell and Akeley types. Known to be less accurate than the German-made Askanias, they were designed primarily for measuring the performance of aircraft, training antiaircraft gunnery crews, and recording positions of antiaircraft bursts (Test Department 1953). The American cinetheodolites had neither the accuracy nor the faster tracking capabilities of the Askanias.

In their earliest iteration at newly emerging missile test ranges Askanias were put to use at WSPG, Holloman Air Force Base (HAFB), the Naval Ordnance Test Station (NOTS) in the

2 The term "Askania" has been used to distinguish the German-made Askania cinetheodolite from the copied and modified US military versions. Therefore, in period publications, and here, "Askania" and "cinetheodolite" are commonly used interchangeably. Early testing literature sometimes describes the instrument as a "theodolite".

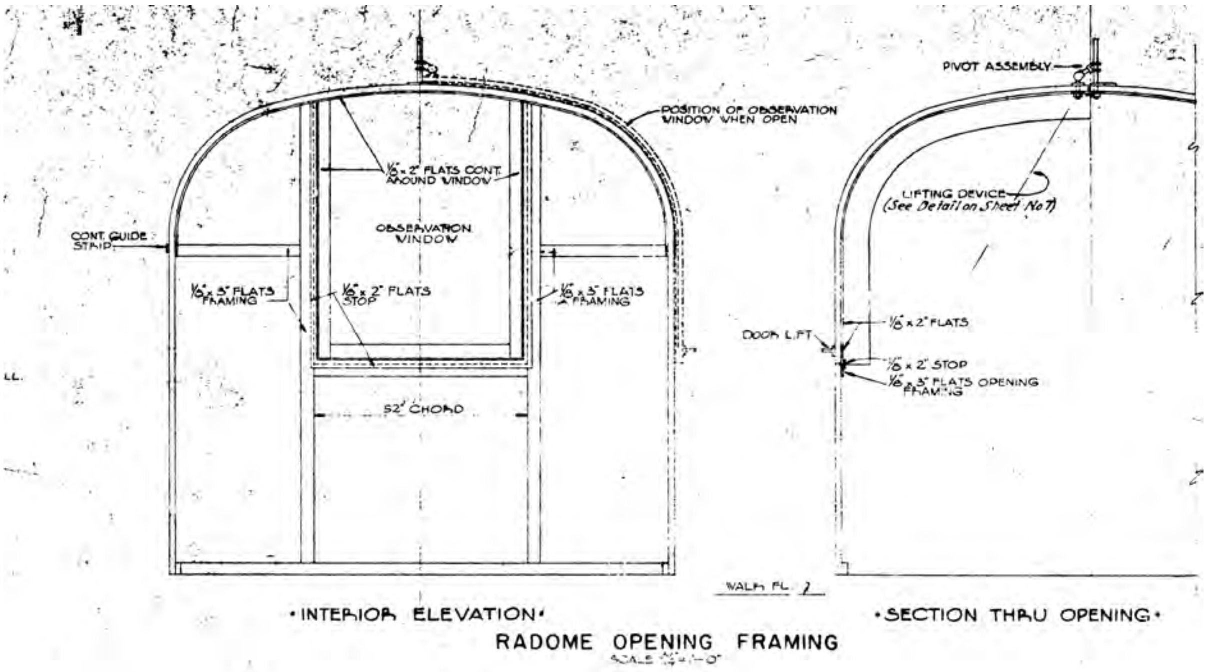

Figure 4. Design for "Theodolite Dome" Fort Bliss, Texas, September 1945 (*Drawing FB-AM, Fort Bliss Real Property Records)*.

California desert, the Air Force Missile Test Center (AFMTC) at Patrick Air Force Base in Florida, and the Naval Air Missile Test Center (NAMTC) at Point Mugu, California. Askania cinetheodolites were typically mounted on camera stands consisting of concrete or cylindrical steel posts atop concrete pads (Figure 5). These allowed for the movement of Askanias and support electronics when and where they were needed. The cinetheodolites themselves were not protected from environmental exposure in these original configurations and were either covered with canvas-type shrouds or detached and removed when not in use. Not permanently affixed to the posts, the extremely heavy Askania was fitted with folding handles and required two individuals to move.

The immediate needs of the test ranges prompted the military to forgo considerations for sheltering the instrumentation other than rudimentary covers to protect the delicate instruments when not in use, a practice that continued up to the 1960s in select areas of WSPG. Interestingly, the only structures erected were for electronics and human shelter (Figure 6). At NOTS, for example, a rigid cylindrical casing nicknamed the "peanut shell" was used (Jack Godett, personal communication 2012) and electronics were typically transported to the site. As missile and rocket testing activities increased dramatically in the late 1940s, a number of factors, primarily environmental (climatic), would drive range engineers to conceive of and implement gradual improvements.

No consideration was given for operator comfort while operating the Askanias. The relative infancy of the test ranges and quickly expanding use of optical instrumentation left operator comfort a secondary consideration. The effects of direct sunlight as the day progressed posed problems for recordation at certain angles in addition to creating a somewhat harsh working environment for operators, who often spent the majority of their time simply waiting for a

Figure 5. Post-type Askania Cinetheodolite, WSPG, New Mexico, 1949 (*WSMR Museum Archives 12.010.076)*.

missile or rocket launch. Missile and instrumentation development progressed rapidly through the late 1940s; however, instrumentation shelters took another decade to coalesce into a unified system that served both the instrument and operator.

Disparate climates provided the impetus for development of instrumentation shelters, each with its own challenges. The two primary inland test ranges, WSPG (now WSMR) and NOTS, are located in desert environments where summer temperatures can regularly exceed 100°F. Specific to these desert environments was an optical effect dubbed “atmospheric boil”, first described in a 1947 article (Riggs et al. 1947). The results of the study revealed that between the hours of 6am and 4pm the heat buildup at ground level creates a shimmering effect that distorts images. Based on a number of reports that emerged in the early 1950s, both ranges were working to resolve the issue. As early as 1949, former German scientist Dr. Ernst A. Steinhoff, working at HAFB, who effectively was developing what would become the WSPG ranges, illustrated the construction of a 35-foot tower on which to mount a cinetheodolite (Figure 7). While not directly related to environmental issues endemic to the equipment itself, it is part of the evolution of maximizing efficiency for the very expensive and sensitive instruments. Steinhoff specifically references atmospheric boil in follow-on recommendations for choosing the best cinetheodolite sites for Hueco Camp Site (Steinhoff 1950: 26).

Three years earlier in 1946, two structures were constructed specifically to mount Askania cinetheodolites at NOTS and are likely the first of their kind in the US. The 26-foot by 12-foot reinforced-concrete, rectangular buildings are raised well above the desert floor, yet no documentation exists to suggest it was in order to minimize the effects of atmospheric boil (Figure 8). Conversely, the height may have simply been a way to reduce the effects of wind-blown dust at grade.

WSPG produced shelters in the mid-to-late 1940s, but these were limited to protecting the instrument while not in use. An extant photo, taken ca.1947, shows how a rudimentary wood-frame “box” served as a protective housing for the cinetheodolite (Figure 9). Another period photo illustrates a boxed base with a fabric tent covering (Figure 10). Again, it appears that the

Figure 6. Bern Site at WSMR with covered cinetheodolite, 1963 (*WSMR Museum Archives)*.

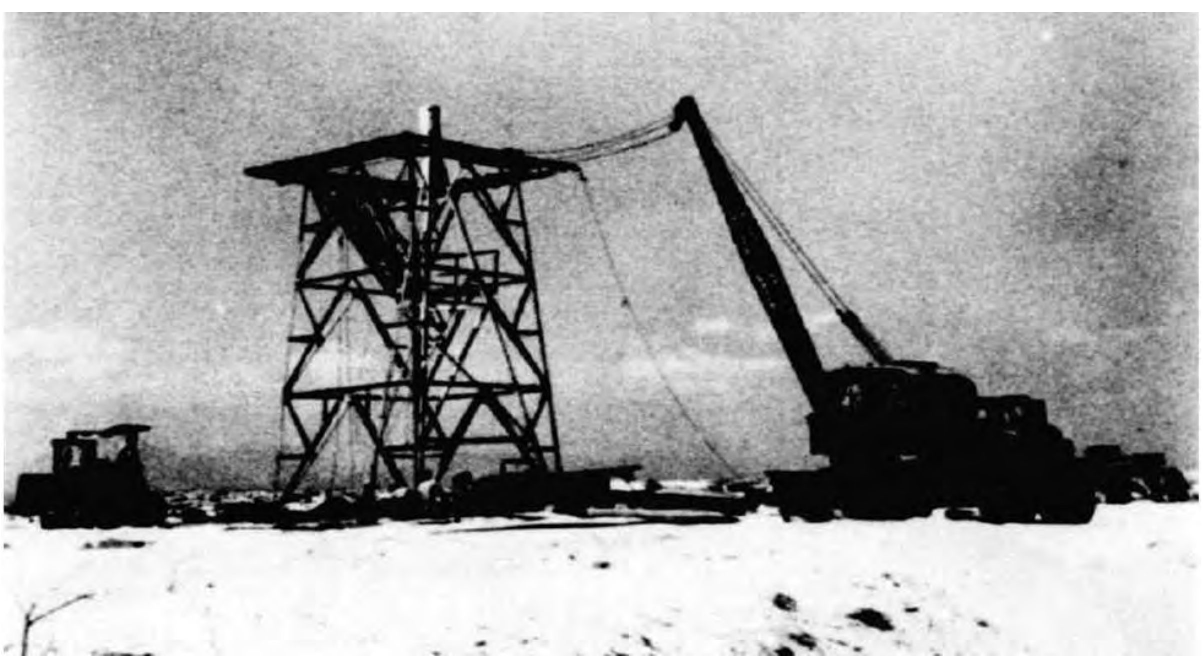

Figure 7. Cinetheodolite Tower under construction at Holloman Air Force Base, 1949 (*Holloman Air Force Base Special Report on Instrumentation, September 1949)*.

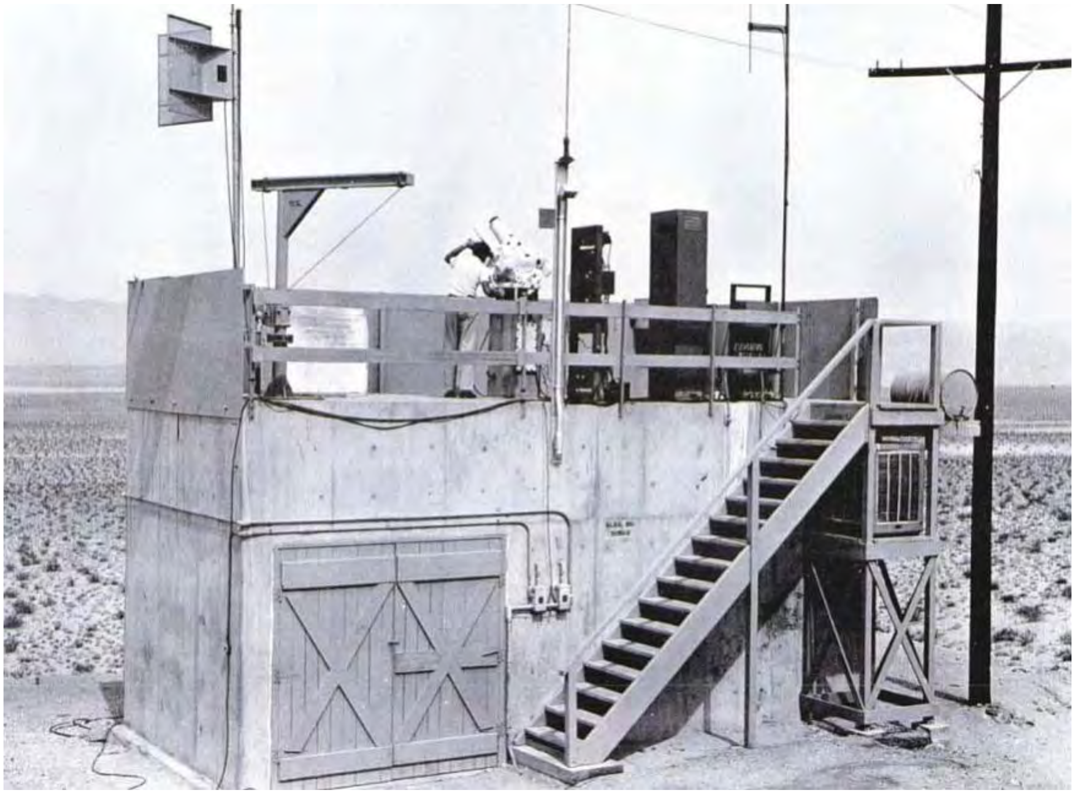

Figure 8. Askania Building (*Constructed 1946)*, NOTS Inyokern, 1953 (*National Archives and Records Administration, Washington, DC; Courtesy JRP Historical Consulting, LLC)*.

Figure 9. WSPG Cinetheodolite Station, ca. 1947 (*Ken Bellinger Collection, WSMR Museum Archives)*.

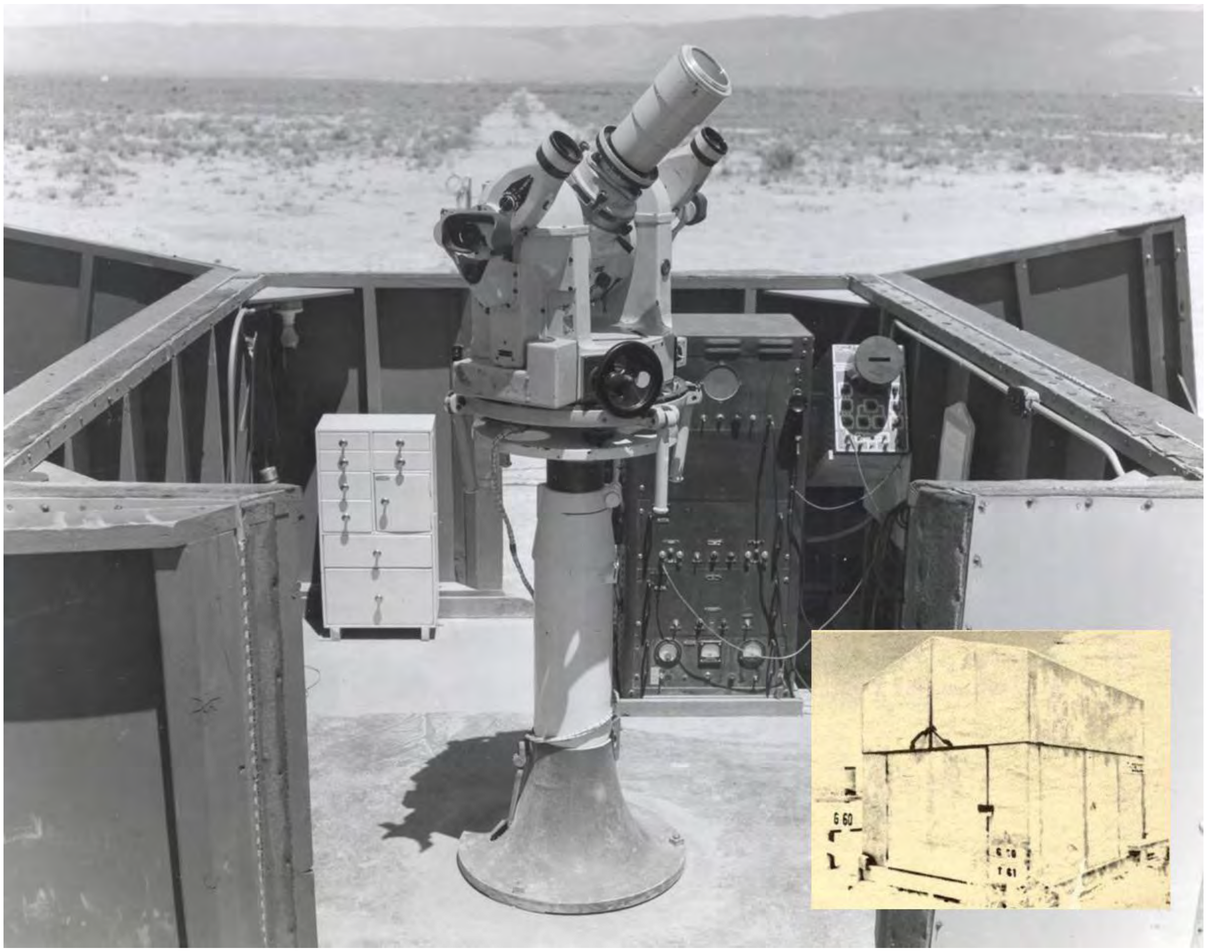

Figure 10. Temporary Fold-down Cinetheodolite Shelter, WSPG, ca. 1948 (*WSMR Museum Archives)*.

canvas covering on the upper portion only protected the instruments when not in use.

By the early 1950s, atmospheric boil had become enough of an issue at WSPG for the instrumentation department to take action on mitigating this effect. From 1950 to 1955 WSPG expanded the range, constructing multiple permanent instrumentation shelters for cinetheodolites erecting concrete frame buildings with concrete block walls set on thick concrete foundations (Figure 11). Rectangular or square in plan (generally 12-foot by 14-foot and 18-foot by 28-foot) and one story in height, the buildings feature a flat roof with a tubular steel safety railing around the perimeter. In an early attempt to protect the equipment while not is use, the Army installed hydraulic lifts that allowed the pedestal and Askania cinetheodolite to be raised through the roof level for use (Figure 12), and brought back down inside for storage and servicing.

At nearby HAFB, Dr. Steinhoff's recommendation of elevating the instrument off the ground resulted in the design of a 2-story permanent structure (Figure 13). Presaging the development of the astrodome, the reinforced concrete structure was fitted with a retractable, pyramidal roof structure; each of the four sides could be opened and closed independently. This unique device helped to stabilize temperatures in and around the cinetheodolite when not in use as well as

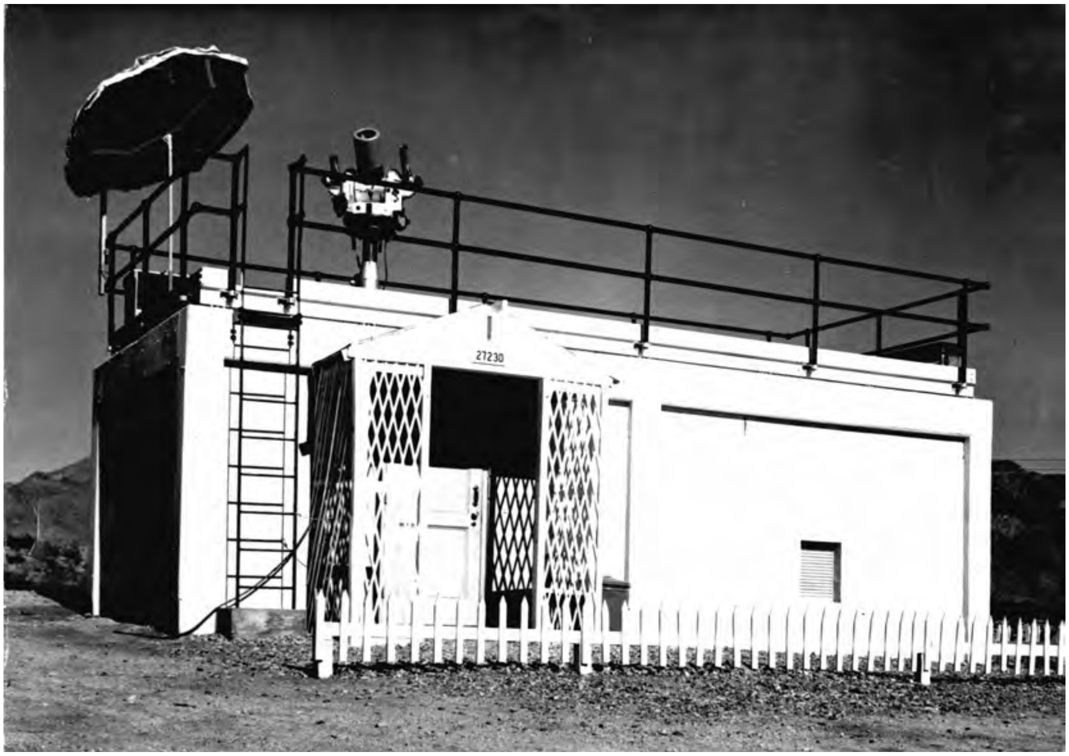

Figure 11. WSMR Cinetheodolite Building, ca. 1955 (*WSMR Museum Archives)*.

Figure 12. Cinetheodolite on hydraulic lift, ca. 1955 (*WSMR Museum Archives)*.

Figure 13. Holloman AFB cinetheodolite shelter, ca. 1970 (*WSMR Museum Archives)*.

create a sun shade by manipulating the individual roof panels. Constructed in 1953 and 1954, HAFB constructed eight of these structures to house Askania cinetheodolites, three on HAFB and five on WSPG.

Despite all the advancements in providing permanent stations to protect the cinetheodolites from atmospheric distortion and appropriate storage when not in use, no consideration was made for the operators who endured continual exposure to a variety of climatic conditions, not to mention extended periods of waiting for frequently delayed test shots. A hint of operator comfort efforts was caught in a WSPG cinetheodolite building image where an umbrella and "homey" appendages have been added to the otherwise basic structure (Figure 11). A vastly improved solution for instrument *and* operator was beginning to coalesce.

3. Coleman Astrodomes

The development of the missile test range astrodome-type shelter was ultimately an inter-service effort, though the Navy is credited with initiating the development for the first astrodome prototype in late 1953. Concurrent with this effort, the Range Commanders Council (RCC), created in August 1951, was formed to address common concerns and needs of the numerous test ranges coming on line in the US. WSPG is credited with being the birthplace of the RCC which, along with its numerous counterparts, used their collective brain power and limited resources to effectively develop range infrastructure nationwide; the RCC Secretariat is based at WSMR. Numerous committees were formed to address specific instrumentation needs common to all test ranges, one of which was the Inter-Range Instrumentation Group (IRIG), formed in September of 1951. A sub-committee, the Optical Systems Working Group (OSWG) was organized to deal specifically with optical instrumentation.

It is no surprise that the Navy took the lead with astrodome development at NOTS with its particularly challenging desert climate. The problem was stated in the background section of a report on the specific subject:

> The need to control the environment of Askania cinetheodolites has long been recognized at this Station. The benefits to be reaped from such control are many: improvement in the quality and accuracy of the data, increased instrument reliability, improvement in operational skill and morale, and decreased maintenance and repair costs. Various types of shelters have been used or contemplated. These ranged from a simple umbrella type sunshade to an all-wooden structure that enclosed the operator and the instrument.
>
> However, all of these shelters exhibited one of two major drawbacks: they either did not provide an enclosed space around the instrument for protection and environmental control or, if such space was provided, the instrument was not protected by controlled environment *during periods of actual use and operation* [DiPol 1957: 1; emphasis added].

It was this all-encompassing goal of providing a controlled environment for the instrument that resulted in the conception of the astrodome. NOTS was being plagued by multiple issues, many of which were identified in a 1954 study entitled, *Control of Environment for Askania Theodolites*, a document that was published as a Technical Memorandum for dissemination to other installations (Pike 1954). The main consideration in the design of the astrodomes was to increase accuracy and reliability by protecting the instruments from fluctuations in temperature, condensation buildup, and fine dust that wreaked havoc with sensitive mechanical components. Operator morale appears to have been an ancillary benefit, though included as a consideration in qualitative studies; maintenance costs and reliability were paramount concerns:

> The present method of operating Askania cinetheodolites in the open, moving them frequently, and storing them with only a canvas cover for protection has long been recognized as costly in reduced reliability and in increased maintenance and depreciation. It has also long been the belief that accuracy of data obtained under the present operating conditions is less than the inherent capa-

> bilities of the Askania instruments. To improve matters, the Test Department has plans to build Askania buildings with servo-driven astrodomes which can be closed when the instruments are not in use and opened for operation, These buildings [under slight positive pressure] will have means to filter and heat or cool the inside air [Pike 1954: v].

Another factor was the effects on the 35mm film used in data collection. Besides the issue of temperature fluctuations causing shrinkage problems and therefore interpretive inaccuracies, low humidity caused the film to be brittle; dimensional stability is a critical factor in reading and interpreting the data on the film. To make matters worse, engineers at WSPG were reporting dust infiltration that was leaving spots on the electrostatically charged film (Pike 1954).

Other subtleties affecting performance and accuracy arising from temperature and humidity variations include refraction in the lenses, dimensional instability of plastic components, effects on viscosity of internal lubricants, and longevity of supporting electronic equipment. The critical factor in working towards controlling the environment would be easing the equipment into the extant outside conditions when preparing for use—if not, many of the issues could quickly arise again, particularly condensation and dimensional stability of plastics and film.

A few period sketches illustrate the evolution of the dome concept (Figure 14). Even mobility was considered with the NOTS-designed Tracking Instrument Mount (TIM) (Figure 15). To address the multitude of issues plaguing the cinetheodolites, NOTS began development and design for the “astrodome type” shelter in September, 1953. Specifications were provided to Coleman Engineering of Los Angeles who produced a prototype by May of 1954 (DiPol 1957: 2). The specifications took into consideration all conceivable factors: current and planned weapons programs to assure the dome would rotate quickly enough when tracking as well as the dimensions of a cinetheodolite, its optics, and a single operator. Out of these factors came a four foot tall cylindrical steel base, 10 feet in diameter, the dimension that would differenti-

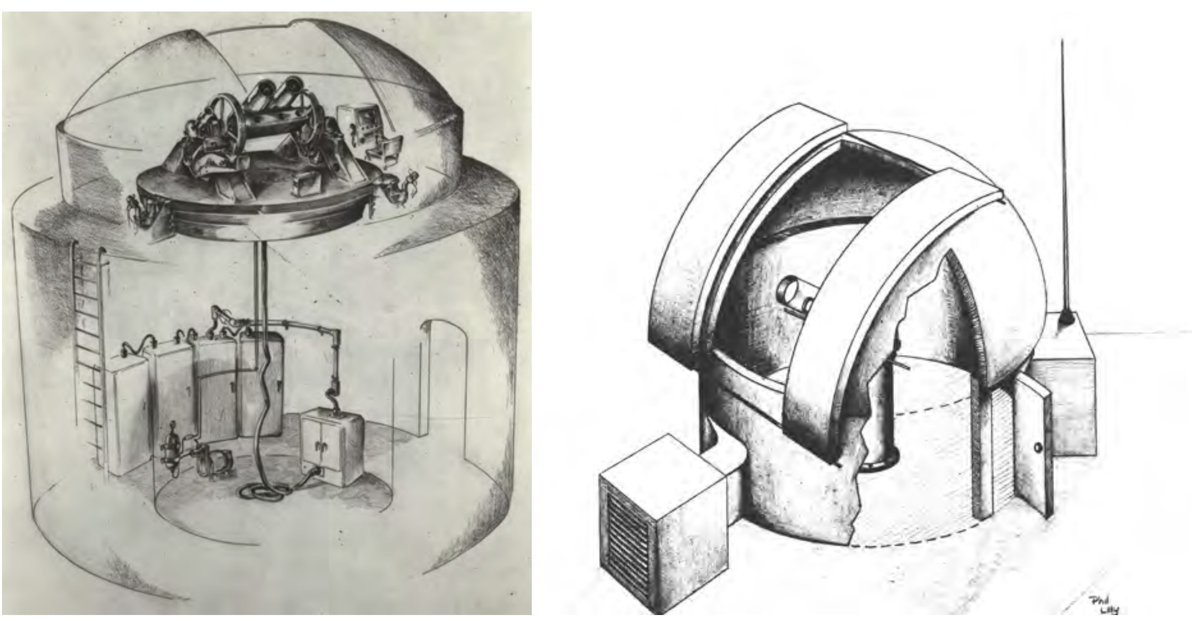

Figure 14. NOTS cinetheodolite shelter concepts, ca. 1950 (*Courtesy Matt Boggs, NAWCWD, China Lake)*.

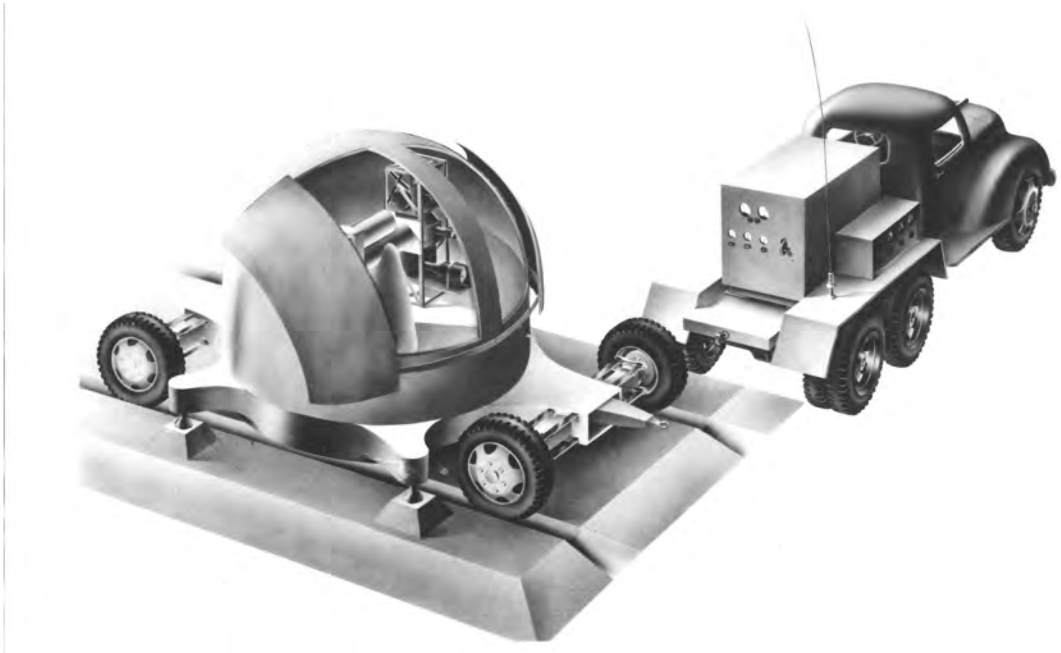

Figure 15. NOTS artist's conception of the Tracking Instrument Mount (*TIM)* with "shelter dome", 1952 (*NP/45 48209, Courtesy Matt Boggs, NAWCWD, China Lake)*.

ate all future astrodomes, on which was placed a fiberglass dome that was designed to freely rotate. Synchronized with the movement of the cinetheodolite, the dome rotates according to operator input which exposes the optical lens to the sky through a 50-inch opening that extends slightly beyond the apex of the dome; in essence, the dome, instrument, and operator all rotated as a unit.[3] Performance specifications required that the dome be able to accelerate and rotate at prescribed rates. The dome is driven by a combination electric/hydraulic drive system that consists of a wrap-around, gear-driven chain moving the entire dome on rollers (Figures 16 and 17). When not in use the entire dome is lifted off the rollers and sealed from the elements with a neoprene gasket on a flange at the top of the base (Figure 17) (DiPol 1957: 3-4).

Coleman Engineering produced two more prototypes in March of 1955 which were tested and, after a few modifications, 15 additional astrodomes were then manufactured and installed at NOTS between June 1955 and April 1956; nine were installed at the Air Force Flight Test Center in California (now Edwards Air Force Base). A second contract was awarded to Coleman for the manufacture of eight new astrodomes on the G-1 and G-2 Ranges at NOTS to house cinetheodolites, and the adaptation of six existing structures (the rectangular-plan "original" buildings) to the astrodome type (Rocketeer 1954: 6; DiPol 1957: 2).

A critical aspect of the astrodome concept and execution was the plan to greatly expand coverage of the range, something that WSPG had conceived of and executed a few years earlier with their "Integrated Range" concept. This concept unified all types of missile test instrumentation into a central timing and control system. Missiles were flying faster and farther than ever before and could be "handed off" to instrumentation stations placed the length of the enormous

3 NOTS conceived of and developed a modification in 1947 that allowed a single operator to control both azimuth and elevation; by the time astrodomes were introduced at WSMR and elsewhere, this had become standardized in cinetheodolite operation.

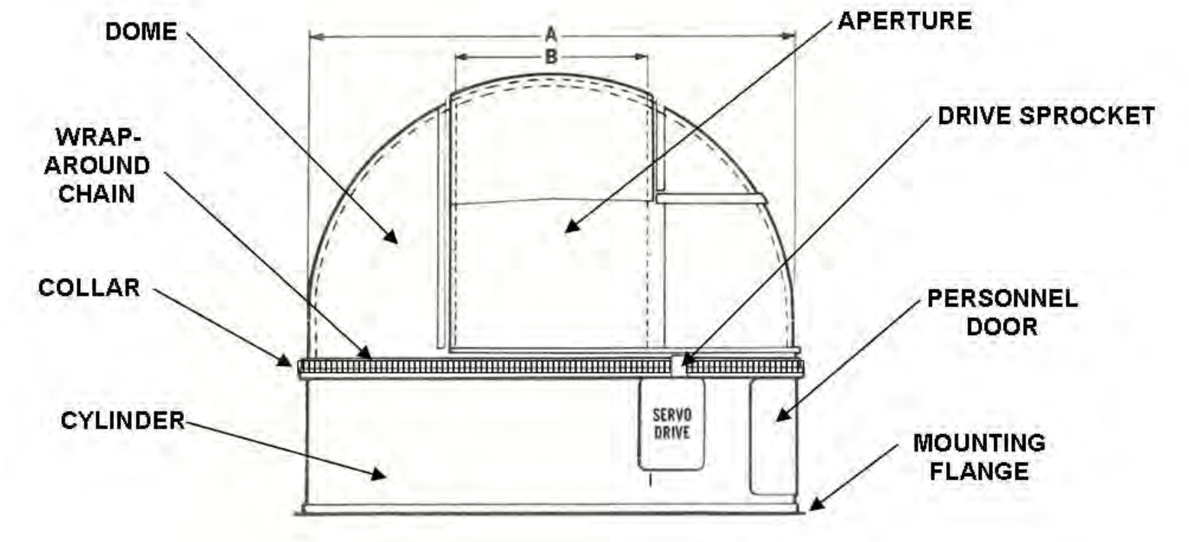

Figure 16. Astrodome Schematic (*From a sales pamphlet produced by MFG West)*.

land mass of WSMR.

In their planning process for full range coverage, NOTS engineers had planned a new generation, raised cine-theodolite mount. In anticipation of the astrodome, these structures were equipped with electronic equipment for the optical instruments, hydraulic units for the revolving dome, and also included air-conditioning which was vented through the concrete ceiling directly into the astrodome (Figure 18). The first generation cinetheodolite buildings were retrofitted to accommodate the astrodome and also vented and fitted for air-conditioning (Figure 19). WSPG would design their own versions of structures fitted with astrodomes, most of which were simple concrete pads on elevated earthen berms.

As a “type”, the Coleman-produced, 10-foot diameter astrodome created a new standard for housing a cinetheodolite controlled by a single operator; the sun, wind, dust, heat, and fluctuat-

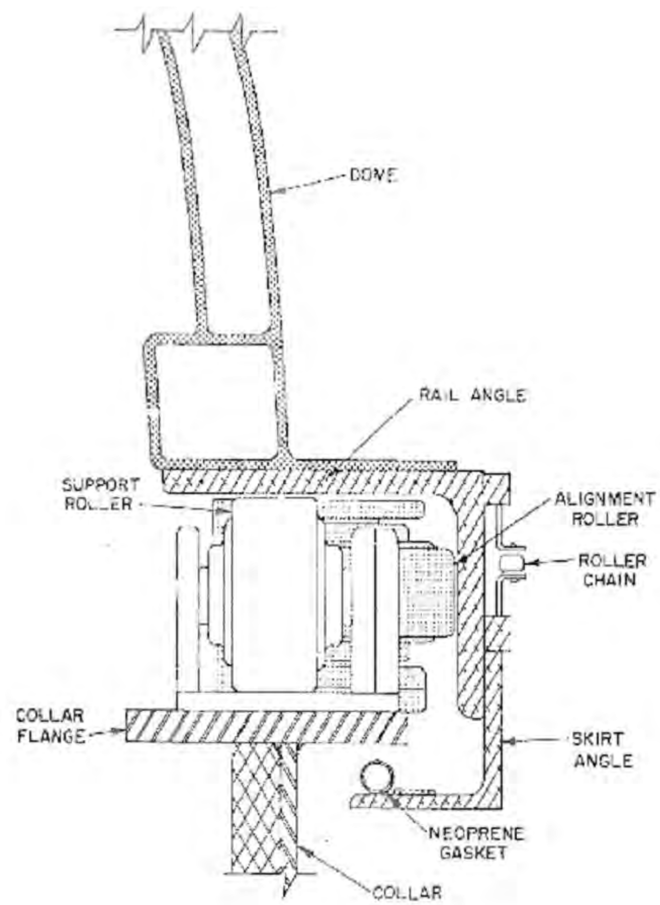

Figure 17. Detail of dome roller assembly (*NAVORD Report 2066)*.

ing humidity levels would be minimized, all the while significantly expanding daytime usability: "The optimum shelter was determined to be one which would provide proper protection from the elements and environment for the cinetheodolite at all times, even during operational use" (DiPol 1957: 1).

Figure 18. Coleman-type Astrodome, ca. 1960 (*NAWCWD Command Artifacts)*.

While a rather elaborate design, the astrodome was conceived for the long haul. Missile range engineers knew that optical tracking and recording equipment like tracking telescopes and cinetheodolites would be used extensively in a wide variety of missile testing; instrumentation would also be built as a permanent component of test ranges. While NOTS is credited with the initial development, the demand was nationwide, driven by the efforts of the IRIG. Based on the volume of astrodomes produced for the military in the three decades following the Coleman prototype and early deliverables, the design is considered a great success. The next part of the story illustrates how one company dominated the market and improved on the Coleman design.

The origins of how Coleman Engineering was chosen by NOTS to produce the first astrodome prototype and manufacture the first 15 units has its roots in the strong relationship between NOTS and the California Institute of Technology (Caltech). It was the innovative and cooperative nature of the Navy and civilian scientists at Caltech that helped establish NOTS by moving testing activities from Pasadena to the Mojave Desert in the midst of WWII (Christman 1971).

Ted C. Coleman was a 1926 graduate of Caltech and, like many of his contemporaries, saw great opportunities in military contract work after the war. According to a ca. 1954 Caltech alumni publication, *Engineering and Science*, Coleman and two associates started the Coleman Engineering Company in 1950 with the intent to "engage in research and development in the guided missile and related field". The company was by then incorporated, and had 110

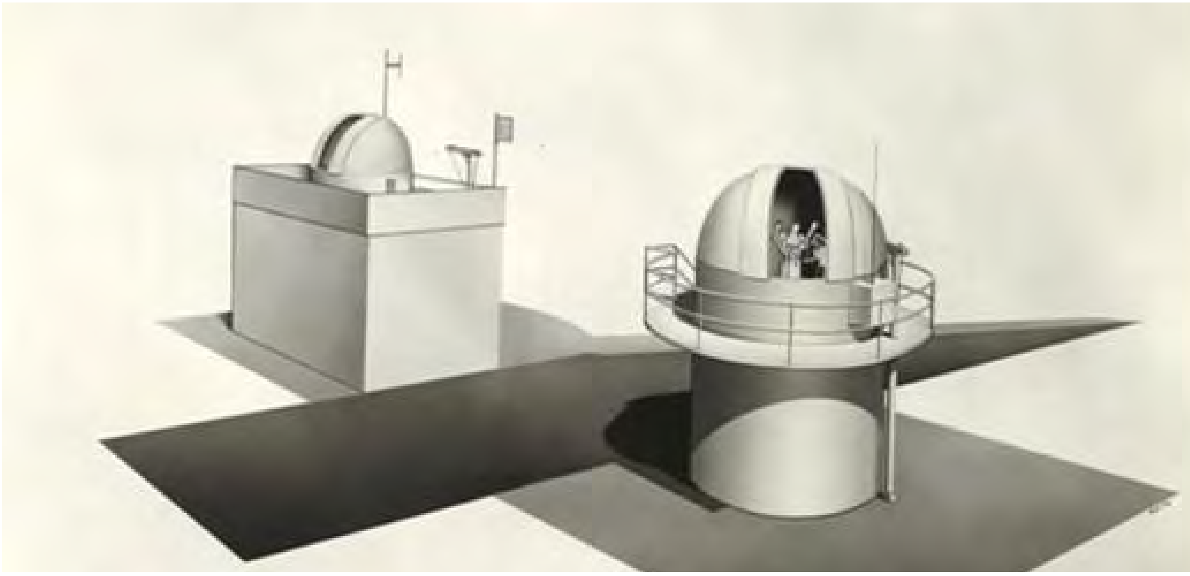

Figure 19. Illustration of first and second generation cinetheodolite shelters with planned "rotatable astrodome" (*NAVORD Report 2066, October 14, 1953; NAWCWD Command Artifacts)*.

employees working in offices and a plant in Los Angeles. Coleman Engineering is best remembered as the primary contractor and operator for the Air Force's Supersonic Military Air Research Track (SMART) in southern Utah, designed and built to test pilot ejection systems.

4. Parabam Astrodomes

After delivering the last of the 15 units to NOTS in 1956, Coleman Engineering appears to have suddenly left the manufacture of astrodomes, superseded by a company named Parabam. This sudden transition was explained by Parabam's (now Molded Fiber Glass West, or MFG) first technician and plant manager, James Sommer.[4] With excellent math skills and a background in chemistry and fiberglass molding attained at Los Angeles Trade-Technical College, Sommer responded to a call for a position to start a facility to build astrodomes. According to Sommer, Parabam was started by three engineers who had worked for Coleman Engineering for a time. Parabam was primarily an electronics firm that continued to manufacture components for military application into the 1970s. While the details are not clear, Coleman stepped aside and let Parabam pursue the tooling and contracts for astrodomes. It was Sommer who was hired to set up a production facility in Hawthorne, California in 1958 (James Sommer, personal communication 2015).

According to Sommer, the fundamental design for astrodomes was carried over from Coleman but the tooling was redone so the product was essentially all new. The first contracts for multiple units were let by WSPG and the NAMTC sea range in 1958. It is clear that the design, prototype and Coleman-built astrodomes at NOTS set the stage for military-wide interest; the efforts of the IRIG, and particularly the OWG initiated demand for the innovative shelters and the NOTS NAVORD 5596 report from 1957 would be distributed to ranges nationwide creating an immediate market for this equipment in support of missile and rocket testing.

As one of only numerous manufacturers of astrodomes at the time, Parabam benefitted greatly from this demand and enjoyed the bulk of sales for many decades; technological developments ultimately changed the marketplace, but optical instruments and operators will always need some type of shelter. Parabam was purchased by MFG in 1985 and continues into the twenty-first century producing fiberglass shelter equipment for military use. A few competitors entered the astrodome field over the years, particularly Houston Fearless (HF), but Parabam and MFG have long dominated the market.

4 Now retired, Sommer continues to work part time for MFG as a senior advisor and project manager. The bulk of the narrative concerning Parabam is from an interview with Sommer conducted at MFG in Adelanto, California on June 2, 2015.

5. Other Astrodome Manufacturers

The Houston Fearless Company was founded by Hub Houston in 1936 as a spin-off from Hughes Development Company which was owned by noted aircraft pioneer Howard Hughes. The company specialized in the production of film equipment and processing for the motion picture industry. The business expanded to include color film production and processing for the military in the 1940s, and by 1950, it merged with the Fearless Camera Company to become Houston Fearless. The firm is proud to have provided high-speed film processing equipment for the USAF SR-71 Blackbird program in the 1960s. The company was sold several times and reformulated as Houston Fearless 76 Incorporated in 1976. Today, Houston Fearless 76 is a military contractor that continues to specialize in camera and film processing equipment, as well as wastewater treatment systems and mobile shelter systems (HF Group 2015). While attempting to compete in the manufacture of astrodomes, the product was not considered by range engineers to be as durable or reliable as the Parabam-made astrodomes. For example, the aperture on the HF units was not particularly well designed (James Sommer, personal communication 2015). One extant example at WSMR is a 10-foot unit atop the former High Energy Laser Instrumentation Development Laboratory (HIDL) (Figure 20).

Two additional firms putting in bids to WSPG in the mid-1950s include the Oerlikon Tool and Arms Corporation and the Astrodome Manufacturing Company of America (Ad Hoc Committee 1956). Oerlikon was a Swiss armament manufacturer with offices in the US. The company aggressively pursued missile development projects with the Air Force in the early 1950s and created a publication for their Intercept Ground Optical Recorders (IGOR) shelter in 1957. Oerlikon filed for and received a patent for an astrodome-type shelter in 1958 (Figure 21). It should be noted that Oerliken introduced the first post-Askania cinetheodolite, the Electro-Optical Tracking Systems (EOTS), EOTS-A in 1950. Swiss manufacturer Contraves A.G. would produce the majority of this type (Delgado 1981: 706). No further references to the Astrodome Manufacturing Company could be found; neither firm appears to have had a substantive market share in the ensuing years.

Figure 20. Houston Fearless fixed astrodome at the former HIDL, White Sands Missile Range.

Another company that manufactured Astrodomes found on WSMR is the Fort Worth Tower Company. Though the company still exists, the astrodome is not featured in their current product lineup. The manufacturers tag reads “Tommy Tower” with the type described as “F.W.T. [Fort Worth Tower] Astrodome Shelter”. In the center of the tag is a stylized steel-frame tower. The name “Tommy Tower” is likely derived from the creator and owner of the company, Thomas Witt Moore. Moore and his wife Betty started and ran the company for over 40 years (Moore 2016).

Another company known to have manufactured astrodomes was the Trio Tech Company. Like Oerlikon, Trio Tech manufactured equipment for the military; astrodomes were part of the Test and Ground Support Division. Little more could be found regarding the company’s early history other than it was incorporated in 1958 with headquarters in Burbank, California. Trio Tech International is still in business today with five segments: manufacturing, testing services, equipment distribution, real estate, and fabrication services. Now based in Van Nuys, California, the company no longer fabricates astrodomes or military-type shelters. A Trio Tech Company astrodome remains abandoned in place on the aforementioned Doña Ana Antiaircraft Artillery Range at Fort Bliss.

From a single product for a particular piece of equipment, Parabam took the lead in providing

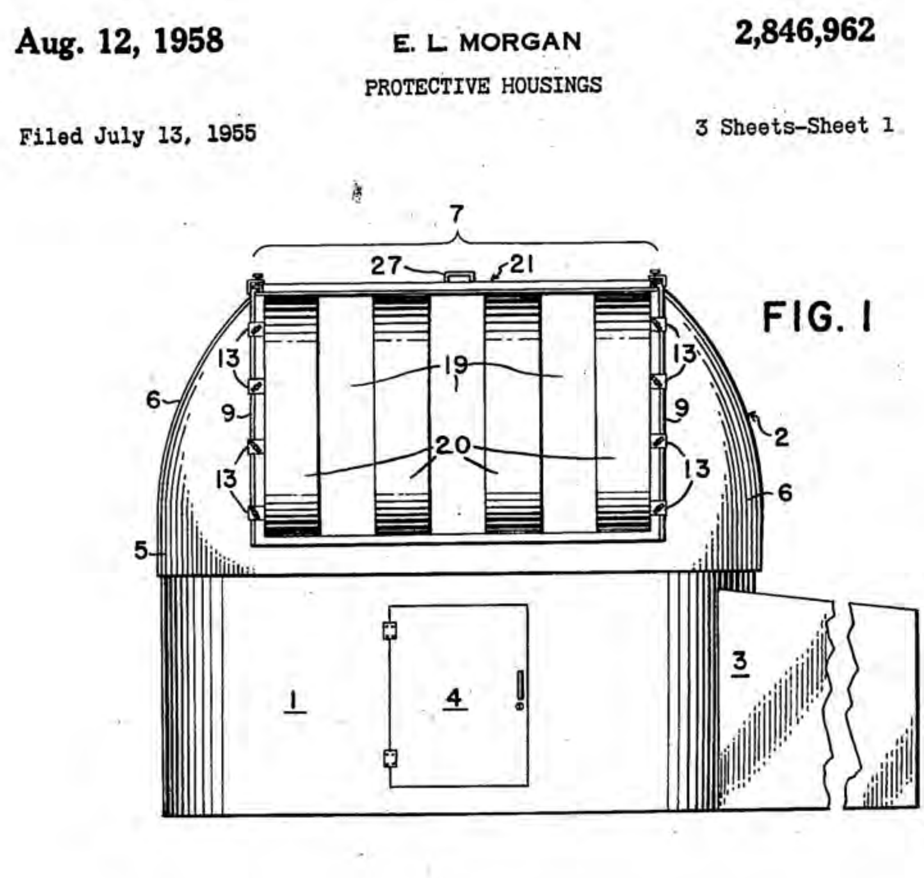

Figure 21. US Patent 2846962, Protective Housings, Patented August 12, 1958.

Figure 22. Modified Intercept Ground Optical Recorder (*MIGOR)* in 10-foot Parabam Astrodome, White Sands Missile Range, 1962 (*Ken Bellinger Collection, WSMR Museum Archives)*.

new astrodome types to serve a greater variety of optical instrumentation needs, not all of which were solely devoted to the cinetheodolite. While the astrodome housed successive generations of cinetheodolites including the Contraves-built version, it was also adapted for instruments such as the IGOR, fixed cameras, ballistic cameras, and tracking telescopes (Figure 22).

6. Astrodome Evolution

The success of the 10-foot diameter astrodome for protecting Askania cinetheodolites combined with the inter-range collaboration under the IRIG's OSWG created an impetus for providing shelters for other types of optical instrumentation. Parabam, with its track record for quality and innovation offered an increasing range of sizes with an option for individualized features that could be chosen for each unit. This included fixed or rotating domes with equipment such as air-conditioning and heat, as well as motorized apertures (James Sommer, personal communication 2015).

As a "type", the Parabam astrodome does not vary greatly. Sales literature illustrates how, into the 1980s, the company offered a variety of sizes including 9-foot, 10-foot, 12-foot, 14-foot and, 16-foot units with some offering different sized apertures—other than the size differential and dome drive units the shelter itself does not vary greatly, regardless of the manufacturer (Figure 23). Dome rotation rates were also specified to assure compatibility with particular instruments. Parabam outdistanced its competitors and kept the lead with innovations such as placing a honeycomb cardboard between two fiberglass panels on the dome for structural stability, ultimately replacing all steel elements with fiberglass, and transitioning the electric/ hydraulic dome drive to a fully electric version. Such was Parabam's dominance of the market that the company was awarded service contracts with most of the test ranges, including WSMR

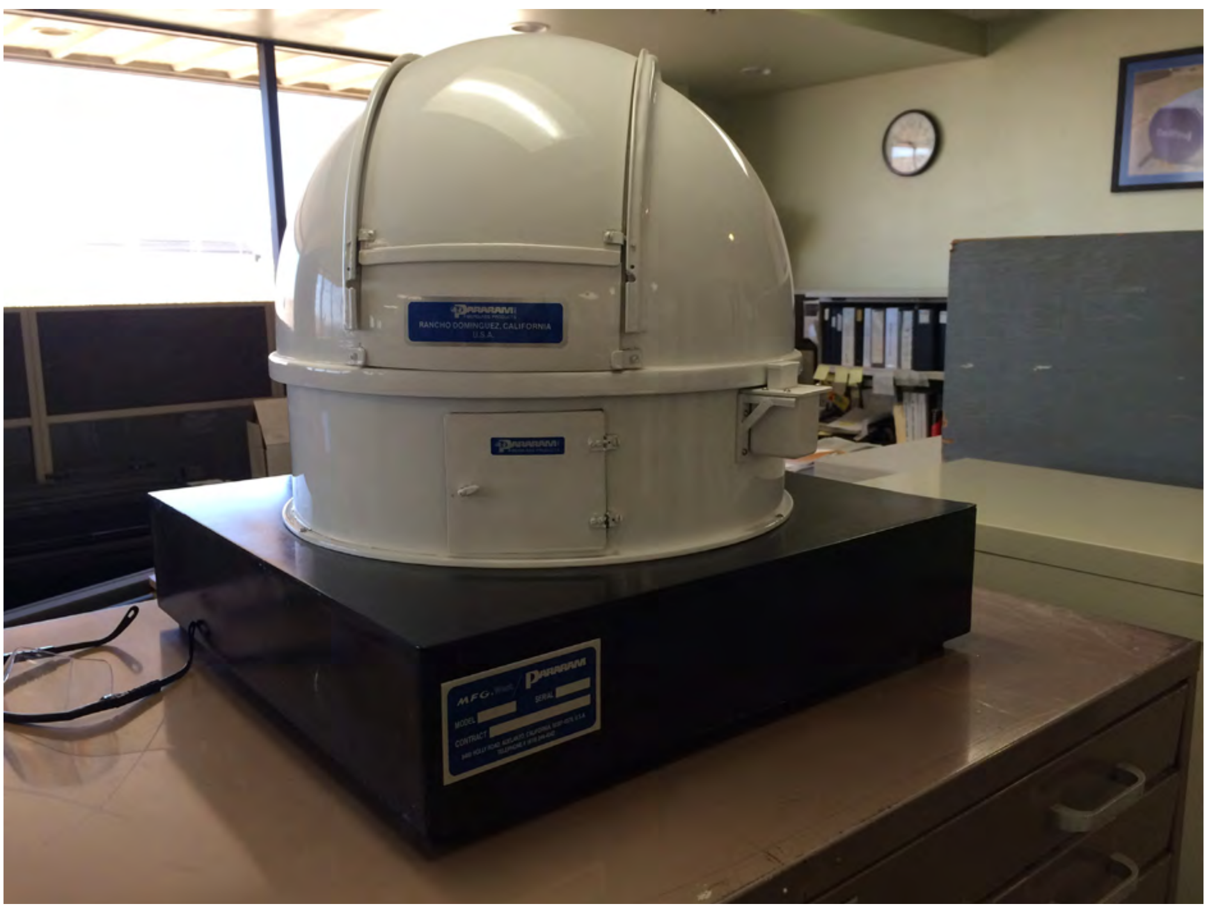

Figure 23. Parabam Astrodome sales display (*MFG West, Adelanto, California)*.

(James Sommer, personal communication 2015).

One type found in smaller numbers on the ranges was the fixed, 6-foot astrodome. Too diminutive for anything but small instruments, the unit, with rubber-roller drive and removable aperture, was best remembered for its role in the Cold War. Set up in series at the Arctic Circle, these astrodomes served the Distant Early Warning (DEW) Line, a radar chain designed to provide early warning in case of a Soviet airborne nuclear strike. Conversely, Parabam provided custom-sized units whose diameter was as wide as 33 feet (James Sommer, personal communication 2015).

In the 1980s, sales for fixed units were outpaced by ones designed to be placed on mobile instrumentation carriages. As these gained in popularity nationwide, Parabam produced 8-foot, 9-foot, 10-foot, 12-foot, and even 14-foot units for big trailers; the 10-foot would be the most common.

Manufacturing and sales data on other astrodome producers could not be ascertained for this research effort. Parabam and Houston-Fearless were the primary suppliers chosen by WSPG. A single NOTS Coleman astrodome was moved to WSMR at some point after 1965 and remains in place atop the former control building for the 1957 Talos Defense Unit effort. A full inventory of extant astrodome–type shelters at WSMR would require on-site investigations.

7. Astrodomes at White Sands Missile Range

Over a roughly 25-year period, dozens of astrodomes were purchased and installed on fixed sites at WSMR. All previous optical instrumentation buildings were phased out and the astrodome, mounted in various configurations, would become standard equipment. As a piece of equipment as opposed to a building or structure, it is fortunate that some type of construction was required for most installations; historical records of equipment purchase can be difficult to track. Construction documents, architectural drawings in particular, often provide the best record of site installations and typically include useful ancillary data. These extant records provided the basis for astrodome types described in this section. However, even with these records, many of the astrodomes and instrumentation have long been removed leaving only steel-frame and concrete remains; some sites were not constructed as planned and many were altered over time. Further, the extant records may not capture all of the construction that included astrodomes. Most will need to be verified in the field to determine current conditions.

WSMR was one of Parabam's first customers with a large order placed in 1958. While the 10-foot diameter astrodome was designed and built primarily for cinetheodolite use, it was apparent that other types of optical instrumentation would benefit from the controlled environment (Table 1). To assist the reader in understanding these instrumentation types, a brief overview for each type of instrument can be seen in *Appendix A, Optical Instrumentation Placed in*

Figure 24. 10-foot Parabam Astrodome, Jed Site (*WSMR)*.

Table 1. Parabam Astrodome Typology for optical tracking assemblies, 1958 (*WSMR Drawing set WS-HK)*.

Site	Construction Type	Instrument	Astrodome Size	Serial Number
Green	Concrete Pad on 10' Mound	Cinetheodolite	10 foot	10
Granjean	Concrete Pad on 8' Mound	Telescope	16 foot	23
Miller's Watch	Concrete Pad	Telescope	16 foot	21
Harriet	Concrete Pad on 8' Mound	Telescope	16 foot	24
Jim	Concrete Pad	Telescope	16 foot	27
Jim	Concrete Pad	Cinetheodolite	10 foot	13
Dam (Carmen)	Concrete Pad	Cinetheodolite	10 foot	14
Panther (Conn)	Concrete Pad on 10' Mound	Cinetheodolite	10 foot	11
Pivot	Pit Structure	R.O.T.I.	16 foot	
Pivot	Concrete Pad	Cinetheodolite	10 foot	12
Gus	Concrete Pad	Telescope	16 foot	22
Gus	Concrete Pad	Cinetheodolite	10 foot	7
Gregg	Concrete Pad	Cinetheodolite	10 foot	25
Salinas Peak	Pit Structure	R.O.T.I.	16 foot	
Curt	Concrete Pad	Telescope	16 foot	28
Curt	Concrete Pad	Cinetheodolite	10 foot	8
NW-30	Concrete Pad on 8' Mound	BC-4 Camera	10 foot	20
East Center 30	Concrete Pad on 10' Mound	Cinetheodolite	10 foot	15
Chuck	Concrete Pad on 10' Mound	Telescope	16 foot	26
Seehorn	Existing Theodolite Structure	BC-4 Camera	10 foot	17
Bell	Concrete Pad	Cinetheodolite	10 foot	9
Nan Site	Concrete Pad on 8' Mound	BC-4 Camera	10 foot	18
Army Two (East)	Concrete Pad	BC-4 Camera	10 foot	16
Jed	Concrete Pad on 10' Mound	Ribbon Frame Camera	10 foot	19

Astrodomes, White Sands Missile Range.

Extant design drawings at WSMR illustrate the locations and for what purpose each astrodome was to be used. This optical instrumentation effort began with an order for as many as twenty-five, 10 and 16 foot astrodome units (James Sommer, personal communication 2015). The drawings indicate that most of the units, regardless of size, were fitted with the electric/hydraulic dome drive system that moved with operator and instrument. The only exception was the 10-foot units fitted with the BC-4 Ballistic Cameras and ribbon frame cameras as both instruments are stationary. Jed site still contains its original astrodome though the ribbon frame camera has been removed (Figure 24).

For this preliminary order, Parabam assigned model numbers to each cylinder and dome indi-

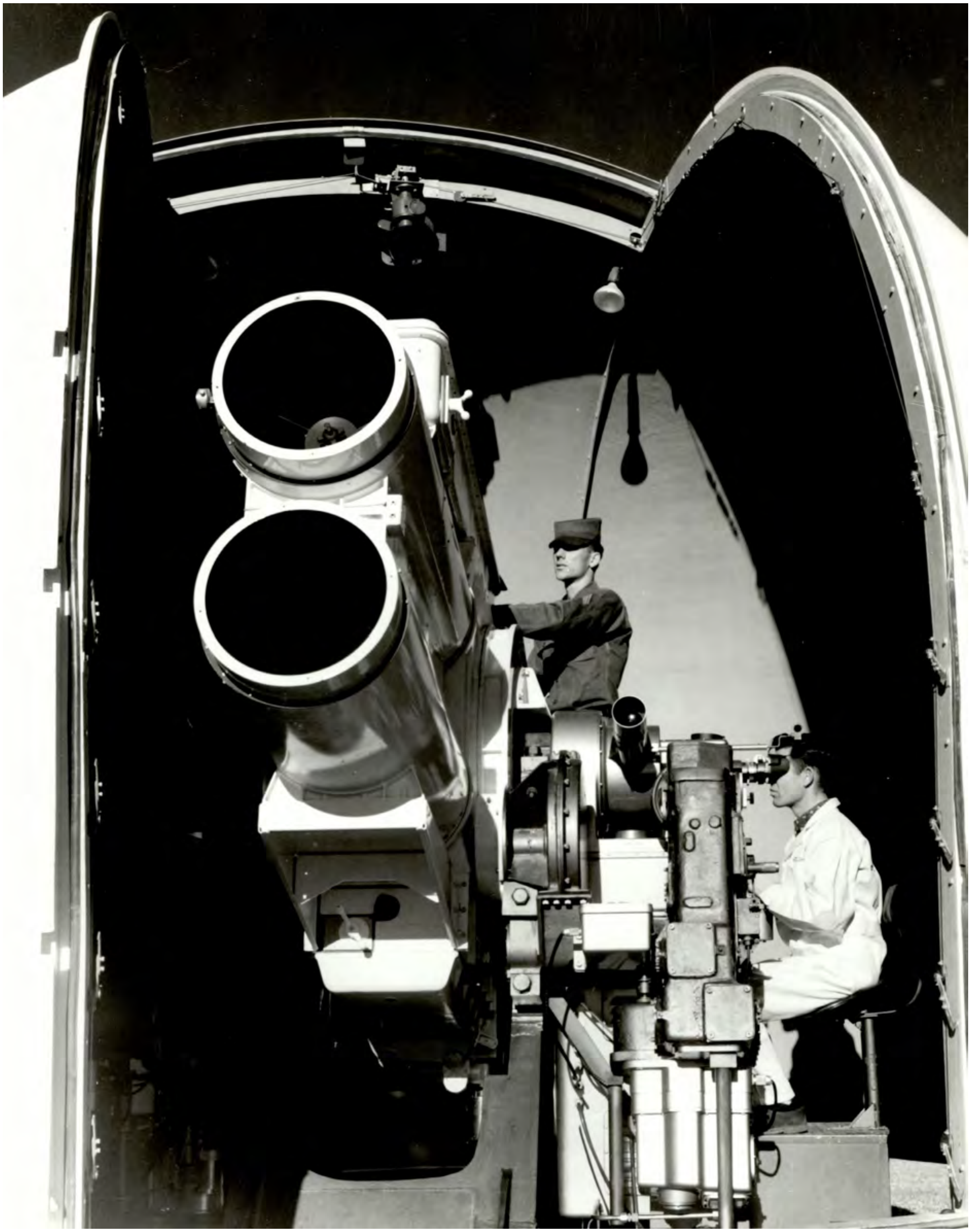

Figure 25. Perkin-Elmer Recording Optical Tracking Instrument (*ROTI)* in 16-foot Parabam Astrodome, ca. 1965 (*WSMR Museum Archives)*.

vidually. The “C” designation is for the cylinders and “D” for domes; model numbers for 10-foot units end in “2”, while 16-foot units are designated “3”. For example, 10-foot astrodomes consist of Models C-2 and D-2, while 16-foot units are Models C-3 and D-3. Astrodomes installed with drive unit also have an accompanying hydraulic power unit. In 10-foot domes they are identified as Model “DU-2” (drive unit) and “PU-2” (Power unit). For 16-foot astrodomes (Figure 25), the nomenclature is the same; the “2” is simply replaced with a “3”.

Despite any confusion regarding models numbers, Parabam manufacturer serial numbers are identical for each component of an assembled astrodome. For this first group of astrodomes, the serial numbers run sequentially from 6 to 27. No serial numbers were notated for the newly-developed Recording Optical Tracking Instrument (R.O.T.I.) sites. It has been suggested that serial numbers 1-5, astrodomes, were delivered to Naval Air Missile Test Center (NAMTC) at

Figure 26. Parabam astrodome mounts at WSMR, ca. 1965 (*WSMR Museum Archives)*.

Table 2. Parabam astrodomes for optical tracking assemblies, 1959 (*WSMR Drawing set WS-IN)*.

Site	Construction Type	Instrument	Astrodome Size	Serial Number
Cal	Concrete Pad	Cinetheodolite	10 foot	86
T-3	Concrete Pad	Cinetheodolite	10 foot	85
Key	Concrete Pad	Cinetheodolite*	10 foot	88
SC-50	Concrete Pad on 6’ Mound	Cinetheodolite	10 foot	87
SW-50	Concrete Pad	BC-4 Camera	10 foot	
WC-50	Concrete Pad on 5’ Mound	Cinetheodolite	10 foot	82
Russ	Concrete Pad on 10’ Mound	Cinetheodolite	10 foot	84
SW-70	Concrete Pad on 10’ Mound	BC-4 Camera	10 foot	79
P-16 (MAC)	Concrete Pad on 5’ Mound	BC-4 Camera	10 foot	80
Ben	Concrete Pad	BC-4 Camera	10 foot	78
Wood	Concrete Pad	Cinetheodolite	10 foot	83
Dam	Concrete Pad	Telescope	16 foot	77
School	Concrete Pad	Telescope	16 foot	75
Mine	Concrete Pad on 10’ Mound	Telescope	16 foot	73
Green	Concrete Pad on 10’ Mound	Telescope	16 foot	74
Marcial	Concrete Pad on 8’ Mound	Telescope	16 foot	76
Gun		BC-4 Camera	10 foot	81

Point Mugu, California (James Sommer, personal communication 2015).

For the five instrument types, different construction types were specified. Assemblies with 10-foot astrodomes fitted with cinetheodolites, ribbon frame cameras, and ballistic cameras were placed on stand-alone concrete pads, some on eight or ten-foot earthen mounds (Figure 27). There appears to be a correlation between cinetheodolite sites placed in the basin at low elevations where concrete pads were placed on raised earthworks—it may be an attempt to minimize atmospheric boil issues. Only at Seehorn Site was a first generation cinetheodolite building fitted with an astrodome to house a ballistic camera. 16-foot astrodomes fitted with tracking telescopes were placed on stand-alone concrete pads, some on eight or ten-foot mounds (Figure 28). For the R.O.T.I. instruments, a special below-grade, reinforced concrete “pit” was developed (Figure 29).

Only a year later another round of instrumentation was installed and sites were expanded; 16 sites were fitted with Parabam-manufactured astrodomes (Table 2). Included in this second order was an unusual new type of shelter designed for the BC-4 ballistic camera. The shelter featured a standard 10-foot cylindrical base on which an elongated “bread box-type” shell with wide aperture was mounted (Figure 30). A newly planned site named Bate was planned simultaneously as a test site for the Recording Optical Tracking Instrument (ROTI) Test Site; it would be housed in a 16-foot astrodome, the third of the partially below-grade design.

Beginning in 1960, WSMR planned the third series of optical instruments to be placed in astro-

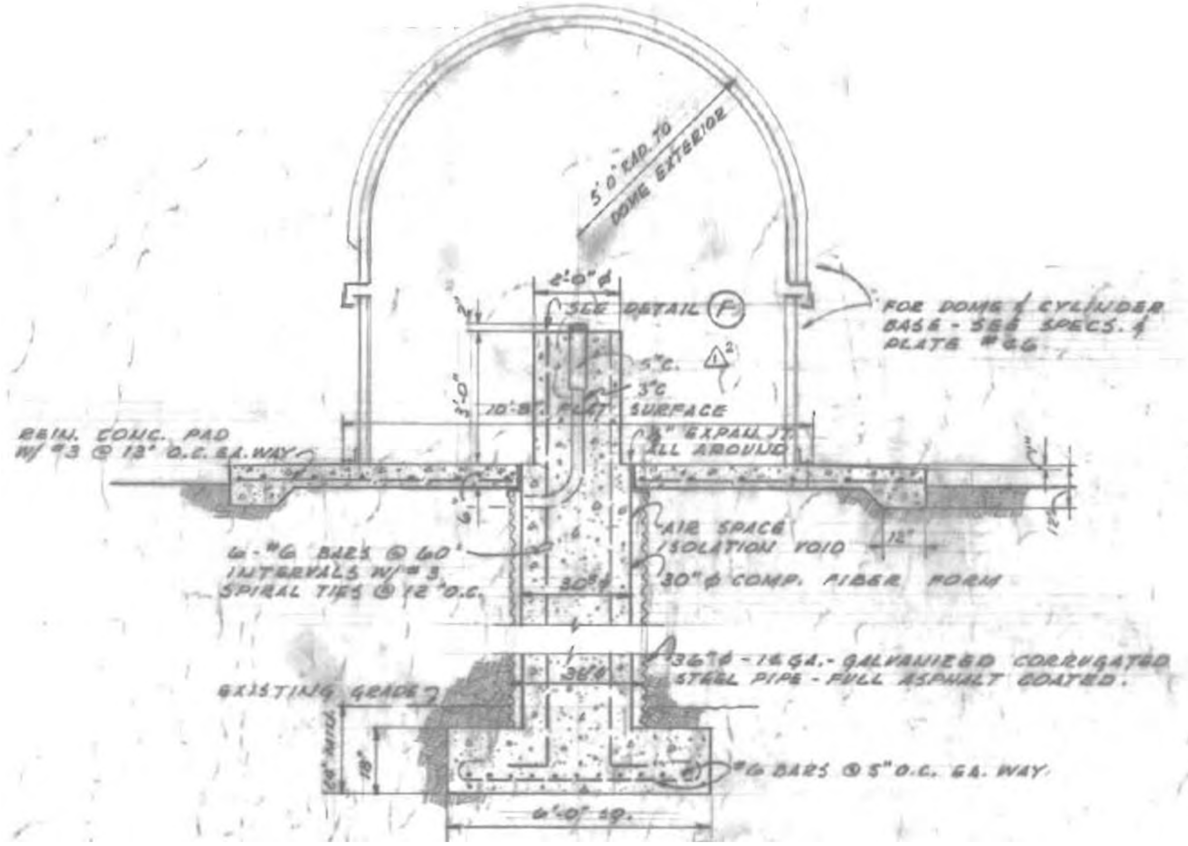

Figure 27. Cinetheodolite pad with 10-foot astrodome (*WSMR Drawing set WS-HK)*.

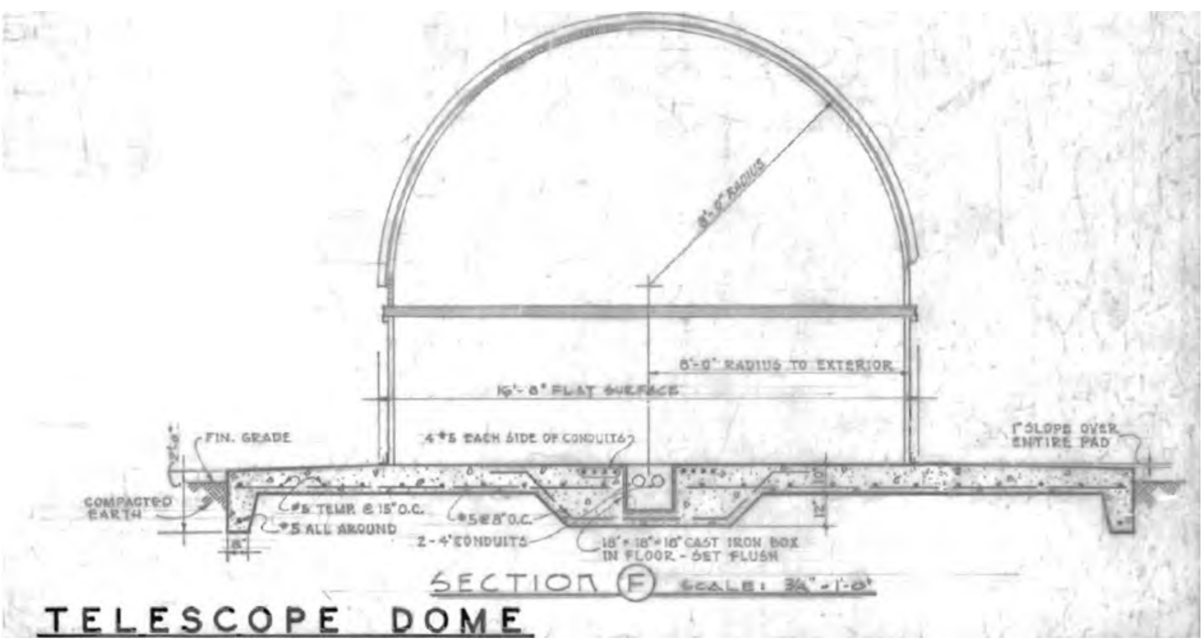

Figure 28. Tracking telescope pad with 16-foot astrodome (*WSMR Drawing set WS-HK)*.

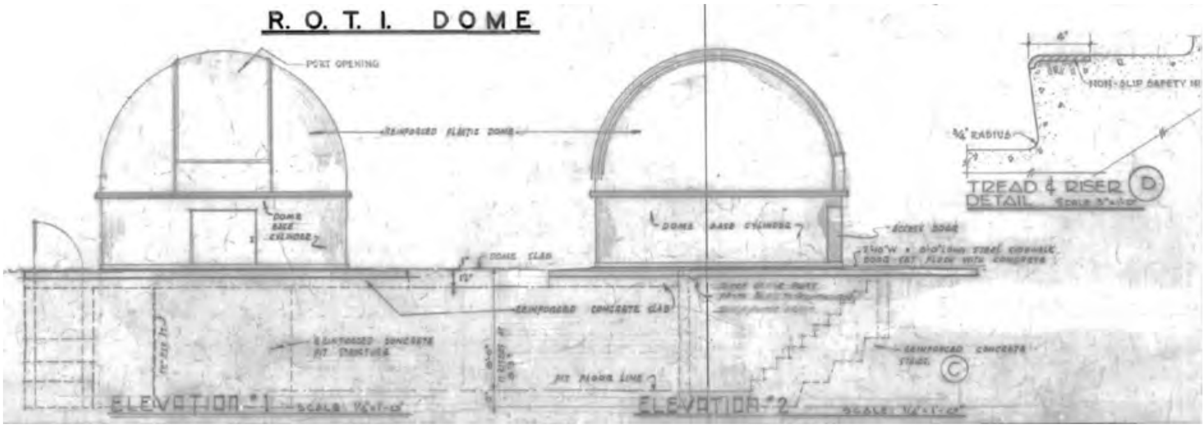

Figure 29. R.O.T.I. "pit" with 16-foot astrodome (*WSMR Drawing set WS-HK)*.

domes. Dubbed "Type A" through "Type D", the new series consisted of eight different types of instrumentation mounts ranging from concrete pads at grade to enclosed, raised steel-frame structures (Table 3). The raised steel-frame assemblies would replace the permanent post and lintel concrete and CMU infill buildings constructed between 1950 and 1955.

Assemblies with 10-foot astrodomes fitted with cinetheodolites and fixed cameras were placed on stand-alone concrete pads (Type "A"), telescopes on raised steel frame platforms (Type "B") (Figure 31), on raised steel frame platforms adjacent to the pre-existing first generation cinetheodolite buildings (Type "B-SS") (Figure 32), and on raised steel frame platforms with the bases enclosed (Types "C" and "D") (Figures 33 & 34).

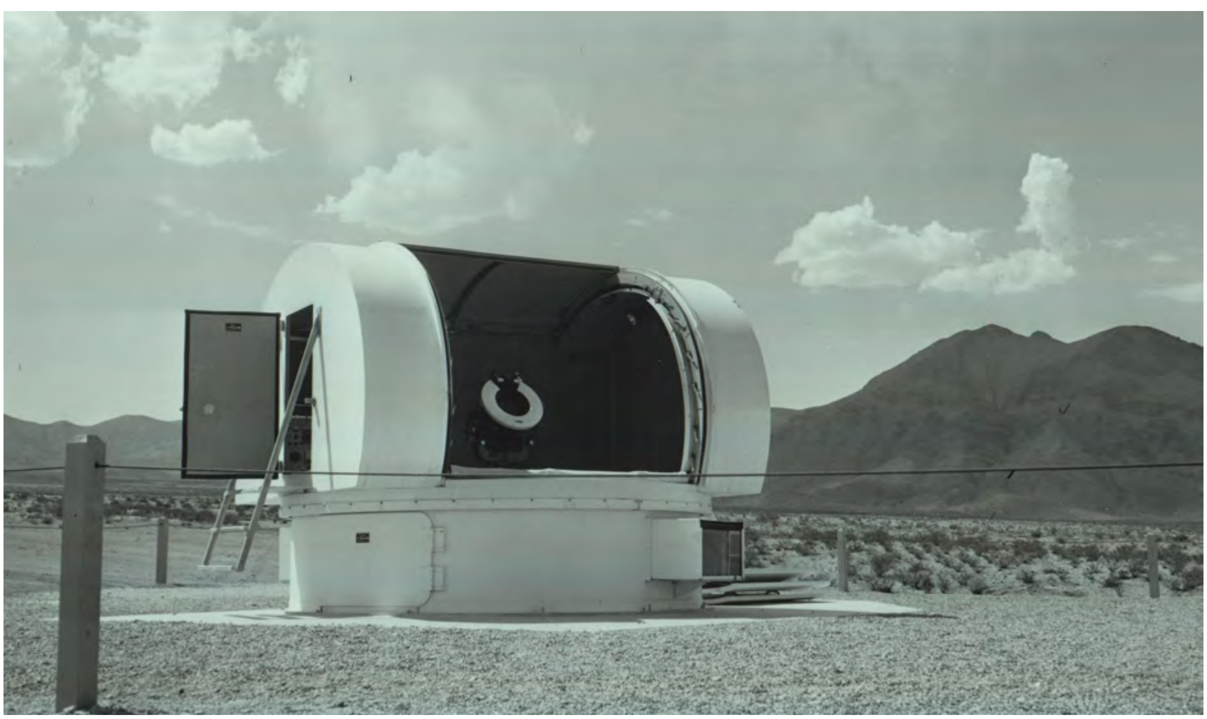

Figure 30. Parabam-built Ballistic Camera Shelter at STAR Site, ca. 1965 (*WSMR Museum Archives)*.

Table 3. Astrodome Typology for optical tracking assemblies, 1960 (*WSMR Drawing set WS-JR)*.

Sites	Construction Type	Type	Instrument	Astrodome Size
Dog, George, Fox, Salinas Peak	Concrete Pad	“A”	Cinetheodolite	10 foot
Uncle, Victor, William, William Prime	Concrete Pad	“A”	Fixed Camera	10 foot
Key, Seehorn, SW-50, NW-50, Oboe, NE-50	Concrete Pad	“A”	Telescope	16-foot
NW-30, NE-70, Two Buttes	Raised Steel Platform	“B”	Telescope	16-foot
C Station, Tare, Nan, NW-30, NW-50, SW-50, Oboe, Beck, North Oscura Peak	Raised Steel Platform (adjacent to building)	“B–SS”	Cinetheodolite	10 foot
Dog	Enclosed Raised Steel Platform	“C”	Fixed Camera	10 foot
Nancy, Gregg	Enclosed Raised Steel Platform	“D”	Cinetheodolite	10 foot
Largo, New Nick	Enclosed Raised Steel Platform	“D”	Telescope	16-foot

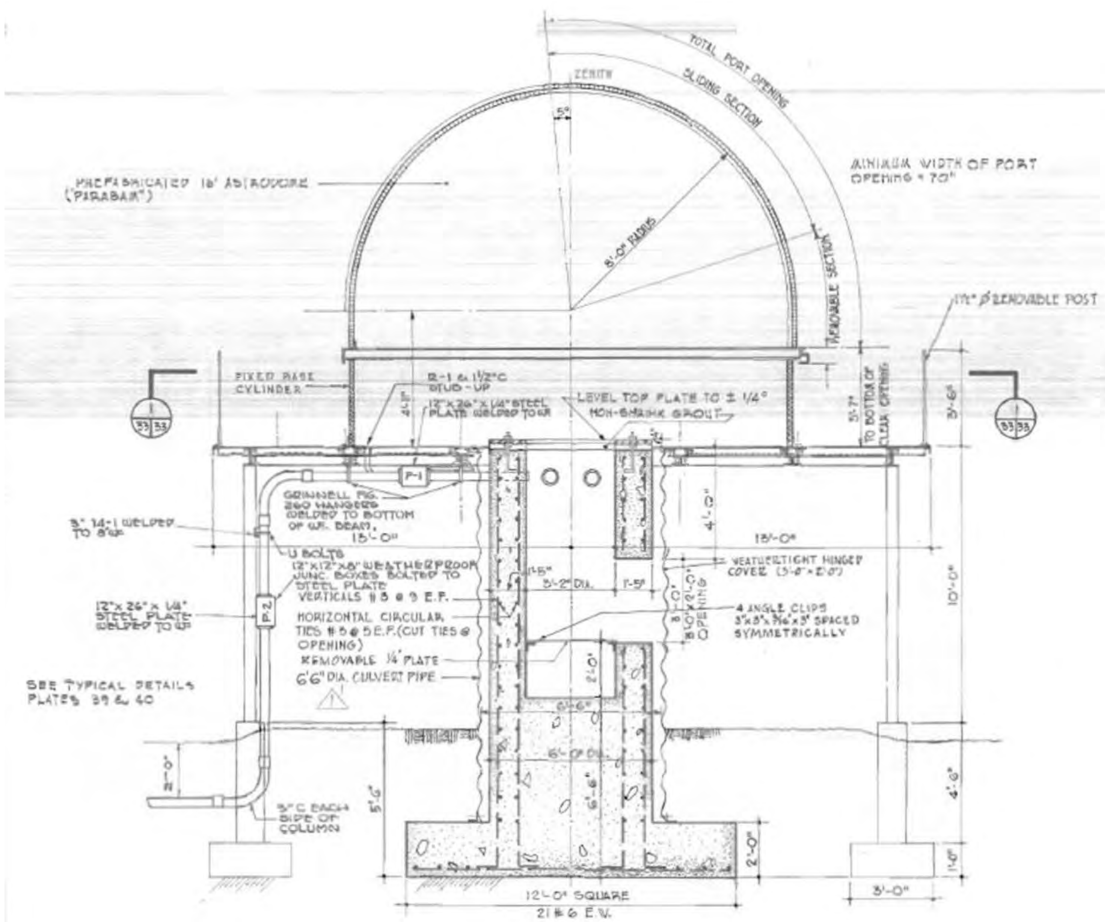

Figure 31. Type “B” telescope stand (*WSMR Drawing set WS-JR)*.

Figure 32. Type “B-SS” Instrumentation Stand, NW 50 Site, WSMR.

Figure 33. Type “D” enclosed instrumentation structure, Gregg Site

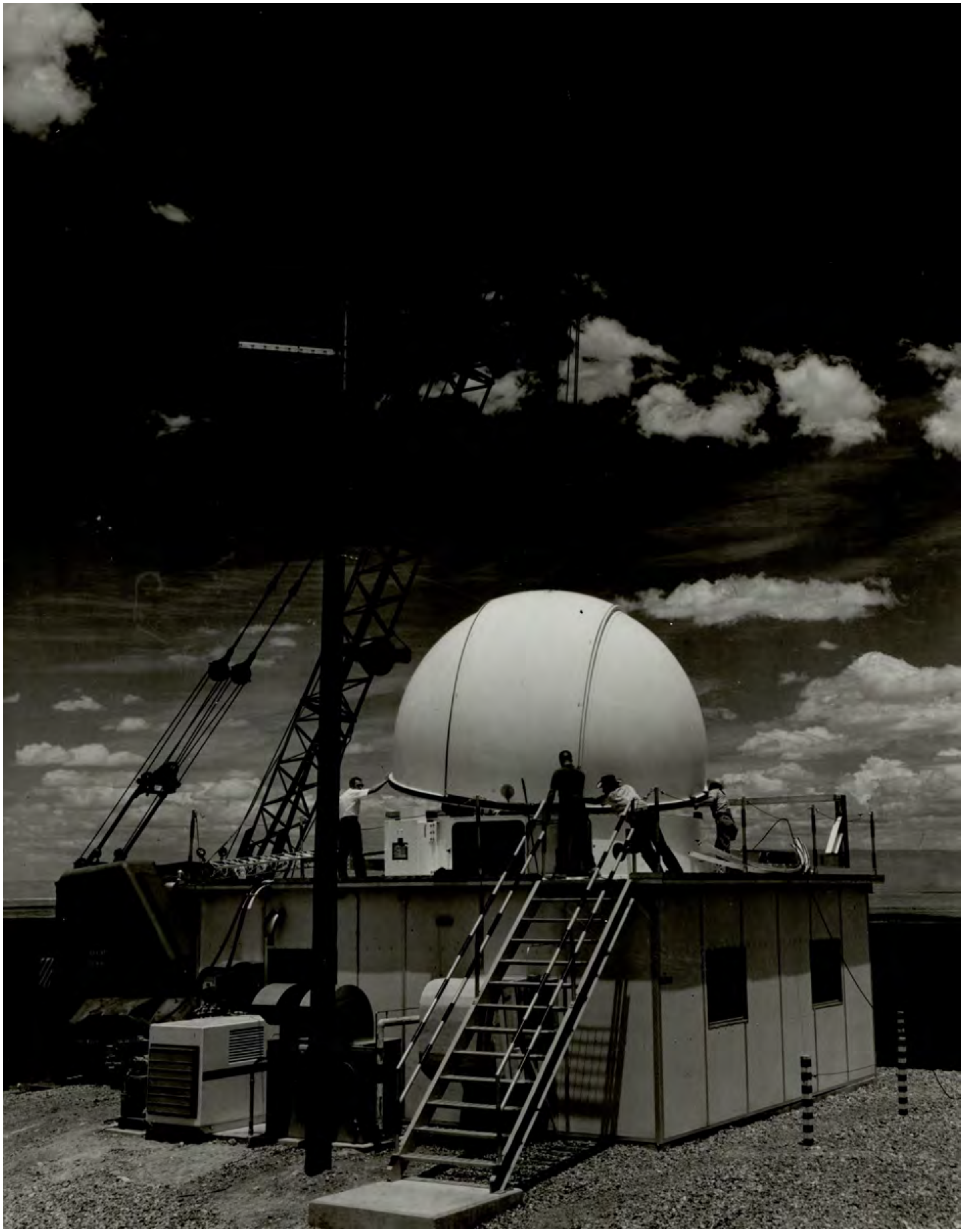

Figure 34. Type “D” Telescope installation with 16 foot Astrodome (*WSMR Museum Archives)*.

Table 4. Houston-Fearless fixed camera astrodomes (*WSMR Transfer of Accountability Sep. 15, 1961*).

Site	Construction Type	Instrument	Astrodome Size	Serial Number
Son	Concrete Pad	Fixed Camera	10-foot	6
NOE	Concrete Pad	Fixed Camera	10-foot	5
SEUS	Concrete Pad	Fixed Camera	10-foot	15
NEUS	Concrete Pad	Fixed Camera	10-foot	16
Bowl	Concrete Pad	Fixed Camera	10-foot	2
Lara	Concrete Pad	Fixed Camera	10-foot	3
More	Concrete Pad	Fixed Camera	10-foot	4
Ron	Concrete Pad	Fixed Camera	10-foot	1

A Transfer of Accountability statement dated September 15, 1961 reveals that eight fixed camera sites were set up in and around the Launch Complex area (Table 4). Records indicate that the "fixed camera type astrodomes" were manufactured by Houston-Fearless Corporation; all were 10-foot units without drive or power units. While no site plans could be found, historic images suggest all were placed on concrete pads at grade. Manufacturer's serial numbers start with number "1" which may suggest that these were the first manufactured by the company.

A new effort occurred in 1961 and 1962 with the construction of instrumentation sites for the "Highspeed [*sic*] Cinetheodolite Installation Phase I" (Table 5). Limited to the vicinity of the launch complexes, the structures consisted of similarly designed 10 and 20-foot steel-frame

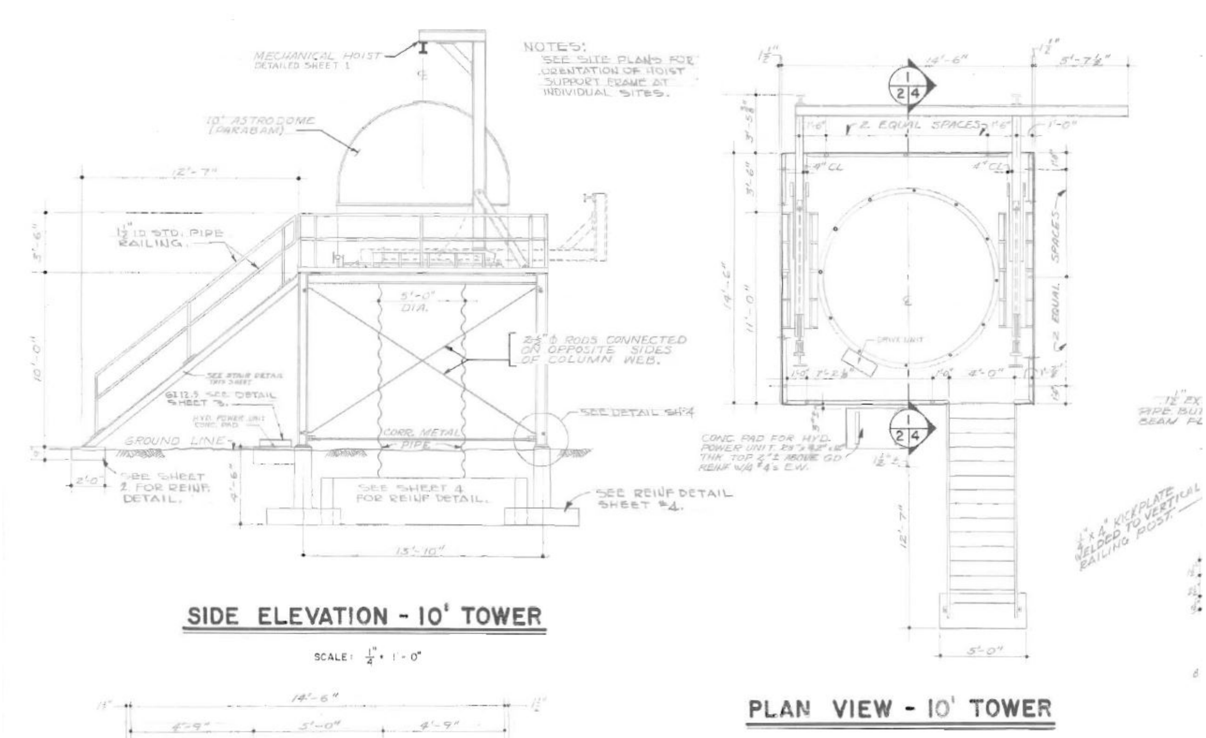

Figure 35. Ten-foot cinetheodolite structure for "Highspeed Cinetheodolites" (*WSMR Drawing set WS-KI*).

Table 5. "Highspeed Cinetheodolite Installation, Phase I", 1961 (*WSMR Drawing set WS-KI)*.

Site	Construction Type	Instrument	Astrodome Size
Ron	20-foot Steel-frame structure	Cinetheodolite	10-foot
Grass	20-foot Steel-frame structure	Cinetheodolite	10-foot
Vega	20-foot Steel-frame structure	Cinetheodolite	10-foot
Velma	20-foot Steel-frame structure	Cinetheodolite	10-foot
Water	20-foot Steel-frame structure	Cinetheodolite	10-foot
Ken	10-foot Steel-frame structure	Cinetheodolite	10-foot
Seus	20-foot Steel-frame structure	Cinetheodolite	10-foot
Tree	20-foot Steel-frame structure	Cinetheodolite	10-foot

assemblies with Parabam-manufactured 10-foot astrodomes (Figures 35 and 36); none of the steel-frames were designed with enclosures. Designed to house the Contraves cinetheodolites, the most sophisticated instrument of its type at the time, it would ultimately replace the Askanias. All of the astrodomes were fitted with dome drive units. These assemblies were all designed to carry steel-frame hoist assemblies to raise and lower instruments.

Beyond these well-documented construction phases and the mobile instrumentation trailers that ultimately supplanted the fixed stations, many additional astrodomes were installed across the

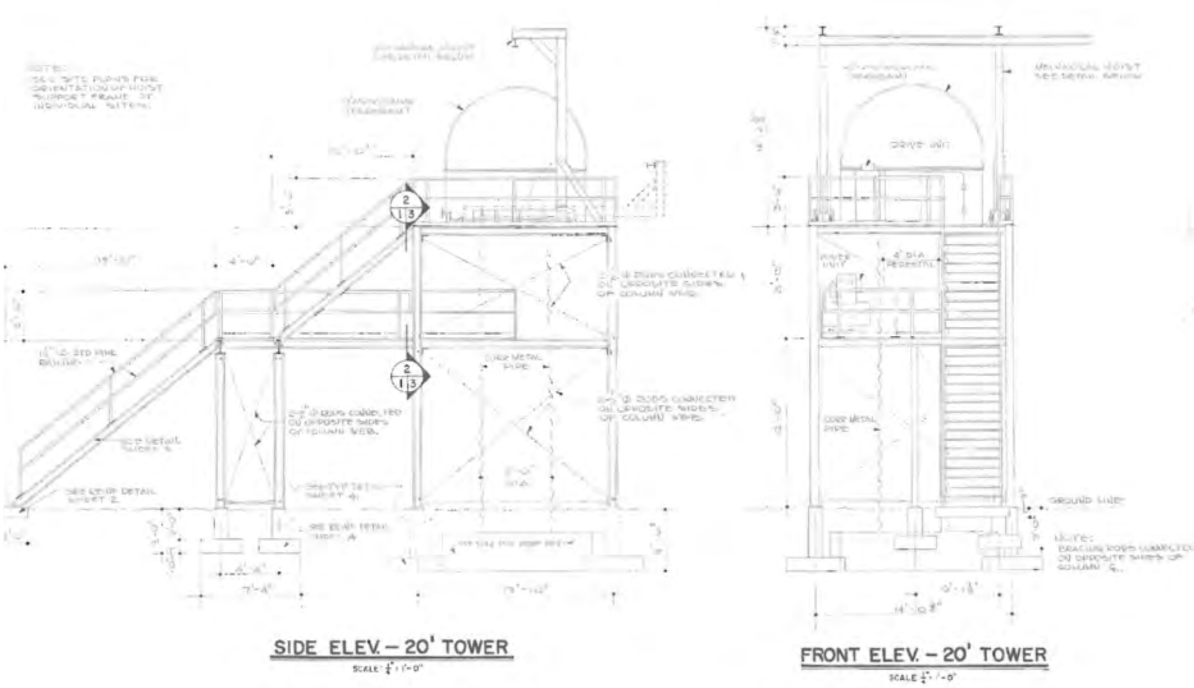

Figure 36. 20-foot cinetheodolite structure for "Highspeed Cinetheodolites" (*WSMR Drawing set WS-KI)*.

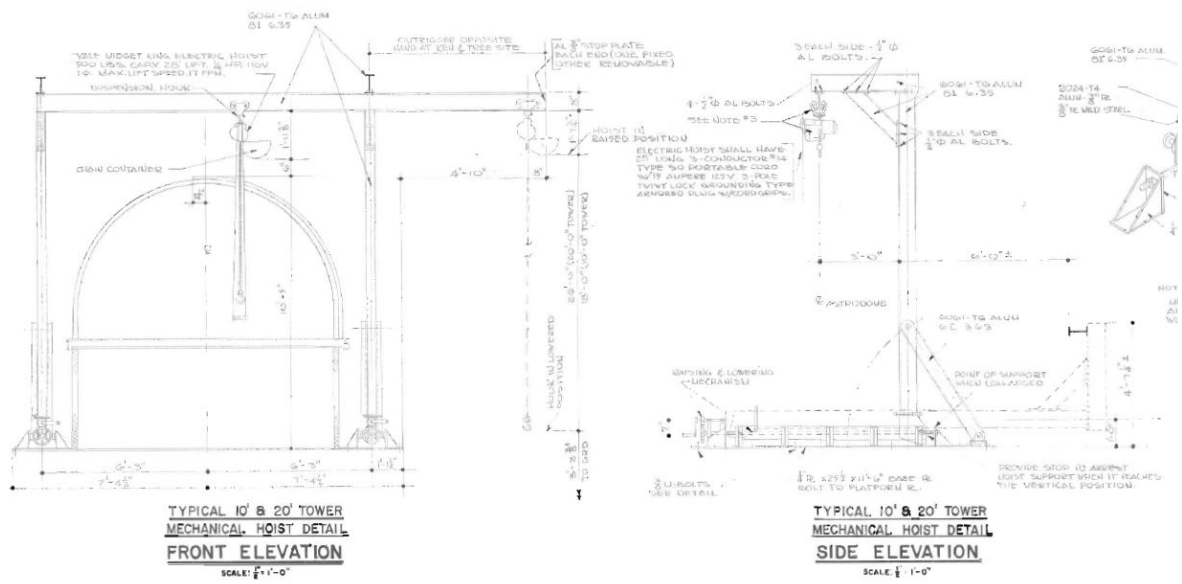

Figure 37. Mechanical hoist configuration for "Highspeed Cinetheodolite" towers (*WSMR Drawing set WS-KI)*.

ranges over time, though construction documents have not been located. One good example is the former "Elevated IGOR astrodome" at Malpais Site in the northern portion of the Range; it is also no longer in use (Figure 38). The steel-frame tower remains but the astrodome and IGOR have been removed. A period image of an Askania cinetheodolite on a concrete pad illustrates the function of the equipment; note the hydraulic power unit connected to the cylinder-mounted drive unit (Figure 39).

Figure 38. "Elevated IGOR astrodome" at Malpais Site, 1963 (*WSMR Range Data Book, 1963)*.

One specifically-designed instrumentation building is found at the southwestern edge of WSMR. Plans were drawn up in 1965 for a "Test Facility for Prototype Cinetheodolite" in which a 16-foot Parabam astrodome (Serial # 321) was fitted to a heavily reinforced structural support system with an unusual, overhead cross-frame (Figures 40 and 41). The "WSMR Prototype Cinetheodolite" was conceived of by Dr. William Mimmack,

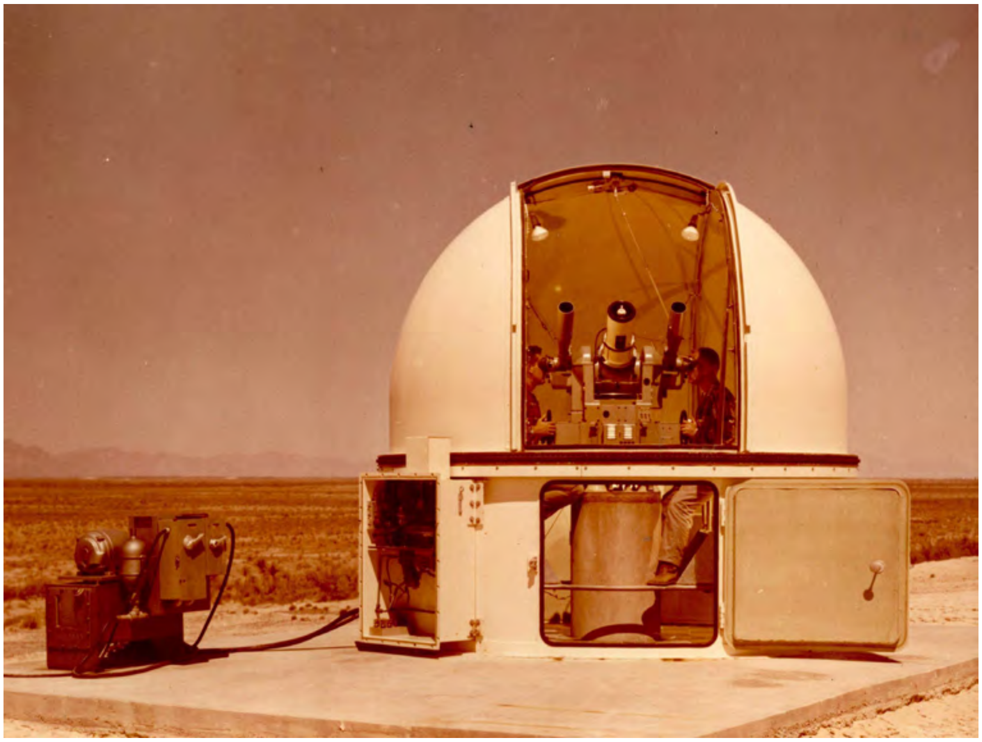

Figure 39. Askania cinetheodolite in 10-foot Parabam astrodome, ca. 1962 (*Ken Bellinger Collection, WSMR Museum Archives)*.

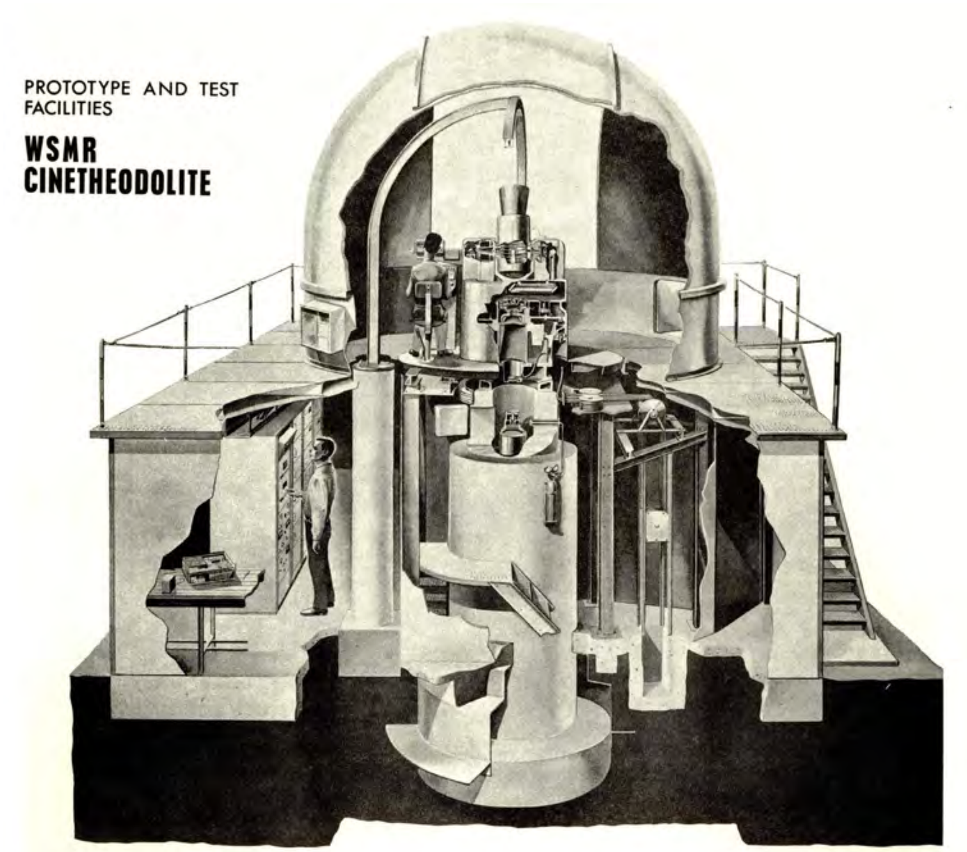

Figure 40. Schematic for Prototype Cinetheodolite (*Ken Bellinger Collection, WSMR Museum Archives)*.

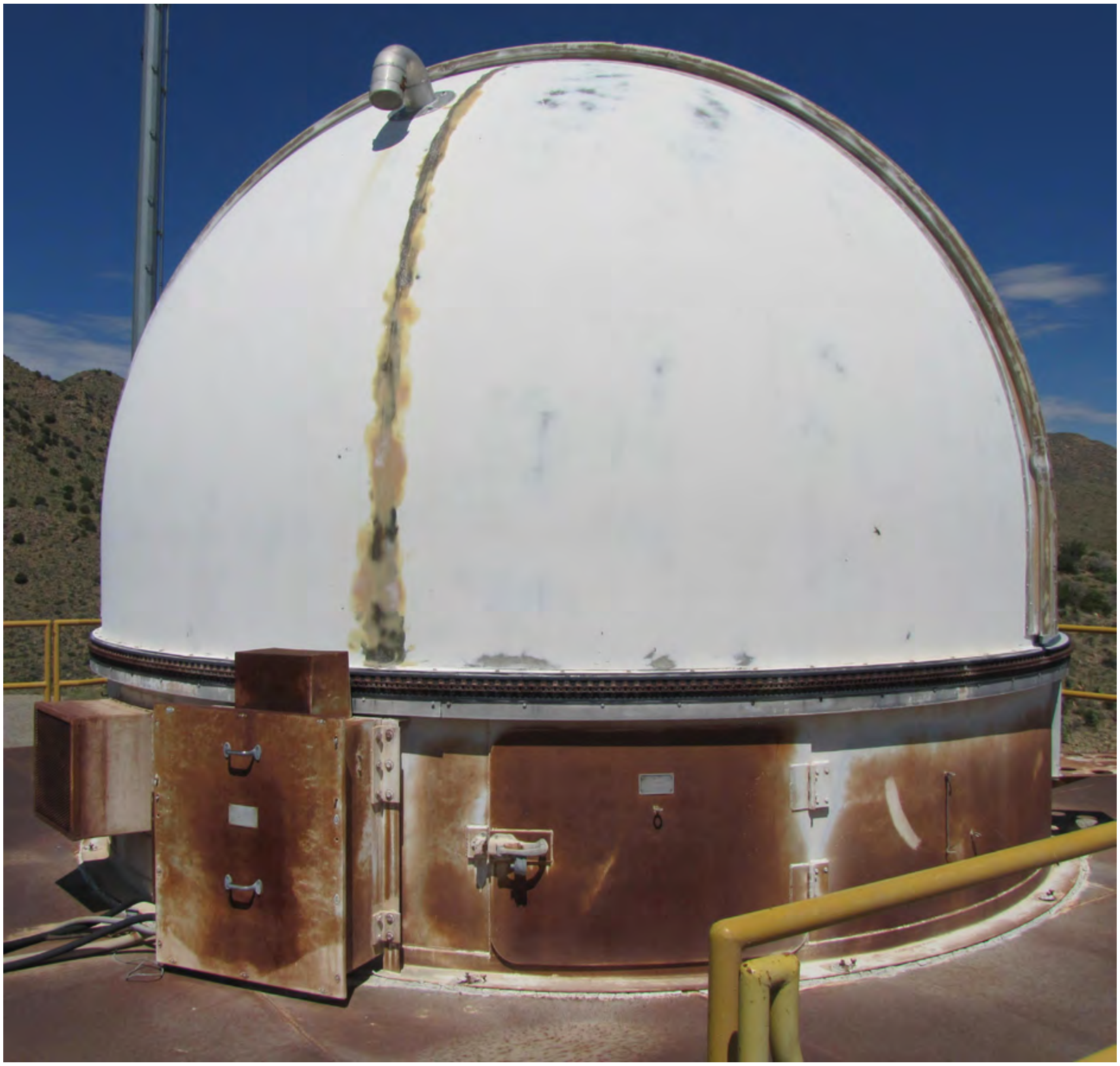

Figure 41. 16-foot Parabam astrodome on Prototype Cinetheodolite Building.

a WSMR physicist who envisioned an instrument with improved accuracy, overcome "bias errors", improve photographic representation, and minimize the "human error" factor (Mimmack and Hall 1963). A prototype with an improved optical system was manufactured and delivered to WSMR in 1970. The WSMR cinetheodolite did not go into production and the program was eventually cancelled.

The last group of fixed astrodomes to be installed at WSMR was in 1979 with 11 fixed telescope sites with identical 20-foot tall steel-frame towers (Figures 42-44). Defined as "fixed telescope sites", the plans reveal no indication as to what type or models were planned, but period photos reveal them to be the then cutting-edge Contraves-Goerz Corporation Distant Object Measurement System, or DOAMS. This was the last of the dedicated instrumentation sights to be constructed with the astrodome as a key component. The astrodomes for this series were manufactured by Tommy Tower; they are all 20-foot units.

Figure 42. 20-foot fixed telescope stand with 16-foot Tommy Tower Astrodome, NW 50 Site, WSMR.

While not the subject of this study per se, the mobile unit continues to serve the ranges to this day. Most were constructed on some type of automobile chassis (Figures 45 & 46).

As ubiquitous as instrumentation shelters are at WSMR, there were dozens of elevated sites constructed for the placement of these mobile tracking devices, otherwise referred to as "trailerized" (Joe Gold, personal communication 2016). Mobile sites have been constructed for many years on the ranges, and consist primarily of a raised berm with a concrete pad to park a mobile unit; some sites were fitted with electrical and timing connections. Trailerized instruments, both optical and electronic were sent all over the ranges wherever a test might required (Figures 47 & 48).

Though placing instruments on wheeled carrier devices was done very early on, it is not until 1960 that the design and execution of these sites

Figure 43. NW 50 Site with DOAMS, ca. 1981 (*Ken Bellinger Collection, WSMR Museum Archives*).

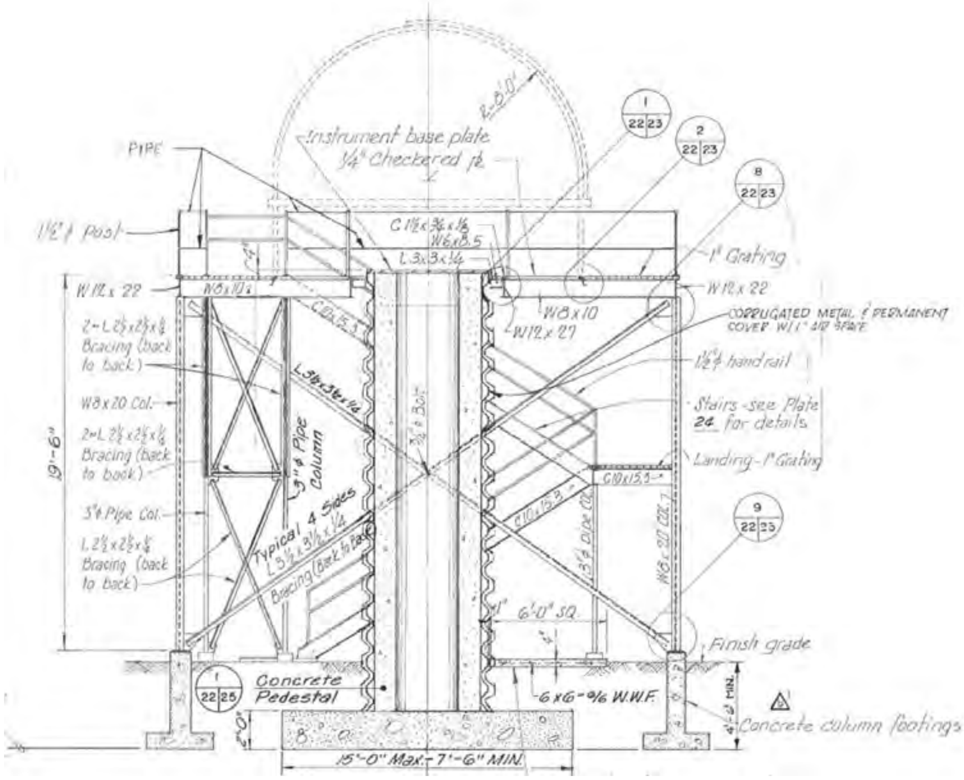

Figure 44. 20-foot telescope platform, 1979 (*WSMR Drawing set WS-UB)*.

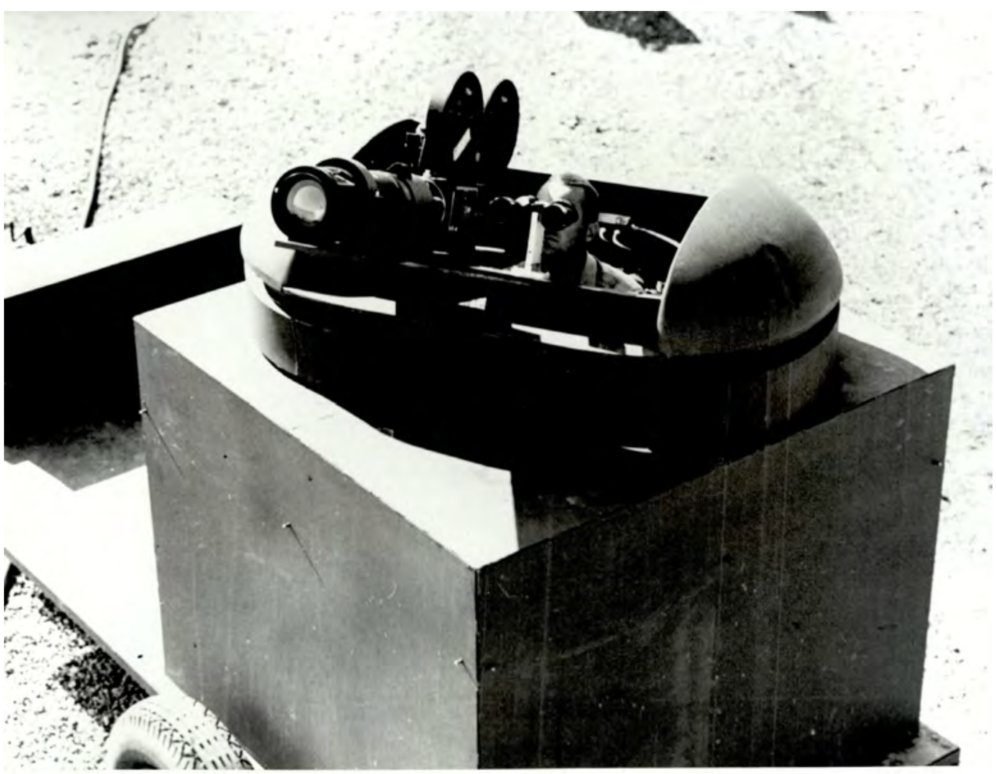

Figure 45. Prototype Turret for mobile tracker, ca. 1955 (*Ken Bellinger Collection, WSMR Museum Archives)*.

Figure 46. Mobile Cinetheodolite Mount (*MCM)* at WSMR, ca. 1963 (*WSMR Museum Archives)*.

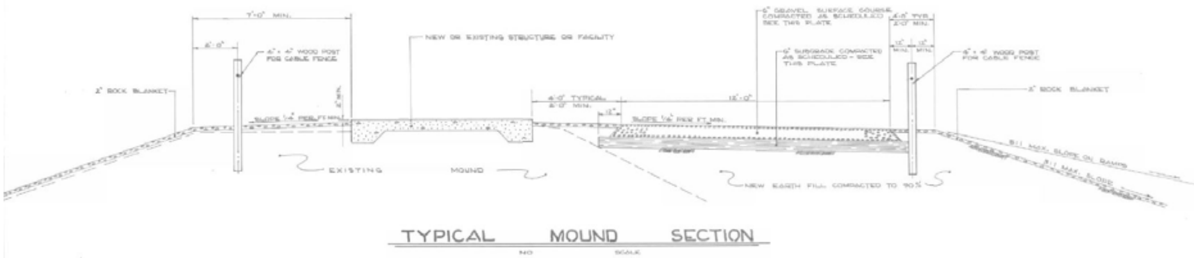

Figure 47. Typical Mound Section, 1960 (*WSMR Drawing Set WS-JR)*.

was formalized. As the ranges moved away from permanent instrumentation structures, these sites were usually raised well above grade and fitted with power, communications, and timing connections. Figure 48 illustrates the more sophisticated evolution with its Mobile Optical Sites program.

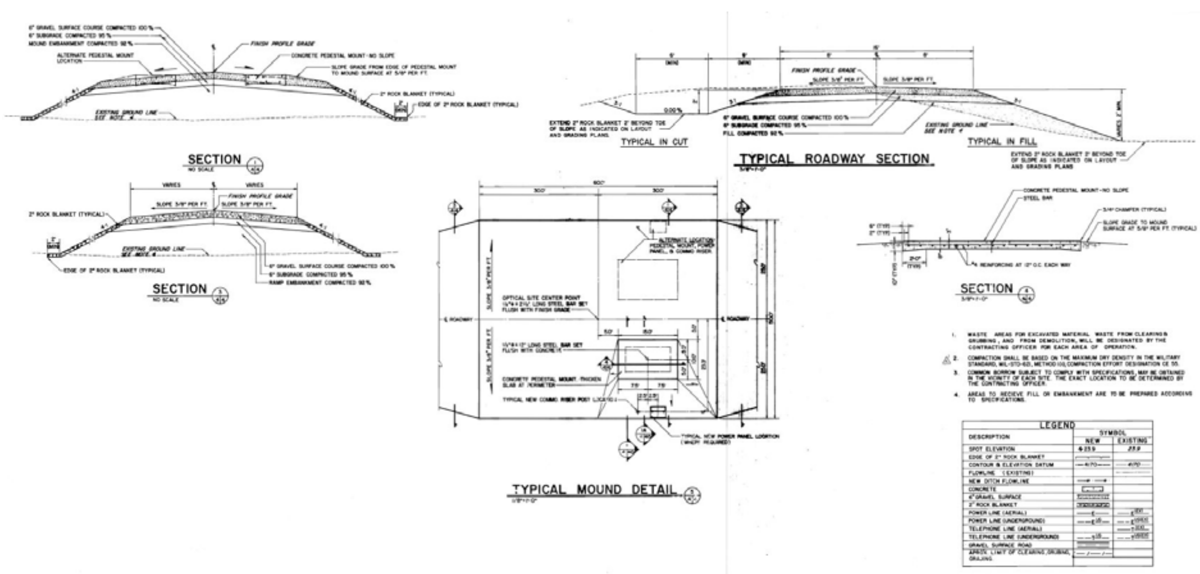

Figure 48. Mobile Optical Sites, 1976 (*WSMR Drawing Set WS-UD)*.

8. Consideration of NRHP Eligibility

In evaluating the potential for NRHP eligibility, buildings, structures, sites, districts, and objects are analyzed in terms of the applicable National Register Criteria:

> (a) that are associated with events that have made a significant contribution to the broad patterns of our history; or
>
> (b) that are associated with the lives of persons significant in our past; or
>
> (c) that embody distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or
>
> (d) that have yielded, or may be likely to yield, information important in prehistory or history.

Special Criteria Considerations are also applied in specific circumstances. Criteria Consideration G is applied to resources under evaluation for a properties achieving significance within the past 50 years.

In assessing buildings, structures, sites, districts, and objects under these criteria, full use is made of the historic contexts for the resources, facts regarding the events that might constitute significance, known facts about the people who were important to the history of the site, and the known attributes of design in the various periods of construction. Of these criteria, Criterion B appears to be the least applicable to systematic application to astrodomes. The more systematic application would be made with respect to Criteria A and C.

Since astrodomes are generally considered equipment, they would be affixed to something more substantial like a concrete pad or steel frame. Therefore, the only likely scenario in which one might consider an astrodome individually significant would be in context with its support infrastructure. Further, since most were built in quantity (i.e. manufactured), it is unlikely any would rise to the level of historic significance under the NRHP. The most likely scenario for NRHP eligibility would be in the case where the astrodome continued to house a piece of optical instrumentation and remained attached to its support infrastructure.

9. Conclusion

With utilitarian origins and largely relegated to the status of "support equipment", the astrodome nonetheless remains a relatively common sight on most test ranges. Most fixed units from the 1950s and 1960s have fallen into disuse and many have been removed; those still in place have likely had the optical instruments removed. Extraordinarily useful for the period in which they were utilized, astrodomes are quite common and were installed in significant numbers, particularly at WSMR.

In determining historic significance under the NHPA, WSMR may want to consider how best to categorize the shelters, how they might fit in to a local and national context, and whether or not they possess genuine historic significance. It may best serve all involved in the evaluative process to retain representative examples for interpretive purposes. Also, due to the ubiquitous nature of the astrodome as a premanufactured instrumentation shelter, this overview may help to serve as the basis for nationwide Programmatic Agreement. This study was intended to facilitate the process by providing a context for assessing historic significance.

References Cited

Ad Hoc Committee, O. S. W. G.

1956 *Astrodome-Type Instrumentation Shelters*. Inter-Range Instrumentation Group. Inter-Range Instrumentation Group. White Sands Proving Ground, New Mexico.

Christman, A. B.

1971 *Sailors, Scientists, and Rockets: Origins of the Navy Rocket Program and of the Naval Ordnance Test Station, Inyokern*. Naval History Division, Washington, DC.

Delgado, Raymond F.

1981 Photo-optical Range Instrumentation: an overview. *Optical Engineering*. September/October 20 (5): 701-711.

DiPol, C. J.

1957 *Astrodome-Type Shelter for Cinetheodolites*. US Naval Ordnance Test Station. NAVORD Report 5596, NOTS 1803. US Naval Ordnance Test Station, Inyokern, California.

Kammer, D.

1997 *Historical Significance of the Askania Cinetheodolite Towers Located on Holloman Air Force Base and White Sands Missile Range*. Prepared for the New Mexico Natural Heritage Program.

L. A. Riggs, C. G. M., C. H. Graham

1947 Photographic Measurements of Atmospheric Boil. *Journal of the Optical Society of America* 37:15-20.

Martz, E. J.

1951 *Optical Performance in Elevated Camera Stations*. Optical Systems Section, Systems Engineering Branch. AD 097415. Flight Determination Laboratory, White Sands Proving Ground, New Mexico.

Pike, B.

1954 *Control of Environment for Askania Theodolites*. Technical Report No. NOTS Technical Memorandum 1767. US Naval Ordnance Test Station, Inyokern, California.

The Rich History of the HF Group, Inc. (Aka HOUSTON FEARLESS 76). Electronic document. <http://www.hf76.com/about_us.asp>.

Steinhoff, Dr. E. A.

1950 *Study of the Range Instrumentation and Instrumentation Facilities at Holloman Air Force Base*. Holloman Air Force Base, Holloman Air Force Base, New Mexico.

Test Department

1953 *NOTS-Modified Askania Cinetheodolites*. US Naval Ordnance Test Station. NAVORD Report 2066, NOTS 772. Inyokern, California.

Ward, W. C.

1948 *A Study of Heat Waves*. U.S. Naval Ordnance Test Station China Lake. Technical Memorandum OMM-2. Experimental Operations Department, Inyokern, California.

White Sands Missile Range

1961 Transfer of Accountability. 15 September. Department of Public Works Property Records, White Sands Missile Range

1958 *Wind and Sand* [White Sands Missile Range, New Mexico] 7 March Vol. 8, No. 48:1. Optical Data Pick-up Capabilities Enhanced by Changes Being Made

Preparers' Qualifications

Phillip Esser, B.S. (Historic Preservation, Roger Williams University), is an architectural historian with more than 15 years of experience who meets the U.S. Secretary of the Interior's Professional Qualification Standards (as defined in 36 CFR Part 61) for architectural history and history. Mr. Esser has a wide range of historic preservation expertise, particularly historic building documentation ranging from individual buildings to large building surveys for state and National Register landmarking as well as Federal Tax Rehabilitation projects. Mr. Esser has extensive experience with Section 110 and 106 evaluations, preparation of National Register of Historic Places Determinations of Eligibility studies and preparation of nominations as well as historic building surveys. Mr. Esser acted as project manager and primary author for the current context, in addition to conducting archival research and conducting oral history interviews.