CHAPTER I

THE SENTINEL PROGRAM

Following President Johnson's decision of September 1967 to deploy the SENTINEL Ballistic Missile Defense System, there were two primary tasks which had to be carried out to bring BMD into reality. The first of these tasks was the completion of research and development of SENTINEL's weapon system, especially the PAR, the missile interceptors SPARTAN and SPRINT, and the Central Logic and Control System master data processing equipment. In the fall of 1967 these components were still in a formative stage, but work was already well underway by prime contractors Bell Telephone Laboratories (BTL), Western Electric Company (WECo), McDonnell-Douglas, and Martin-Marietta, together with a host of subcontractors to perfect them. For the most part, it was a matter of extending previous NIKE-X contracts in order to adapt proven technology to SENTINEL's requirements.

The second major thrust following the SENTINEL decision was the design and construction of hardened facilities and attendant support structures to house the weapon system and its operators. It was logical that this mission should have been assigned to the U.S. Army Corps of Engineers, a branch of the Army organized in 1775 to provide for the service's military engineering needs. During the American Revolution, a handful of French and American engineers supervised the building of fieldworks, an effort which culminated with the victorious siege of Yorktown. From these beginnings in the Revoluntionary period, Army engineers were actively involved in nation building throughout the eighteenth and nineteenth centuries. Engineers in uniform helped explore and chart the West; laid out canals, roads, and railroads; made navigational improvements in streams and rivers; and, towards the end of the 1800's, began the first civil works intended to tame the Mississippi River. The Corps' extensive civil undertakings continued in the twentieth century with such projects as the Panama Canal and the Jadwin Plan for further Mississippi flood control. After 1940 the Corps' work expanded into the area of military construction, including ammunition plants, Army posts, airfields, housing projects, and the great Pentagon Office Building in Washington, D.C.

As the Army's missile program evolved after World War II, the Corps of Engineers had been closely associated with it. Private contractors under Corps direction were responsible for constructing numerous facilities essential to guided missile research and training at White Sands and at Fort Bliss, Texas. During the 1950's and early 1960's the Corps had constructed installations for the emplacement of NIKE-AJAX and NIKE-HERCULES batteries across the United States. Not long after, Army engineers supervised the sinking of massive hardened underground concrete silos for TITAN and MINUTEMAN ICBM missile bases scattered across the Midwest.

The Corps of Engineers grew up with the Army's antiballistic missile program after March 1958. Its participation in BMD-related work steadily increased from a limited role in construction only for the basic ZEUS facilities at White Sands Missile Range to the development of criteria and final design, as well as construction, for the MAR-I and SPRINT launch facilities at the New Mexico range. When the Kwajalein Missile Range went into operation after 1959, the Corps of Engineers provided criteria development, facility design, and construction for the ZEUS installations there as well as for the later Meck Island prototype NIKE-X MSR building and its associated SPARTAN-SPRINT launching cells. Thus as President Johnson and his advisors debated the pros and cons of BMD during the summer of 1967, the Corps had already logged extensive missile facility experience in its record. Although none of the above listed facilities represented true prototypes of those required for SENTINEL, there was considerable similarity and much of the experience gained could be applied directly to the new system. On the other hand, the Army had never attempted to design and construct a missile program as large and sophisticated as SENTINEL in so short a time. This, it was thought, called for special measures.

As has been seen in the Prologue, on 2 December 1966 NIKE-X System Manager Lt. Gen. Austin W. Betts issued a Letter of Instruction that the Corps of Engineers should prepare itself to carry out the mission of designing and constructing NIKE-X tactical facilities if the order to go with his NIKE-X program should be given. General Betts' own NIKE-X Systems Command would continue research and development of the weapon system per se, i.e., the military hardware in the radars, missiles, and computers. In less than five months the Office of the Chief of Engineers responded with a detailed sixty-one page "Corps of Engineers NIKE-X Mobilization Plan," dated May 1967, which projected a unique NIKE-X Division, or CENXD, to execute any future

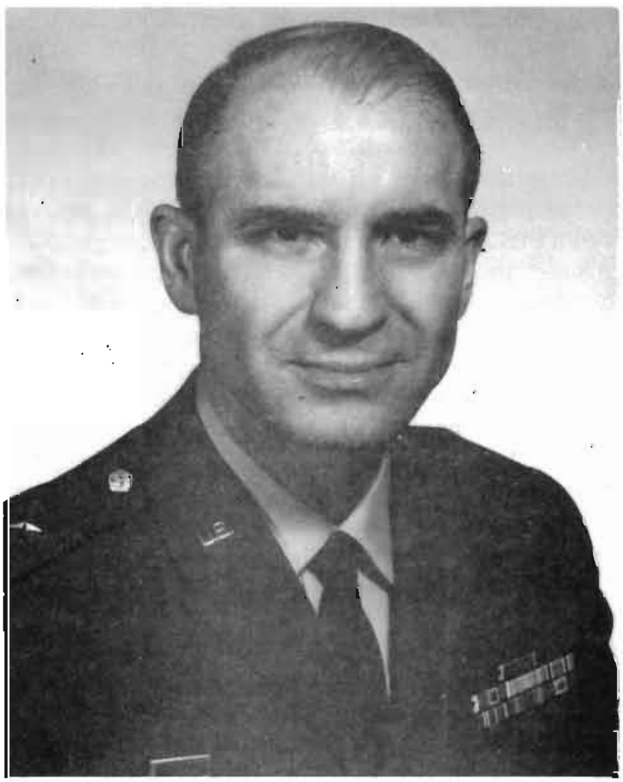
NIKE-X mission for the System Manager. This mobilization plan is especially meaningful to the history of the Huntsville Division, because under it the Division was conceived and actually born as the NIKE-X Division.[1]

Unlike existing Corps of Engineers divisions and districts, the NIKE-X Division-to-be was to have no geographical limitations on its operations; instead, it would be organized and operate in conformity with an exclusive national deployment mission that might take it into all fifty states. The May 1967 plan formally defined that mission as:

> To manage and provide technical control and direction of all aspects of the design and construction of Nike-X weapons system facilities and other Nike-X systems related construction. The CENXD function encompasses development of criteria, design and construction of R&D and tactical facilities, design and/or procurement of various types of Government furnished equipment, preparation of maintenance and logistics documentation, test and turnover of completed facilities and may include interim operation prior to turning over certain facilities to the using organization (ARADCOM).[2]

The Division's specialized mission also meant it would be under the command of the Chief of Engineers but operationally attached to the NIKE-X System Manager, or his deputy for technical matters, for programming and budgetary assistance in facilities acquisition. The details of command relationships and management procedures were to be worked out later in actual operations. According to the plan, formation of the NIKE-X Division was to take place in three phases: the first an indeterminate cadre period before "D," or deployment day; the second a Phase I permitting assembly and assumption of initial duties; the third a Phase II extending from assembly to the first construction contract award. Phase I would take about 180 days and Phase II no more than an additional 180 days to achieve full mobilization and independent operations; in the meanwhile the Division would be a foster child partially supported by other Army units as needed. The plan further envisioned that most of the Division's nucleus would come from the NIKE-X Cadre and Planning Group of four men already in being at OCE Headquarters under the Directorate of Military Construction, and from the NIKE-X Engineering Division, of the Mobile District. Others could be absorbed from the Advanced Technology Branch, Military Construction Division, OCE, a small group which had been exploring hardened electric power plants for NIKE-X. Peak authorized strength, excluding area offices, ultimately would be five military and 522 civilians under the command of a major general as division engineer.[3] This OCE plan swung into operation when the Department of the Army ordered SENTINEL deployment during the first weeks of October 1967.

The unit that would become the U.S. Army Corps of Engineers, Huntsville-Division, was formally organized by authority of Department of the Army under OCE General Order No. 17 dated 9 October 1967. As of 15 October, there would come into existence the U.S. Army Corps of Engineers NIKE-X Division organized as a separate Class II activity under the command of the Chief of Engineers, to be headquartered at Huntsville, Alabama. Later the same day a modified General Order No. 17 from OCE corrected the earlier text to read U.S. Army Corps of Engineers, Huntsville Division (USAEDH)--the hectic haste that would characterize the Division's first months was already evident in its birth certificate.[4]



MAJOR GENERAL ROBERT P. (RIP) YOUNG
HUNTSVILLE DIVISION ENGINEER
OCTOBER 1967 - NOVEMBER 1970

Concurrently with the organization of the Huntsville Division, the NIKE-X Cadre and Planning Group, OCE, and the NIKE-X Engineering Division, Mobile District were transferred to it, but these personnel were to remain at OCE in Washington or at Mobile until activation. They did not have to wait long for their new jobs, because activation of the Huntsville Division was duly authorized on 15 October 1967 under Table of Distribution and Allowance No. CEW2V6AA00, which initially allocated it four Army officers and 136 civilian spaces. About one-fourth of these came on board immediately on a temporary duty basis from Washington or Mobile. Two days later, on 17 October, Brig. Gen. R.P. Young was named first Division Engineer. A graduate of West Point in 1942 and Harvard in 1948, General Young had served in North Africa and with the MANHATTAN Project during World War II. Prior to his Huntsville Division assignment, he had been Commander of U.S. Army Engineer Command, Europe. General Young's new division began to assemble in temporary quarters at 421 King Street, Alexandria, Virginia, while suitable office space was sought in Huntsville. The Division Headquarters stayed at King Street exactly two months.

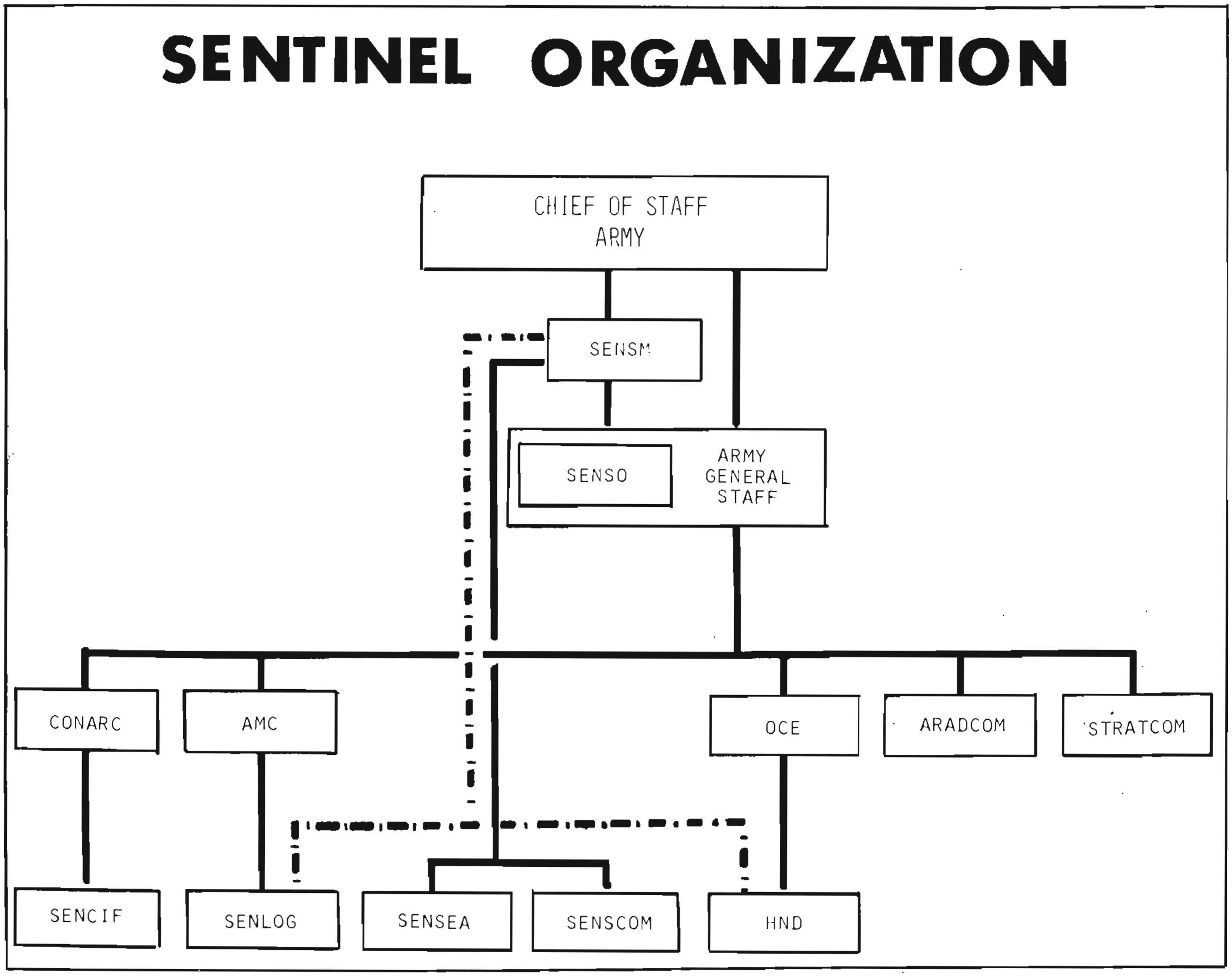
While the Huntsville Division gathered at King Street during October and November, the larger Army infrastructure that it was to serve also began to take on an identity of its own. On 2 November the Department of the Army ordered that its DEMOD 1-67 ballistic missile defense system would thereafter be referred to as the SENTINEL System, and the next day the first ten site locations were announced. SENTINEL was now officially split off from the NIKE-X System, which continued a separate existence under General Betts to do advanced research in BMD. Timely progress in development and deployment of the SENTINEL System became the responsibility of SENTINEL System Manager Lt. Gen. Alfred D. Starbird, with the support of a SENTINEL System Office in Washington, D.C., immediately under the Chief of Staff, U.S. Army. General Starbird, then Director of the Defense Communications Agency, assumed his post on 15 November 1967. He would shepherd the SENTINEL System throughout its history and conduct its successor, SAFEGUARD, until April 1971. General Starbird's chief field organization was the SENTINEL System Command, or SENSCOM, with its headquarters in Huntsville, Alabama, conveniently near the missile talent and technology of Redstone Arsenal. The Commanding General of SENSCOM, Brig. Gen. Ivey O. Drewry, was also Deputy System Manager. SENSCOM's

LIEUTENANT GENERAL ALFRED D. STARBIRD
SENTINEL SYSTEM MANAGER

mission was to bring the entire SENTINEL System to the point of operational readiness, whereupon it would be released to the Army Air Defense Command, or ARADCOM, the ultimate users of the System. In practice, SENSCOM's prime in-house concern was mostly with weapon system components, the radars, computers, softward programs, and missiles, while the Corps of Engineers prepared sites and built tactical support facilities to meet SENSCOM's requirements. In this mission General Starbird and SENSCOM were to get independent evaluation, review, and testing from the SENTINEL System Evaluation Agency headquartered at White Sands Missile Range, while logistical support would come from the SENTINEL Logistics Command. Other contributions would be taken from existing Army agencies and commands such as the Army Materiel Command, the Strategic Army Communications Command, the Continental Army Command, and the Army Air Defense Command. Training for the System would be conducted at the SENTINEL System Central Training Facility to be built at Fort Bliss, Texas.

It was understood from the beginning that Huntsville Division's special mission would necessitate both a singular internal organization and some unusual external relations with OCE and with SENSCOM. Accordingly, soon after activation took place efforts were begun to draft to a formal statement of the Division's organization and functions. It quickly became apparent that the standard ER 10-1-3 regulation governing the assignment and structure for Engineer units could not be stretched to cover Huntsville's unique mission, and on 26 December 1967 OCE recommended that a special regulation for the Division be drafted similar to those for other atypical Corps formations. Huntsville Division concurred, and on 17 January 1968 it submitted a draft "Organization and Functions" proposal for consideration. OCE ultimately approved this proposal as ER 10-1-22, but only after the relationships between SENSCOM and Huntsville had been defined.[5]

A written Memorandum of Agreement defining the relations between the Corps of Engineers and the SENTINEL System Organization was not signed until 14 May 1968, or seven months after activation of the Division.[6] Essentially this statement simply formalized tentative assignments and working arrangements envisioned under the earlier "NIKE-X Mobilization Plan" and already put into everyday usage during the winter of 1967 and spring of 1968. The heart of the agreement was the understanding that Huntsville Division would be under the command of OCE but would provide service to SENSCOM under General Starbird's operational control. SENSCOM would supply general SENTINEL facilities configuration requirements to Huntsville Division, while the Division would furnish SENSCOM with the



three steps necessary in building all SENTINEL installations. In the earliest stage the Division would engage an architect-engineer firm (AE) to draft design criteria, a set of detailed parameters for one particular type of facility such as the PAR Building or MSR Power Plant. In a few cases, the Division assumed some criteria contracts already in existence as the legacy of NIKE-X. Having received, reviewed, and approved the design criteria, the Division would then negotiate for final design with a suitabie AE, usually but not necessarily the same firm that had prepared the criteria. The AE's final design had to implement all the Division's criteria in the form of minute plans and specifications, sometimes running to thousands of printed pages and design drawings. Finally, the Division would advertise, award, and manage a construction contract or contracts on a site-by-site basis. As usual with Corps procedures in such projects, the Division would supervise, guide, manage, and review work actually performed under contract with a variety of private firms.

Huntsville Division also agreed to work with Corps geographic divisions and districts in selecting, acquiring, and preparing the real estate for the SENTINEL sites located in their regions. Work schedules, layouts, and specifications for each site would be established by the Huntsville Division Engineer in coordination with SENSCOM to ensure that its requirements were met. In these activities, and in conducting public relations, the Division Engineer was expected to work hand-in-glove with SENSCOM's staff, and with General Starbird if necessary, to ensure that the interface between weapon system requirements and facilities compliance functioned smoothly. Formal control over both weapon system and facilities configuration always remained in the hands of the System Manager, who established milestones against which the program would be reported, including schedules, cost, and personnel. Funding for Huntsville Division's personnel and overhead came out of SENTINEL program funds included in the Corps of Engineers' budget, while the costs of real estate, design, and construction would be met out of SENTINEL funds administered by the System Manager. All SENTINEL real estate, design, and construction funds were authorized and appropriated by act of Congress in annual Military Construction Bills.

As Huntsville Division began to form as a unit in Alexandria, Virginia, after 15 October, a search went on in Huntsville for suitable office space. The hunt was not an easy one, because under the impact of the burgeoning space program and expansion of NASA at Marshall Space Flight Center, Huntsville was experiencing a boom akin to those of Old West mining towns. Office space was at a premium, and the Corps had to compete with private industry and with other Government agencies for the city's limited capacity. Nevertheless, a home for the new Division was eventually rented in the Huntsville Industrial Center Building, a three story former textile mill located in an older neighborhood at the corner of Meridian Street and Oakwood Avenue. Fortunately, the homely exterior of the building belied the interior, which some years before had been comfortably remodelled with carpets, paneling, and planters. The office on Huntsville Industrial Center premises opened for business at 0800 on Monday, 18 December, and sheltered joint Division-SENSCOM operations for the next year and a half while more modern quarters for both were built in Huntsville's new Cummings Research Park area. Early operations at the Division's temporary home were greatly facilitated by administrative and logistical help given by the U.S. Army Missile Command at Redstone, which supplied the Division with its first desks, typewriters, and file cabinets, and a generous supply of administrative assistance.

When the Division began its first workday in Huntsville on 18 December, fifty-six individuals reported for duty, and an additional thirty-two positions were committed. This strength represented just a little more than half of the Division's initial authorization of four officers and 136 civilians, and throughout the remainder of 1967 and the first months of 1968 active recruiting went on throughout the Corps of Engineers and other Governmental agencies to find qualified personnel. As in the case of office space, competition for talent was vigorous because of the simultaneous creation of SENSCOM and SENLOG, but the Corps' task and the Huntsville location were attractive, so there was no real dearth of applicants. By the end of December 1967 ninety-five positions, including four military, had been filled or accounted for, and by the end of January 1968 almost the entire initial personnel allowance of 140 job slots had been filled.

While recruiting for authorized spaces went on apace, the newly-arrived Dewey Rhodes, Chief of the Manpower Management Branch, and his assistants busied themselves planning the Division's future Table of Distribution and Allowances, refining the Division's organization, and considering the layout of a prototype area office. Their guidebook was the "NIKE-X Mobilization Plan," which furnished a substantive model both for the Division's beginning organization and for its future growth. In mid-January 1968 the Division received a requirement from the SENTINEL System Office to make a comprehensive estimate of the Division's manpower needs for FY 1969 through FY 1977 with explanations for positions over and above end strength projected for the end of FY 1968. The resulting study indicated an immediate need for at least 230 civilians by the end of FY 1968 (30 June), and it predicted the Division would achieve a peak headquarters employment of seventeen officers, two enlisted men, and 525 civilians sometime in FY 1971. Peak levels for field offices would come with the crest of construction in July 1971, when thirty-six officers and 1,290 civilians would be on area office payrolls. The January study was approved, and the Division's explosive expansion during the spring continued when an additional ninety spaces were verbally authorized in mid-April, in part to permit immediate hiring of a large, highly skilled technical group then being released from Cape Canaveral District through a reduction-in-force. In fact, on 30 June 1968 the Division counted 263 (including eight military) on-board, with an additional eighteen civilian spaces committed.[7]

As Huntsville Division fleshed out during the winter and spring, its organization began to manifest two features unique within the Corps of Engineers, both of which could be directly traced to the Division's mission. Ordinarily the Corps' geographic divisions and districts maintained a military staff in their Executive Offices made up of a division engineer and one or two deputy and assistant engineers, but in the Huntsville Division this arrangement had to be elaborated to cope with the far-flung construction activities forecast for its future. As his chief assistants, Division Engineer General Young had Deputy Division Engineer Col. George A. Rebh, assigned to Huntsville on 27 November 1967, and no less than four assistant division engineers who joined in 1968. Among their responsibilities these four assistant division engineers acted as the Division's contracting officers, officially representing the U.S. Army in signing construction contracts. Construction in the Eastern Region of the United States fell under the supervision of Col. Robert W. McBride, the Central United States to Col. R.L. Kackley, Jr., and the Western Region of the country to Col. Lochlin W. Caffey. It was anticipated that one of these three contracting officers stationed centrally at Huntsville would supervise all SENTINEL construction sites located within his region. From Huntsville their liaison would spread down and outward to each of the half-dozen or so area engineers who headed on-the-job field offices at each site. Thus the chain of military responsibility for SENTINEL construction would run from the area office on-site to the assistant division engineer for the region in Huntsville to the division engineer and thence to OCE and SENSCOM. The fourth assistant division engineer, Col. Henry K. Mattern, was responsible for all the Division's vast procurement of standard hardware such as diesel engine generators, valves, electrical components, shock isolators, and chillers that the Government would purchase and furnish to contractors as Government Furnished Property (GFP).

Outside of the Executive Office the structure of the Division's technical staff also reflected Huntsville's singular mission. Other Corps divisions and districts maintained one engineering division to perform their engineering services, but from the beginning the "NIKE-X Mobilization Plan" had envisioned that the urgency, enormity, and complexity of the SENTINEL facilities design would demand not one engineering division but two within the NIKE-X Division. As the Division's mission took shape, this projection was fully vindicated. To satisfy Huntsville's large and sophisticated engineering workload, assignments were apportioned between a Systems Engineering and Development Division and a Facilities Engineering Division. Distinction between the pair's activities was often fuzzy, but Systems Engineering primarily worked closely with the weapon system contractors, so that as design progressed on radars, missiles, and computers, criteria development for their buildings and power plants could begin. Systems then researched alternative engineering solutions for specific criteria headaches such as the effects of shock and developed them to the point that final design could take over. Configuration management, standardization, systems effectiveness, reliability, availability and maintain-ability, value engineering, and programming also fell under the purview of Systems Engineering. This Division received its first chief on 5 May 1968 when John P. Coony joined by transfer from the Mediterranean Division in Livorno, Italy. Prior to his Mediterranean tour, Coony had participated in design of the enormous Saturn Vehicle Assembly Building for Launch Complex 39 at Cape Kennedy. Coony served throughout the SENTINEL program, leading a division responsible for many of the imaginative solutions found for the peculiar demands of hardened BMD installations.[8]

Next door to Systems Engineering the Facilities Engineering Division undertook project management for the final design of PAR and MSR buildings, their power plants, remote missile sites, and for miscellaneous support facilities needed at each site. For the most part this meant the technical direction of contractors who were trying to meet frequently shifting directives handed down from BTL and other SENSCOM weapon system contractors. Facilities Engineering Division also handled engineering design duties such as survey, and site work, paving and drainage, architectural and structural, and utilities, and it provided engineer support services such as estimating, drafting and specification formulation. The first head of Facilities Engineering was Joe L. Harvey, formerly Chief Engineer of the Cape Canaveral District, who joined the Huntsville Division in December 1967. Like John Coony, Harvey was a seasoned military engineer whose career with the Corps of Engineers since World War II had included designing IRBM and ICBM launch facilities as well as installations for Mercury, Gemini, and Saturn space programs in Florida.[9]

Outside of the twin engineering divisions, the structure of Huntsville's technical staff was generally conventional. A Construction Division with Management, Inspection, and Reports Branches oversaw construction contracts let for each site. Bernard L. Trawicky was assigned as Construction Chief in December 1967. Trawicky's Corps career as a hardhat had begun in the European Theatre in World War II and continued in civilian life after 1946 as a permafrost construction researcher in Alaska. This background carried over when he became construction engineer at the great strategic air base at Thule, Greenland. Trawicky would remain at the head of the Construction Division throughout the SENTINEL and most of the SAFEGUARD period, transfer briefly to Chief of the Engineering Division, and retire in September 1975 after thirty-six years in Government service.[10] Huntsville's technical staff was rounded out by the Supply Division, whose first chief, Thor S. Anderson, came from the Defense General Supply Center in late 1967. As experienced as any of his colleagues, Anderson headed a division with responsibility for administering the myriad procurement and supply contracts buying millions of dollars' worth of crucial Government furnished items incorporated in SENTINEL facilities.

Inseparable from the establishment and shaking down of the Executive Office and technical staff was the setting up of housekeeping operations by the Division's administrative and advisory services. As in all parts of the Division, administrative staff personnel came from many backgrounds and parts of the country. To cite a few out of many situations, personnel for the Budget Branch initially were recruited from the Corps' Pacific Ocean Division, San Francisco District, Alaska District, and the Marshall Space Flight Center. William A. Campbell, the Division's first comptroller, joined on a temporary duty basis from the Ohio River Division to assist in the initial organization of the Huntsville Division at its temporary location in Alexandria, Virginia. He was permanently assigned to Huntsville Division in December 1967 following this TDY tour in Alexandria. The Internal Review Branch staff was obtained from the NASA Regional Audit Office and the Tulsa District, while the Management Analysis Branch cadre was derived from personnel recruited through the Memphis District and the North Atlantic Division.

Among the earliest support offices to take shape was the Office of Counsel which provided the Division with legal consultation on the fine points of contract law clauses. Again the Division enjoyed rich experience and high capacity in its General Counsel Emil Vuch, a quiet, gentlemanly lawyer who brought with him thirty-seven years of experience in Government legal service when joining the Huntsville Division in December 1967 from Canaveral District.[11] In addition to legal services, the Comptroller's Office, the Finance and Accounting Branch, Internal Review Branch, Budget Branch, and Management Analysis Branch also got off the ground during the early weeks of 1968, but some of these offices could not function on their own until mid-1968 because of the training, breaking-in, and orientation process.

The experience of the Finance and Accounting Branch was perhaps fairly typical of this maturation phase of early 1968. Personnel for this branch were obtained throughout the Corps: the Finance and Accounting Officer came from the Army Map Service, his assistant from the Baltimore District, and others from the Okinawa, Mobile, and Canaveral Districts, as well as from four of the Corps' civil works districts. The civil works group was not fully acquainted with military accounting procedures and was trained by accountants detached on TDY from the Mobile District. The Mobile District also tendered a lifeline by maintaining Huntsville's cost and finance records until 1 May 1968, when its own FCUSA Disbursing Station 5412 became operational. The first expenditures authorized by Huntsville's Finance and Accounting Office were made on 1 May, when $89.15 was paid out to Bowman's Rubber Stamp Co. of Huntsville for forty-five rubber stamps. Expenditures quickly became more substantial--the next day the Division purchased $4,046.47 worth of adding machines, which allowed some of those borrowed from Missile Command six months before to be returned. By 1967 all Corps employees in the U.S. were being paid from a central payroll office in Omaha, Nebraska, so the Finance Office had no extensive payroll activity, but during the spring it still had to assure the prompt payment of Permanent Change of Station Claims for the 200-odd new-comers tranferring in. To assist with the heavy workload the services of four extra voucher examiners were obtained on a TDY basis from the Albuquerque, Buffalo, and Pittsburg Districts. During this same time the Budget Branch assisted in coordinating Mobile District support and the transfer of budgetary responsibilities to Huntsville. It also worked at laying ground rules for internal budgets and for the Division's operating program.

Even as Huntsville's first arrivals flowed in, set up housekeeping, and shook themselves down into a routine, attention in the engineering divisions was already focusing on the Division's first SENTINEL objectives, the selection of sites and the compilation of design criteria. Before detailing how the Division completed the initial phase of its mission, however, a word must be said about the general status of the SENTINEL program at its inception. Certain conditions of paramount importance prevailing in late 1967 remained throughout the ensuing months, combining to produce a dynamic and yet uncertain atmosphere for the Division's work which persisted until the suspension of SENTINEL in February 1969.

One of the most impressive characteristics woven into SENTINEL from the beginning was haste. From the deployment decision early in September 1967 to suspension of activity in February 1969, the entire infrastructure of the SENTINEL program labored under intense driving pressure dictated by tight scheduling. Having once established that a Sino-Soviet threat warranted building a BMD, the Administration and the Joint Chiefs of Staff apparently believed that its deployment should be rushed to the utmost. The exact scheduling of intermediate milestones planned for the program is still shrouded in secrecy, but two very important deadlines stand out--SENTINEL was to be designed, constructed, tested, and made operational fifty-four months after the deployment decision was taken.[12] In four and a half years, research and development had to be completed on all components and facilities, production undertaken, and seventeen sites constructed from unbroken ground that had been neither selected, investigated nor acquired. And since ground was to be broken on the first site at Boston, Massachusetts, by 24 September 1968, less than eighteen months were allocated for perfection of the weapon system, formulation of facilities criteria, final design for the first installations. Moreover, design decisions made during this period demanded a high degree of surety, because extensive standardization was planned for follow-on sites with the least possible variation amoung them. The large quantities of standard items to be procured--several dozen immense diesel engine generators among them--also demanded a lenghty lead time for supply, increasing pressure to award contracts as early as possible.

By itself, tight scheduling would have presented a sufficient challenge for the Division, but other factors intervened to further complicate the situation. The most bothersome complication was probably the development of the weapon system by SENSCOM in parallel with the early stages of building design. Apparently the original SENTINEL deployment decision had hinged upon the use of off-the-shelf NIKE-X radars, computers, and missiles to meet the fifty-four month deadline.[13] Unfortunately, the existence of such off-the-shelf NIKE-X units was a mirage since many of them were still undergoing development and some had not yet reached the prototype stage. The impact of this situation on Huntsville's work was direct, because there had to be a hand-in-glove integration of the weapon system with the building. Many aspects of facilities design hinged upon the confirmation of weapon system requirements and could not go forward until these were finalized. To cite just one example of many, the radar phase shifters and associated electronics generated enormous quantities of heat that had to be absorbed in the PAR and MSR Building's cooling systems. Design of these cooling systems, however, could not proceed with certainty until the requisite type and capacity of cooling was established by the weapon system contractor. As late as 6 June 1968 General Electric Co. was still uncertain as to whether it would use air or water cooling for its PAR phase shifters, and a final decision as to the quantity of cooling air needed was not reached until the fall.

Adjustments in facilities design could be accommodated fairly easily for the data processing equipment and the missiles, but the lack of definitive specifications was particularly embarrassing in the area of the radars, where an especially intimate interface had to be maintained between electronics and building. This situation was most notable in the case of the PAR Building, because no prototype of either the radar or its building existed. It was intended that the first PAR scheduled for Boston, Massachusetts, would do double duty as a prototype and production-type installation, drawing on extensive prior experience with the MAR-I type radar at White Sands. Confidence in the configuration of the MSR could be much greater because a semi-soft prototype with two antenna faces was nearing completion on Meck Island in the first months of 1968. The natural consequence of this fluid situation was that changes in building requirements were numerous and continued to be handed down well into 1968, persisting even after the initial production contract for $85 million worth of SENTINEL radars was awarded to prime contractor Western Electric on 1 April 1968.

Essentially, then, at the inception of the SENTINEL program, the contractors had to translate mostly proven technology into a weapon system whose existing components were still unfinished and had never been assembled as a whole. But not all changes could be laid at the door of BTL, WECo., McDonnell-Douglas, Martin-Marietta, General Electric, and other purveyors of hardware. There is evidence that Department of the Army issued significant changes in the configuration of certain SENTINEL installations sometime during 1968. The exact nature of these modifications is still secret in 1977, but it is highly probable that the original intention to build all PAR's with a single face was being changed to a plan to build some PAR's with an additional seaward face to deal with Soviet submarine-launched missiles. One of these two-faced PAR's was to be installed at Boston, a fact which further pressed for a quick design solution.[14] Responsibility for this state of affairs lay outside Huntsville Division and beyond its control, but the Division's engineers soon learned to expect constantly shifting SENSCOM needs and to meet them without unduly compromising deadlines or incurring excessive cost penalties.

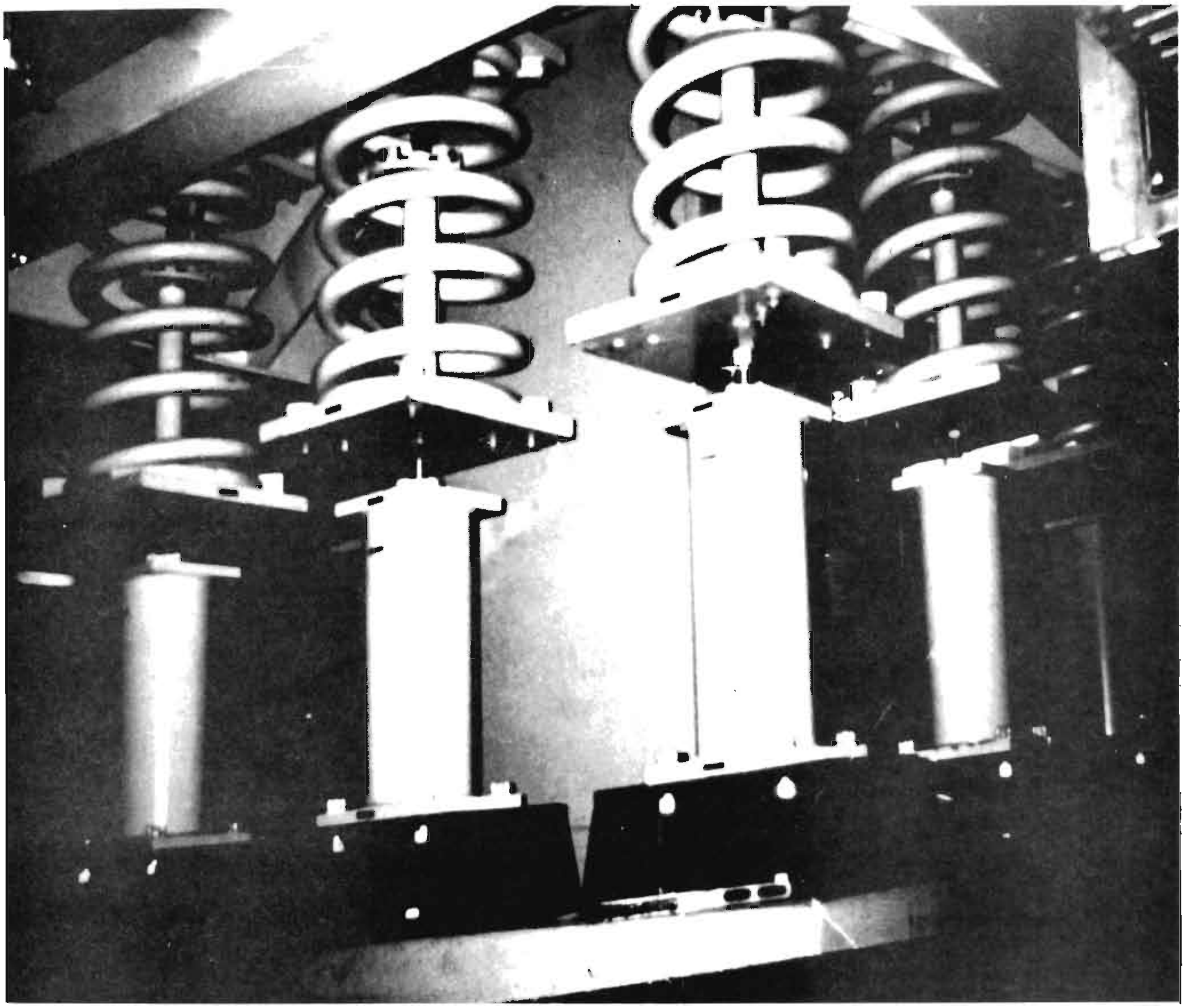
In the first major phase of its mission for SENSCOM, the Huntsville Division was asked to develop all the necessary criteria to "harden" the SENTINEL radar buildings, their power plants, and the SPARTAN-SPRINT missile launching stations. In military engineering parlance,"hardening" means protection from the immediate and after effects of nuclear explosions near the facilities--the precise number and size of the explosions and the "circular error of probability" or distance from the blast over which protection extended constituted the requisite amount or degree of hardening. Another factor was the length of time that buildings had to remain self-sufficient, or "buttoned-up" after combat ensued. In the case of SENTINEL facilities, the degree of hardening has remained secret, as has the "buttoned-up" period, but despite this a general picture of the engineering problems and some of their solutions can be offered here. The degree to which these solutions would have proven successful under the conditions projected for them, of course, continues to be debated, but the controversy has no part in this history. In all cases the Division solutions met or exceeded the requirements laid down by SENSCOM and SENSO and did so with a high degree of reliability and cost effectiveness.

The necessary criteria for SENTINEL buildings might be broken down into the overriding ones prevailing under attack conditions and some less dramatic ones prevailing during round-the-clock, day-in and day-out operations of peace-time. Reduced to their essentials, the hardening criteria demanded the creation of partially buried, multistory structures that would permit the delicate radar apparatus and its three-shift crews to survive nearby nuclear explosions and go on operating on a self-sufficient basis during the hostile aftermath of the explosions, probably for a period of several days thereafter. No hardening was planned for support facilities such as barracks, commissaries, chapels, classrooms, recreation facilities, headquarters buildings, and the like. These were considered expendable and were designed with straightforward methods and materials.[15]

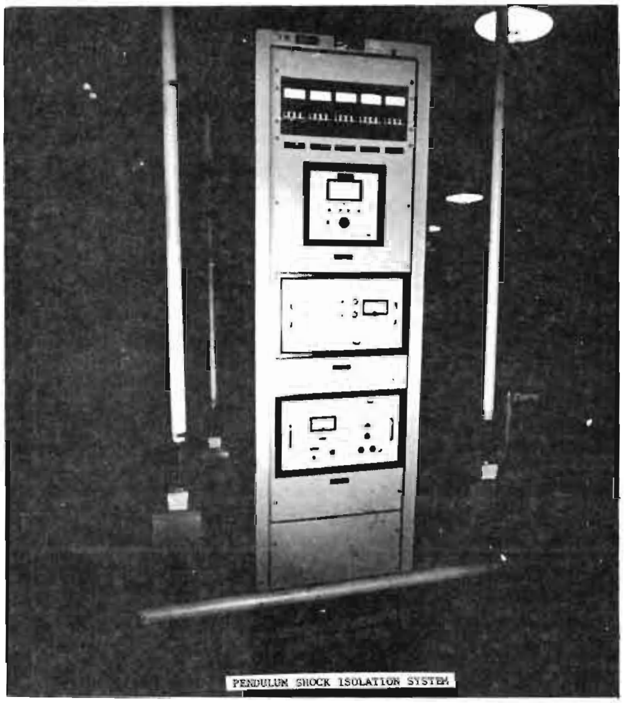
During and immediately after a nuclear blast, SENTINEL buildings would be hit with a powerful blast of heat and light, followed by a tremendous shock wave through the air and ground. The air pressure of the blast was usually called overpressure and was measured in pounds per square inch of surface area. Though the exact figure remains secret, private sources indicate that SENTINEL buildings likely had to withstand about twenty-five p.s.i. of overpressure, or about two and a half times normal atmospheric pressure.[16] The ground shock wave could cause the earth to heave several inches for a few moments as if it were a plastic medium. This would in turn transmit severe shocks throughout nearby buildings, electronic equipment, piping, wiring, and power generating machinery. Countermeasures adopted for building shells generally followed conventional construction practices: concrete walls and floors of great thickness were strengthened by liberal use of large reinforcing steel rods throughout. Windows, of course, were totally ruled out and other openings minimized, most access being through a buried concrete tunnel leading to the power plant and thence to the outside.

It was predictable that some special problems would be forthcoming as a result of shock effects on the internal environment of the buildings. Until March of

1968 limited research and development studies in the area of shock isolation led both BTL and the Corps to believe that shock isolation would not be a significant problem. However, by March new studies using sophisticated computer programs indicated that shock loading would be higher than previously thought and would require either "ruggedization" or shock isolation of certain sensitive tactical support equipment. Two possibilities emerged: either more durable equipment could be designed, developed, and procured, or readily available ordinary commercial components could be protected through careful shock isolation procedures. Early cost trade-off studies indicated a clear advantage for using protected comercial equipment, and this became a vital design requirement, especially for the radar buildings which housed delicate electronic components and systems. In late October of 1968 design AE's were instructed to include shock isolation in their designs, and in November 1969 a contract was awarded to Wyle Laboratories for shock isolation testing of sensitive mechanical and electrical equipment.[17]

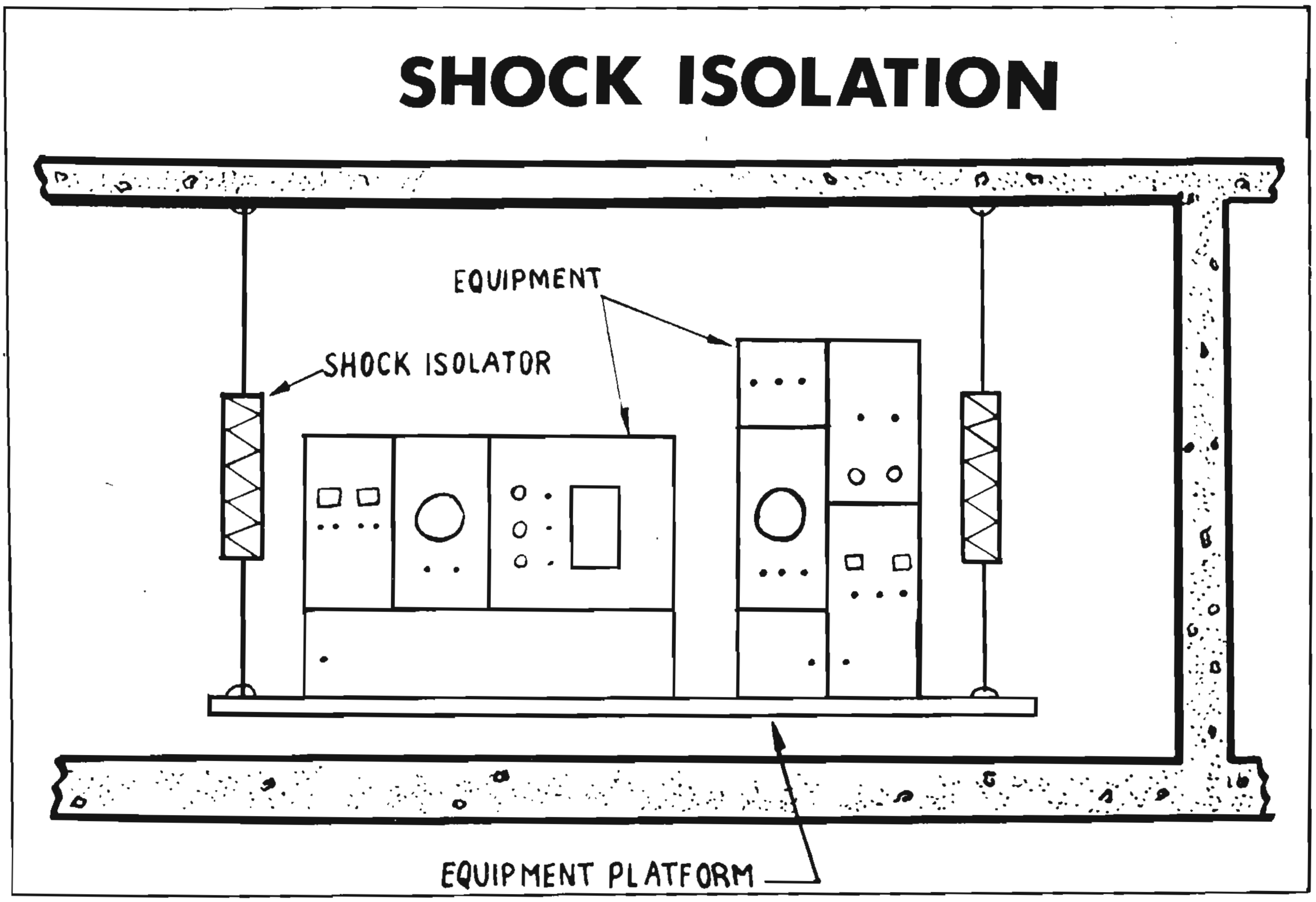


BASE MOUNTED HELICAL SPRING SHOCK ISOLATION SYSTEM



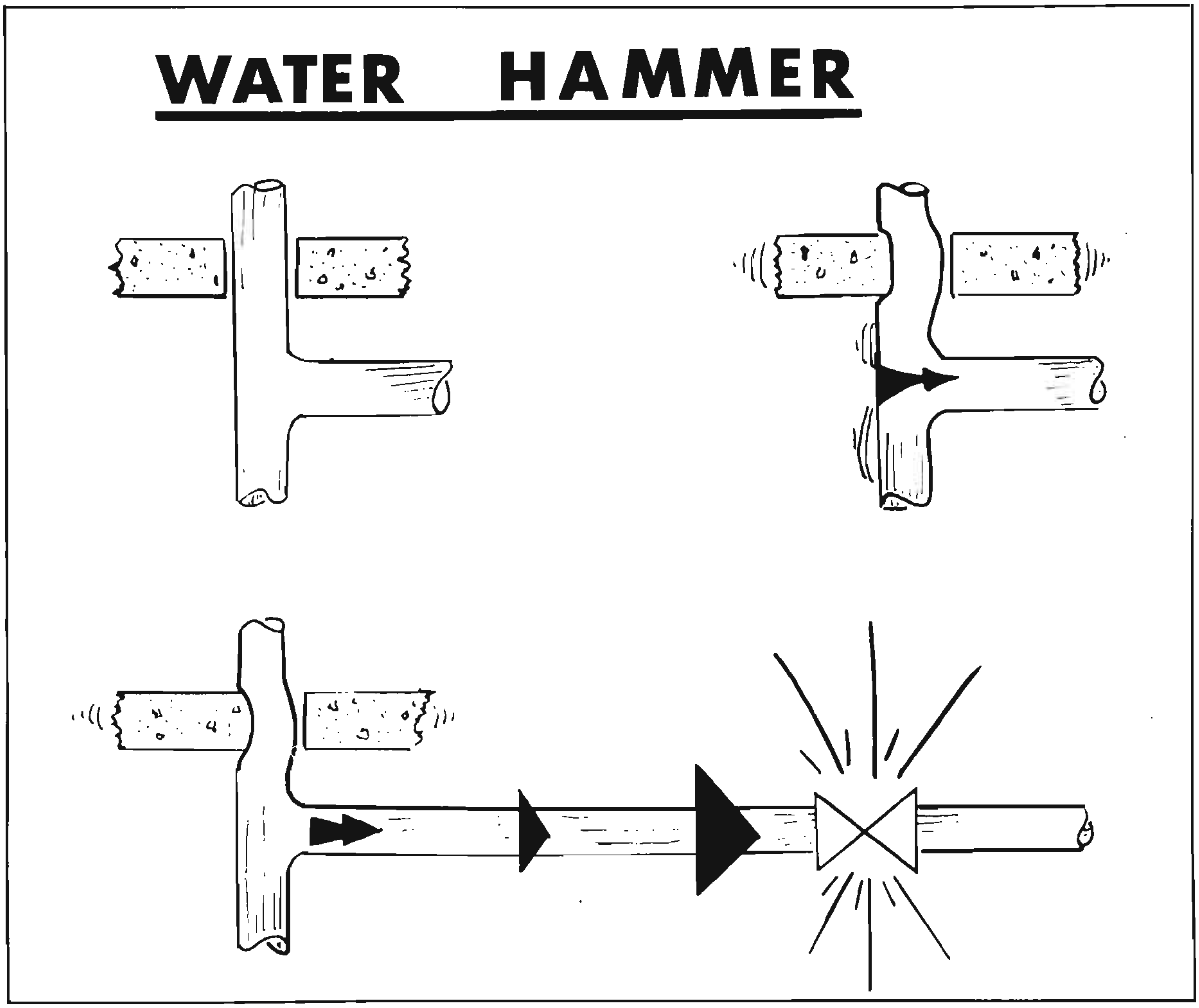
PENDULUM SHOCK ISOLATION SYSTEM

Wyle's testing considered the three dimension nature of the problem, the movement displacements involved, the flexibility of supported loads, accessibility, damping, and other considerations. Interestingly enough, the eventual solution produced was astoundingly simple in theory: both helical coil springs similar to those on automobiles and air spings were used in both pendulum and underfloor mounting positions. Air springs were used for spring loads greater than 2,000 pounds; coil springs were used below this load level. Eventually over 300 platforms were shock isolated, ranging in size from very small panel platforms two feet square requiring only two isolators to very large platforms of 3,000 square feet that required sixty isolators. More than 1,200 kinds of isolators were used with static load capacities ranging from 128 pounds to 40,000 pounds. The largest supported load was 260,000 pounds, or 130 tons.[18]



A second effect of the severe shock environment was the introduction of a pulse through fluids in piping. This created a transient condition of high hydaulic pressures in water, sewerage, and fuel lines--in layman's language, a kind of water hammer surge--that could burst line or jam valves, causing breakdown of equipment and the possibility of oil-fed fires. After recognition of what a shock-induced surge could do, in September of 1968 Illinois Institute of Technology's Research Institute was contracted to study the problem and recommend solutions. Ultimately it was demonstrated that surge attenuators placed in piping would alleviate the hydraulic effect and that flexible connections between rigid lines and shock-mounted equipment would absorb relative movements experienced during the blast period.[19]

Accompanying the immediate blast effects of heat, overpressure, and shock were certain other phenomena peculiar to nuclear explosions, including gamma and neutron radiation and a burst of electromagnetic radiation known as the Nuclear Electromagnetic Pulse, or NEMP. At the inception of SENTINEL, the effects of various kinds of atomic particle radiation were fairly well understood from prior nuclear testing, and it was known that thick concrete walls and similar shielding features could deal with them. NEMP, however, was quite another matter. In effect it can be best described as a broad band electromagnetic radiation causing disruption of unshielded electronic units similar to radio noise interference but of greater intensity. The NEMP effect could penetrate concrete walls, thus requiring

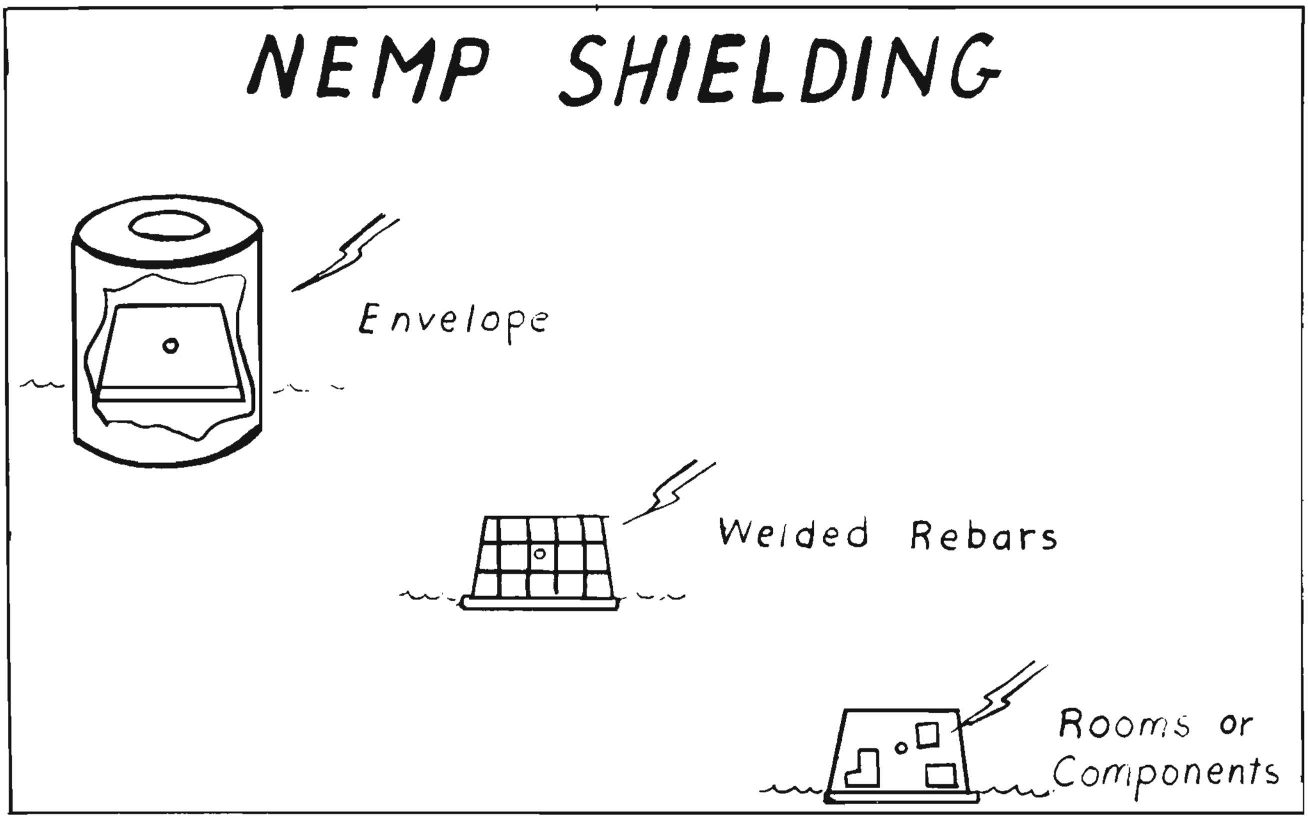


extensive metallic shielding against both the electric and magnetic components of the electromagnetic field. It required much study and effort to understand and cope with this phenomenon on the scale of SENTINEL buildings and their electronic contents because the NEMP could seek out the smallest gap, connection, fault, or break in an electrical ground so as to wreak havoc with components and circuits. Design decisions had to take into account the size and distance of explosions, the type of equipment being protected, the integration of shielding with the remainder of the structure, and the cost of potential solutions. Additionally, it was especially difficult to research the problem in the field because atmospheric nuclear testing had been suspended since the early 1960's, and underground testing did not yield wholly conclusive answers.

Study of the NEMP phenomenon at Huntsville began when the Division assumed a contract let in 1965 to General Electric Co., Pittsfield, Massachusetts, by OCE for "Development of NEMP Protection Evaluation." But no plain answers were yet in hand by 1967. NEMP requirements remained unsettled throughout the early sping of 1968, and on 21 March the SENTINEL NEMP Studies Committee decided that a wholly conservative approach calling for total external shielding of radar, power plants, and interconnecting tunnels had to be taken. It was estimated at the time that this would cost about $3 million per site, and this additional cost perhaps helped delay final approval of any shielding scheme for as long as possible. In May 1968 it was decided to use welded reinforcing bar loops in the walls of the less sensitive power plants, with further study to be given the thornier problem of the radar buildings. A final decision on NEMP remained in abeyance throughout the summer of 1968, though the matter was extensively discussed at the Vulnerability Task Force meeting of the Defense Sciences Board at Redstone Arsenal on 21-22 August. At the meeting BTL made a presentation concerning NEMP protection for its system, but General Starbird requested that a detailed discussion be deferred until a full position could be developed. The old bugbear of how much cost for how much protection was evidently still at work. The issue of NEMP protection for the radar buildings was finally resolved on 23 October, when General Starbird decided that the shielding at Boston and following sites must incorporate the totally shielded principle for radar facilities and limited critical area shielding for the less sensitive power plants. Huntsville Division was to choose the most effective and economical application of this principle.

The method to be used for the radars was determined as a result of feasibility and cost studies carried out by The Ralph M. Parsons Co. and Amman & Whitney, the AE firms designing the MSR and PAR Buildings. One month later, on 22 November, Parsons and Ammann & Whitney reports indicated that different approaches for the MSR and PAR Buildings would be most appropriate. In the case of the simple cubical PAR Building, Ammann & Whitney developed a structural design providing an uninterrupted internal envelope shield made of 11 gauge steel plate completely lining the ceiling, four walls, and first floor of the twelve-story high building. In effect, the PAR Building was totally canned on the inside. The toughest part of the design was maintaining continuity of the shield at the floor-wall intersections without impairing the structural integrity of the building. Every butt joint and each penetration the liner for reinforcing bars, piping, wiring, conduits, ducts, bolts, or punctures of any type had to be carefully welded and then magnaflux tested to insure the electical continuity of the joint. The magnitude of the problem was staggering when one considers the thousands of such joints, each of which had to be done to perfection.[21]

The same degree of perfection had to be maintained in the MSR Building which was much more complex geometrically. Considering its unusual triangular turret walls, oblique intersections, and huge antenna openings, the Parsons solution opted for a room-by-room approach. Only the areas containing sensitive electronics equipment were continously shielded in much the same way as the Ammann & Whitney design for the PAR. [22]



Inextricably associated with immediate nuclear effects were an immense variety of other exotic engineering challenges that resulted from the hardening requirement. Just a few of these can be mentioned here, but among other things Huntsville Division had to devise a means to pass the PAR's phased-array antenna elements through a concrete face wall ten feet thick (the "A" or antenna face wall), then pass the bundles of collected element group power feed cables through the "A" wall-floor intersection without weakening it while still maintaining integrity of the NEMP liner plate. Inside both the MSR and PAR Buildings, solutions had to be found for engineering a habitable environment for electronic parts and crew alike. This was a formidable undertaking indeed, embracing such diverse factors as fire protection within a sealed building, separation of male and female quarters, climate control, utilities, and psychological stress resulting from closed quarters.

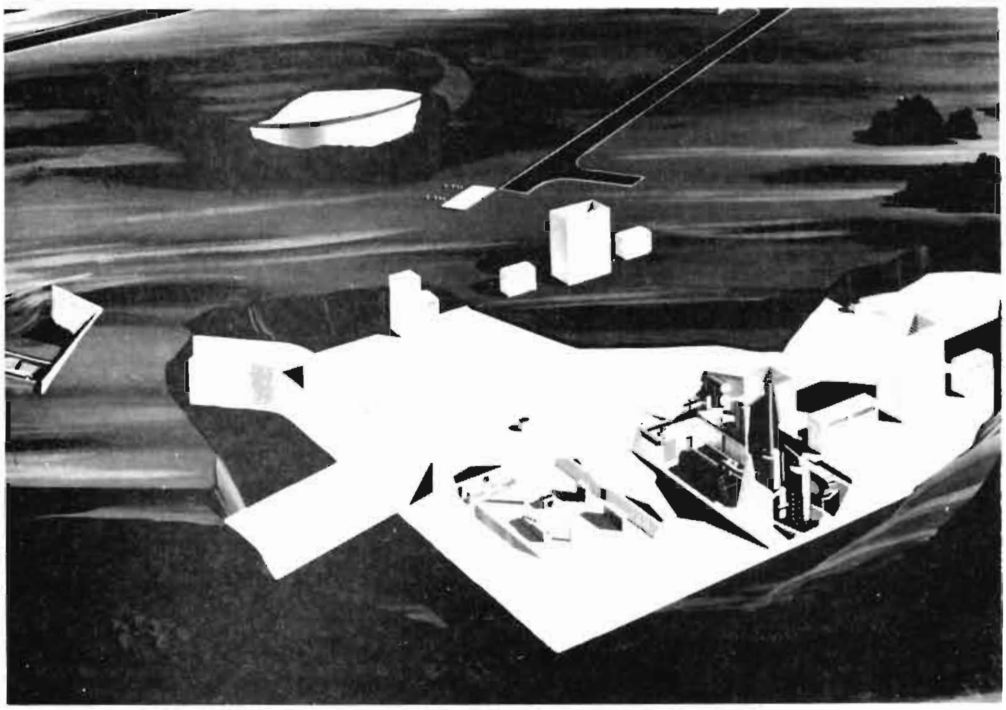
Lest the sophistication of these demands be underestimated, the reader should consider for a moment the superficially simple problem of fire control within a "buttoned-up" building. There were two possible solutions, and each had its limitations. Chemical firefighting was especially suitable for the kinds of electrical and oil fires expected, but the use of chemicals in the closed buildings might have generated dangerous toxic fumes worse than the fire hazard. A more palatable but less effective alternative was the utilization of water and a drain system--but where was one to drain off the water once it was sprayed on a fire? And what would be the consequences of water in electrical gear? Eventually it was decided that the latter scheme offered fewer risks than the former, and it was adopted.[23]

Not the least problem in facilities criteria was to provide a suitable power plant for the MSR and PAR Buildings which could generate enough electricity for a city of 40,000 and go on doing so for several days after a nuclear strike. This involved shifting from external commercial ties to internal emergency power automatically, then supplying facility generators with fuel, filtered air, and cooling water through sealed self-sufficient systems that would be fail-safe in the "buttoned-up" mode. Large fuel storage tanks had to be made rupture-proof, intake air cleansed of choking dust, and a recirculating water system devised to incorporate vast underground heat sinks for cooling. Early OCE studies during 1964-1967 had weighed the merits of both turbine and diesel engine generating equipment, but the excessive fuel consumption of turbines discounted their employment in favor of multiple diesel units. Blast resistance dictated that the whole plant be buried underground, except for the exhaust and intake stacks; other parameters mandated that the plant adjoin its radar and be accessible to it through a large hardened tunnel. These factors in turn provoked other considerations, such as a shear-proof joint between the tunnel and radar building that would also be NEMP-protected.

Finally, in addition to the signally stringent engineering criteria set out for wartime operation, there were numerous other lesser requirements for normal operation stemming from climate, local electromagnetic conditions, accessibility for maintenance, and other factors. The potential effects of freezing and snowfall on facilities had to be investigated; so too did the indigenous interference from local radio, television, and microwave transmissions. Even mundane problems sometimes grew to significant proportions: limited interior space handicapped movement and replacement of large components, while maintenance outside had to take into account the arc swept by powerful radar emission that could prove dangerous to human and animal intruders wandering in front of the antenna faces.

The development of criteria for some of the types of facilities needed for the SENTINEL program had actually gotten underway as part of the NIKE-X program during 1965 and 1966. As noted above, when Huntsville Division was activated in October 1967, a small group of engineers in the Advanced Technology Branch of the Military Construction Division at OCE in Washington, D.C., was already at work on hardened electric power plants for NIKE-X. At Mobile District, about thirty men in the NIKE-X Engineering Division was busy researching other aspects of design criteria for NIKE-X buildings, producing among other things the layout for the prototype MSR located on Meck Island in the Pacific. These pre-SENTINEL activities resulted in a broad foundation whose value was greatly increased by the expertise that transferred with OCE and Mobile personnel in 1967.

The prior accomplishments at OCE and Mobile District were particularly evident in the time that was saved in designing the MSR and MSR Power Plant. On 1 September 1966 the Mobile District had awarded a contract to the AE firm of The Ralph M. Parsons Co. of Los Angeles, California, for the development of design criteria for the MSR Building.[24] The criteria arrived at under this contract were being finalized just as the Huntsville Division came into existence in October 1967, and during the next few months the new division assumed management of this contract. In a like manner, Huntsville Division also inherited all of the very considerable knowledge that had been gained about hardened electric power plants through several dozen contracts dating to the beginning of the NIKE-X era. A large part of this fund of prior knowledge was directly applicable to the MSR Power Plant.[25]



BMD POWER PLANT CUTAWAY. Underground entrance on left, heat sink at upper left, cooling towers upper right, and intake and exhaust stackes in center of rendering.

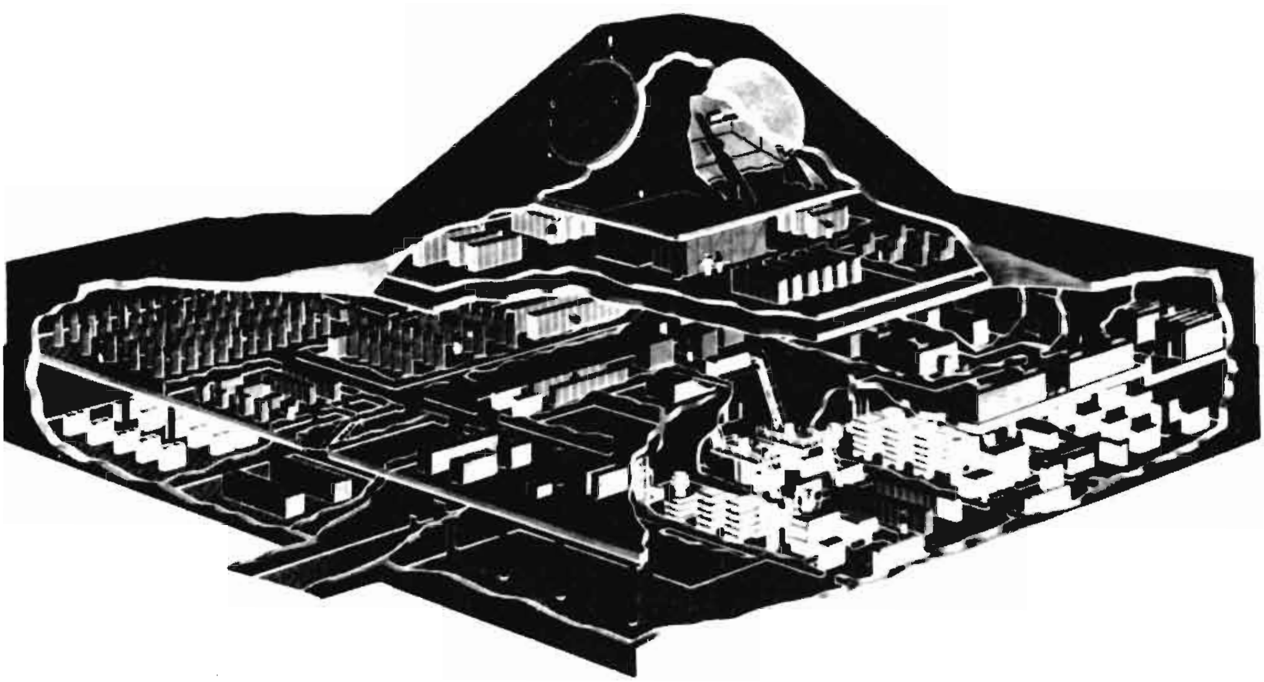
The advanced state of work on the MSR and its power plant permitted final design of these to be started early in 1968, even before the Huntsville Division was staffed to handle the necessary contracts. On 29 January 1968, the Mobile District awarded contract DACA87-68-C-0001 for $4,904,174 to The Ralph M. Parsons Co. for final design of the MSR Building based on criteria previously drafted by them.[26] This contract was one of four necessary to complete the design of major SENTINEL facilities, and although technically awarded by Mobile District, it was a land mark in the history of Huntsville Division, since Huntsville promptly took over its management. The contract for the MSR was quickly followed by a similar one for design of the MSR Power Plant. On 12 February 1968, Bechtel Corporation of Vernon, California, was engaged to submit a final design proposal for electric power installations associated with the MSR. The cost-plus-fixed-fee contract amounted to $1,627,469.[27]

The Parsons MSR Building design bore a close resemblance to the prototype then being finished on Meck Island and was almost identical with the Missile Site Control Building (MSCB) later deployed in SAFEGUARD. The MSR Building comprised a massive reinforced concrete structure having 127,000 square feet of usable floor space distributed among four levels. In form, the building could easily be pictured in the mind's eye as a combination of two simple geometric solids. Visible above ground was a four sided truncated pyramid, each of whose four faces was set with a round radar "eye" flush with its surface (some MSR's were to have fewer antennas). The seventy-nine foot pyramid turret rested on a larger two level square structure 231 feet on each side completely buried underground. Because the turret's sloped walls offered less vulnerability and the subterranean construction more protection, the MSR Building could be more lightly constructed than the above ground PAR: the exterior walls were three feet thick and the interior walls one and one-half feet thick.

The most interesting engineering features and problems of the building lay in the turret design and construction. Each of the four turret faces held a thirty foot diameter MSR antenna mounted integrally with the turret wall; that is to say, there was no concrete directly behind the area of the antenna face. This meant that the antenna had to be strongly made and well secured to the surrounding concrete to offer sufficient hardening. In fact, each MSR antenna weighed over 400,000 pounds, or 200 tons, a weight which had to be emplaced and held in a round opening in the turret face. The eventual engineering solution was to support the antenna in an antenna adapter ring consisting of a thirty foot inner diameter steel ring divided into thirty-six shear keys equally spaced around its perimeter. The steel ring contributed nothing to the strength or stiffness of the opening, for each shear key acted independently to deliver its load directly to the adjoining concrete. In the rear, the antenna and antenna adapter ring were supported on massive towers and a radial framework resting on the fourth floor slab. Together the ring and support system made up a tremendous weight and necessitated a major engineering effort to ensure that the permanent structure was not over-stressed.

The equipment that made the MSR Building a tactical nerve center in the overall BMD scheme was housed in the two lower levels beneath the turret. Here were located the radar transmitting and receiving components, phase shifters, switching gear, and many of the systems necessary to keep the building operating and habitable under all conditions. Here too was located the data processing equipment that in milliseconds received crude signals from the radar antenna (and in some cases, a distant PAR), digested it into machine language, discriminated among incoming objects, computed intercept trajectories, and finally guided the intercept with SPARTAN's and SPRINT's. The sensitive electronics of this area were protected against NEMP room-by-room on an as-needed basis by the continuous 11 gauge liner plate shielding described previously.

The power plant for the MSR was housed nearby in a partly buried hardened concrete structure mounded over with earth at the surface for blast protection. Inside the plant, six sixteen-cylinder diesel engine generators with a capacity of 17.3 megawatts could supply precisely regulated power for use under alert-attack and post-attack modes, but peacetime power requirements were to be met from commercial sources with some of the generators idling in one of three lesser stand-by modes. Provision for emergency operation was complete with interconnected hardened fuel oil supply sufficient for several days and a sealed recirculating water cooling system featuring a vast underground storage cavern as a heat sink. The power plant was connected with the MSR through a concrete two story tunnel fifty feet long. Utility lines, control cables, hoses, and the like were routed through the upper story, while through the lower level ran an ingress and egress passage for personnel and equipment. Tunnel and MSR were joined by a flexible junction that maintained NEMP protection throughout.[28]



CUTAWAY OF A MISSILE SITE CONTROL BUILDING (MSCB)

Through no fault of the Corps of Engineers, the initiation of final design for the PAR Building and PAR Power Plant proved to be far more lengthy and trouble-ridden than for the MSR facilities. Because no exact prototype of either the radar equipment or the building existed when SENTINEL began, BTL, the radar prime contractor, found many adjustments necessary in the configuration of its product as it was prepared during 1968. For example, in January 1968 BTL was undecided about radar power levels, about air or water cooling for phase shifters, about whether it would use a horizontal or vertical transmitter layout. Just as in the MSR, there was a close tie between weapon system and building, with changes in the former often directly influencing changes in the latter. To absorb some slippage on the part of the weapon system contractor, Huntsville Division often agreed to squeeze its tight schedule still further. A typical instance of this is dryly recorded in the "Historical Summary" entry for 15 March:

> SENSCOM stated a need to reduce scheduled construction period for the Boston PAR by as much as 6 months to provide the WSC [Weapon System Contractor] additional time to install, test, and evaluate the first generation PAR system. This site is essentially an R & D installation. A CPM [scheduling] evaluation of the latest PAR concept indicated 25 1/2 months for a normal construction schedule. SENSCOM was advised that, by doing excavation and foundations during the summer and fall of 1968, and by the use of multiple shifts, the new BOD [Beneficial Occupancy Date] could be met at a 35 percent or $10.4 million increase in cost.[29]

Scheduling and rising costs got thorough scrutiny during the first weeks of April, but it was still found that a normal schedule, already very tight, had to be accelerated by at least five months. To these pressures and ambiguities were added other, still classified, modifications apparently originating at Department of the Army level that were concerned with designing a single face PAR that could be expanded into two faces, or possibly with one and two face buildings that used common features. The net result of these factors taken together was that launching the final design for the PAR facilities lagged by at least six months behind the MSR facilities.[30]

The development of the PAR building by Huntsville can be said to have actively begun with the award of an engineering contract to the AE firm of Ammann & Whitney by Mobile District on 7 December 1967. Working closely with BTL, Ammann & Whitney proceeded to prepare several short-term analyses for buildings with radars of various power levels. On 9 February 1968, BTL decided that it would utilize a single combination transmitter-receiver antenna array in the PAR, and shortly thereafter it opted for the horizontal layout of transmitter elements. By 15 May, Ammann & Whitney had produced a report offering three major building choice varying in the amount of floor space and location of the power plant under the building or to one side. At this time, floor space was estimated at 210,000 square feet, but it was hoped that this could be significantly reduced to save money.

Some decisions on these configuration matters and others at the end of May and early June paved the way for award of a final design contract. After briefings and reviews by SENSCOM Commanding General Drewry and SENSM General Starbird, and AE contract in the amount of $3,216,209 was awarded to Ammann & Whitney on 14 June for final design of the PAR Buildings to be located at Boston, Massachusetts, and at Detroit, Michigan.[31] Design of the power plant for the PAR encountered fewer vicissitudes than the main building, and a $939,594.93 design contract was awarded on 28 June to Black & Veatch Co. of Kansas City, Missouri.[32]

Even after award of final design contracts, however, the configuration of the PAR Building and its power plant was continuously re-evaluated in the light of new information. On 21 June, General Starbird approved design of the PAR Building based on a 167,000 square foot building, but he also directed that study of alternatives be continued with the hope of cost savings. About this time, it was found that the building would probably have some excess space, at least until another radar face was added, and changes were inaugurated to move some of the soft administrative and support structures such as the headquarters building and classified classrooms into the PAR Building. On 13 September, another major reconfiguration made by the System Manager was estimated to delay design completion by about two to three months and cause changes in foundation design for the first phase construction contract that was already being advertised for Boston.

On 24 September 1968, Phase 1 construction excavation for the first PAR began at Boston, but on 11 October another configuration revision required a change in the construction contract to increase the size of the foundation excavation. In this instance, the power plant was moved twenty-feet closer to the PAR and lowered ten feet. This was more economical construction-wise but called for more rock excavation. On the same day, 11 October, design of the PAR was finally frozen--but when on 7 November BTL again offered some savings in floor space, Ammann & Whitney agreed to accept the change without slipping the 1 April 1969 completion deadline for final design.

The 1968 Ammann & Whitney design for the two face Boston PAR was distinctly odd, featuring an irregular polygonal wing jutting out one side of an otherwise cubical building. Of the design, the Division's historian later wrote:

> Unfortunately, the required geometry of the building did not lend itself to presenting a nicely proportioned structure of rectangular shapes. However, until models of the building were constructed, no one had visualized it's unusual appearance and some people tended to object. A number of different ways have been reviewed to improve the geometry of the building without incurring major design, unacceptable delay, or increased costs. This effort was not successful. The PARB is not necessarily an ugly building, and, in this era of modern art and architecture, it will not be an isolated example of unusual building form.[33]

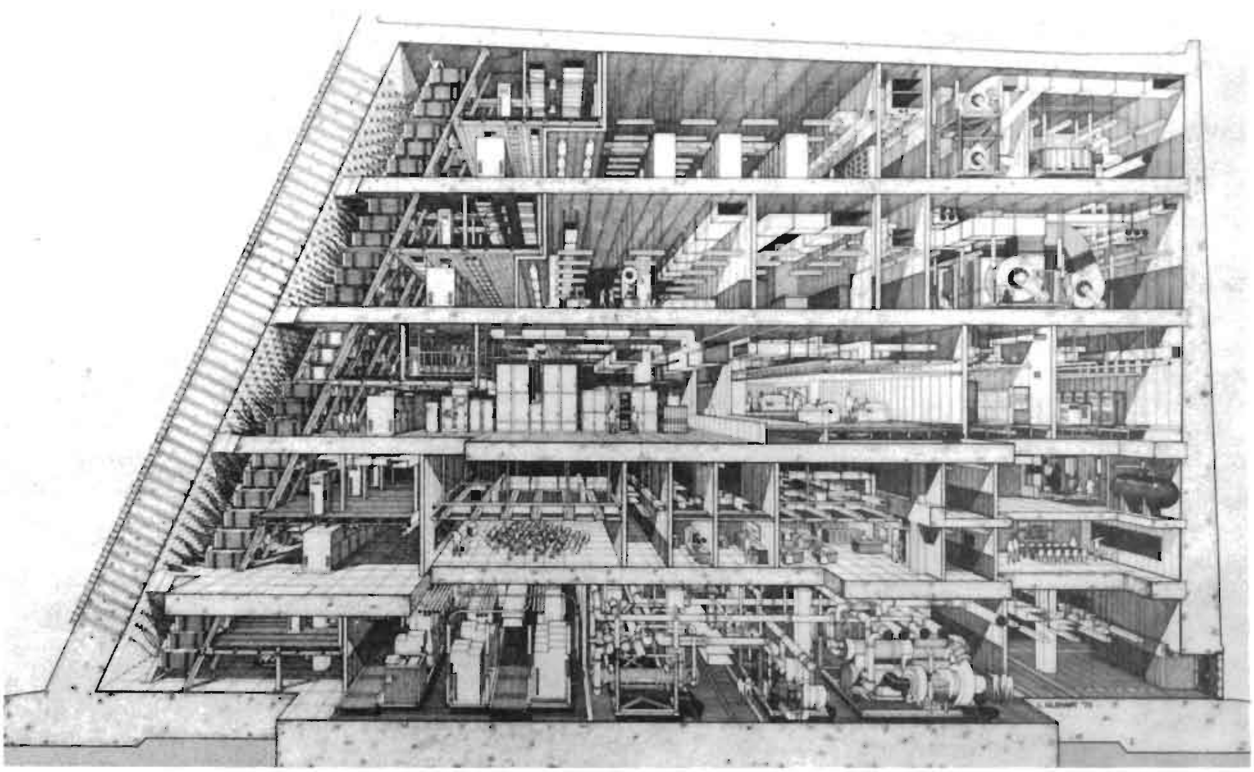
Perhaps happily for the history of architecture, the Boston PAR building never got beyond foundation excavation because of the play of external events that will be described later. Instead, with the suspension, then cancellation, of SENTINEL in early 1969 and the substitution of the SAFEGUARD program thereafter, all attention turned to a single face PAR design to be deployed near MINUTEMAN ICBM bases in the Midwest. This, the definitive PAR design, was a simple, nearly cubical shape of 204 by 213 feet at the base rising over 120 feet, or roughly twelve stores, above ground level. Unlike the MSR, there were no subterranean levels. The antenna face wall sloped inward at 25^{0} from vertical, while the side and rear walls had slight inward runs attributable to reduction in their thickness towards the top. The shape was dictated by antenna dimensions and placement plus internal volume needed to house the essential apparatus.

The SAFEGUARD PAR ultimately built after the SENTINEL design may be the most solidly constructed building in the world, the Egyptian pyramids not withstanding. The antenna face wall (the

"A" wall) measured a uniform seven foot thickness (the original SENTINEL design was ten feet); the side and rear walls tapered from eight feet at the base to three and one-half at the roof. The building shell rested on a base slab eight feet thick. The basic concrete was of 5,000 p.s.i. strength and incorporated a dense mesh of no. 11 gauge reinforcing bars in vertical, horizontal, and diagonal directions. These bars were about as thick as a man's wrist and accompanying photographs testify to their close spacing. About 63,000 cubic yards of concrete and 8,700 tons of reinforcing steel were required.

The interior of the PAR included five full floors with a mezzanine between the second and third levels. Approximately twenty-two feet of clear space separated the floors, this being bridged by an elevator and multiple stairs. The area immediately behind the antenna wall was devoted to the radar phase shifter components and power feed cables, for which the mounting, access, and service aspects involved many special design considerations. Service platforms for the phase shifter, for example, were suspended from the ceiling of the floor above. Passage of the power cables through the floor also necessitated the incorporation of I-beams bolted to the antenna wall interior face to maintain its structural integrity under load. Access to the interior of the building could be gained through two blast locks closed by concrete filled heavy steel sliding doors or through a single story tunnel leading to the adjoining power plant.

Design of mechanical and electrical systems serving the interior of the building presented several unusual challenges because of the need to remove heat generated by the large quantity of electronic equipment contained in the building. Another challenge was to provide a self-adapting power distribution network from the power plant to the electronic equipment which would operate without a flicker under nuclear attack, continuing to supply both precise and conventional power while shifting from commercial to emergency internal power. This could be done in a five stage transition from normal surveillance operations through two degrees of alert to attack and post-attack modes. As with the MSR, the PAR was outfitted with a complete partially buried, partially mounded, electric power plant annexed to the building and connected via a short tunnel. The layout of this power plant and its features were quite similar to the MSR's, save that its five diesel engine generating units produced a maximum of 14.7 megawatts.[34]



CUTAWAY OF A PERIMETER ACQUISITION RADAR BUILDING (PARB)

The MSR, MSR Power Plant, PAR, and PAR Power Plant represented the four major installations required for the SENTINEL System, and their size, sophistication, and significance naturally justified the lion's share of effort devoted to them as the program got underway. By contrast, the design of support facilities at the radar sites, the Remote Launch Sites (RLS's), and the Central Training Facility presented simpler, less expensive, and less pressing needs. Nevertheless, in its own way, each of these was essential to the overall system, and they began to receive some preliminary attention by the Corps and SENSCOM during 1968.

At SENTINEL's inception, it was deemed desirable to make each MSR and PAR site an independent, self-contained entity. Hence, the impressive radar buildings would have to be complemented and supported at each site by a host of humbler auxiliary structures catering to the operation of the base. Housing had to be provided for a garrison of three crew shifts, plus command and administrative staff, and these men also required a separate mess, assembly and classroom facilities, recreational areas, a commissary, and a chapel. Various elements within the complex demanded their own depots and work areas for maintenance. As a secret installation, careful security measures such as sentry stations and fencing were required.

Design for these elements began on 20 March 1968 when a SENSO conference produced agreement on a basis for design of tactical support facilities. Rising costs, however, dictated the deletion or consolidation of some features, such as a chapel and helicopter pad for the Boston PAR. A realistic list of facilities did not appear until July, when the Department of Defense revealed that some "typical building groupings" would include: the headquarters and dispensary building; the barracks and enlisted mess; and "industrial complex area" (technical warehouse, general warehouse, post engineer, and vehicle maintenance); the assembly, classroom, and library facility; the officers' open mess; and sentry stations.[35] Huntsville's principal concern was cost-effectiveness over the site standardization then expected, and this resolved into a choice of prefabrication or conventional masonry construction. On 23 August, a Division study concluded that conventional masonry would be the less costly approach, and design proceeded on this basis throughout 1968.

At the beginning of the SENTINEL program, both SPARTAN and SPRINT missiles were just starting their flight testing, and very little attention had been paid to an operational model of their launch cells. The second successful SPARTAN launch did not take place until the summer of 1968, and the SPRINT program was in about the same status. Thus criteria and design for the requisite launch stations got only limited resources at Huntsville during the SENTINEL period. The design of the cells and the SPRINT RLS's is more properly part of the SAFEGUARD story and will be recounted as part of it.

Much the same relaxed scheduling held true with the SENTINEL training facilities which would not be needed until the program was far downstream. At the inception of the program, it was forecast that a mini-university would grow up at the CONARC Air Defense School at Fort Bliss, Texas, to train the thousands of highly specialized technicians needed to man SENTINEL installations. Preliminary studies for the training facility started in 1968, but Huntsville Division was only peripherally involved with it before the suspension of SENTINEL in February 1969.

The letting of Huntsville Division's first major design contracts for the PAR Building and the PAR Power Plant in June brought increased attention to procurement and contract management procedures for what was looming as one of the Government's biggest and most complex defense shopping ventures ever. Following the Armed Services Procurement Regulation (ASPR) and the Corps' own ER 1180-1-1 Engineer Contract Instructions (an implementation regulation), the engineering divisions and the Procurement and Supply Division began to study the special demands of hardware and fittings for SENTINEL buildings during the spring months of 1968. As in the engineering of the facilities themselves, certain features of procurement for the BMD program emerged that warrant special attention because of their significance to SENTINEL and most especially because of their profound influence on the later history of the Division.

The largest part of Huntsville's procurement for SENTINEL revolved about the concept of Government Furnished Property (GFP). This concept was simply the idea that to achieve a high degree of standardization throughout all seventeen BMD sites, the Government should specify, buy, and have delivered to construction contractors at each location some of the equipment items they needed for completion of a facility. In early planning for a NIKE-X deployment, the Army had determined that for many reasons the degree of standardization within any future antiballistic missile system built had to be considerably greater than for any previous missile weapon system facility construction program. Hence, during the design phase of the SENTINEL (and later

SAFEGUARD) facilities, a primary objective was the standardization of components and construction details within and between the facilities. The ultimate objective was a commonality of equipment and working environment so great that a crewman or technician could be blindfolded, whisked unknowingly from one site to another, and begin work immediately in familiar surroundings. A large measure of this uniformity was achieved. Out of a total of 10,098 separate line items involved in construction of one site (exclusive of the weapon system components), the standardization effort resulted in only 1,703 different makes and models being required. This wide standardization effort was far beyond the norm for the Corps of Engineers, and as a result a significant portion of SENTINEL (and SAFEGUARD) tactical support equipment and system components were purchased by the Government under competitive bidding and furnished to each construction contractor for his installation.

Standardization for a national program as vast, complicated, and expensive as SENTINEL had many advantages over the alternative approach of allowing individual construction contractors the run of the market in fulfilling their contracts on site-by-site basis. A standardization scheme of centrally directed procurement would vastly simplify the inventoy of repair parts, components, and consumables needed at national, regional, and local depots. This in turn would reduce the initial capital outlay for facilities and repair parts and cut the yearly costs of operations and maintenance. With standardization would also come important simplification and cost reduction in training operators and maintenance personnel, in documentation, and in provisioning of test equipment and special tools. Bettering of the maintenance, training, and replacement parts situation would enhance the operational effectiveness of the entire system by reducing "down time," or periods when equipment was out of action due to servicing and increase the flexibility of personnel likely to be moved from site to site. Standardization had great advantages from the view of time, too. Certain items needed for SENTINEL--diesel engine generators and switchgear, for example--required a long lead time for production. Given the short time allowed for installation in the construction schedule, the only solution for meeting deadlines was to standardize many items accross the board.

Having weighed the merits of a Government Furnished Property program and found them worthy, planning began in the spring of 1968 to implement such a scheme. The first step was a series of consultations between engineering personnel and the AE firms to draw up a Master Equipment List from which items might be selected for standardization. Engineering staff then prepared the necessary criteria, specifications, and design for each item standardized. The list of standard items was then forwarded to Procurement and Supply Division for advertisement and award of GFP contracts. In the identification and grouping of items for procurement, items with like characteristics were combined into single identities where practical to do so without compromising a functional requirement while creating anticipated savings. Categories for items were established as standard items, interchangeable items, and limited standard items. These categories provided the basic framework for the GFP procurement effort. Because of the great volume of equipment involved, a data bank was developed to provide an automated basis for tracking GFP equipment items. The status of the Master Equipment List and of each item on it was tracked by means of codes and a data bank entry containing lead times, item characteristics, and specification references. This data bank became the focal point for coordination of construction with GFP equipment delivery schedules and for the in-house administration and tracking of GFP. Schedules were prepared on the basis of anticipated construction progress, and thirty or sixty day "windows" were allowed for delivery on-site.[36]

For the administration of the GFP program, a separate position of assistant division engineer for logistics was established to assist the division engineer in managing all GFP activities. The engineering divisions were charged with implementing and operating the standardization program and with developing criteria, procurement specifications, and design. The Construction Division coordinated and integrated the GFP into the construction network and insured that the special provisions of the construction contracts accurately reflected the items and deliveries identified in the equipment contracts. GFP contracts were solicited, awarded, and administered by the Procurement and Supply Division in conjunction with the Automatic Data Processing Branch.[37]

The first items subjected to GFP procedures were the diesel engine generating units needed to drive the MSR and PAR Power Plants. Development of power plant requirements had begun early in the spring of 1968 and continued until early June. By 12 June, the Division was able to show that if all the power units in the thirteen SENTINEL sites then announced were identical, the cost savings over the life cycle of the units would be $3,665,000. The Division's plans to standardize the procurement were approved. Anticipating this decision and the complex nature of a diesel engine generator procurement, an Advance Notice to Bidders was issued noting the major specifications that suppliers would have to meet. Then on 21 June a pre-bid conference was held at Huntsville to discuss the anticipated procurement with bidders. Out of this came a need to delay bid issuance by a week to allow more time to consider the Corps' specifications. These specifications included stiff reliability parameters and an evaluation by Huntsville of the operating costs over a ten year life cycle. Invitations for Bids for three types of medium and low speed diesel engine generators totaling sixty-nine units was duly issued on 16 July and bids opened in Huntsville on 30 July. Seven large industrial concerns offered bids for the generator contract. Unhappily, however, no award could be made immediately because there were protests by the three lowest bidders. The protests were referred to the Comptroller General, who ruled in decision B-165292 on 6 November 1968, that the bid of the principal protestor contained substantial omissions, errors, and lack of other proprieties. The next day, 7 November, power units contract DACA87-69-C-0008 for $26,158,291 was awarded to the Cooper-Bessemer Company of Mount Vernon, Ohio.

Of this 1968 Cooper-Bessemer contract, the Division historian later wrote:

> The award of the generator contract to Cooper-Bessemer on this date was an important milestone for SENTINEL construction. An adverse decision would have caused slippage in the design and construction schedule for Boston and would have imposed a heavy burden on HND to execute a new procurement while at the same time revising other plans to minimize the impact of delay.[38]

The historian was quite correct in assessing the impact of complications. Unknowingly, he was perhaps even more correct in prognosticating that this successful buy would have significant consequences for the future:

> This was a complex procurement action for both HND and OCE. But despite the administrative problems resulting from the protests, it proved to be a sound procurement action which included two fairly new procurement concepts. One of these was the use of life cycle costs as basis for bid evaluation; the other was the inclusion as one evaluation factor the savings that can be achieved through standardization. The experience gained in these areas should be useful throughout the Corps and perhaps to AMC.[39]

Utility to the Corps or AMC aside, what the historian could not then have known was that the Cooper-Bessemer contract paved the way for a series of other massive purchasing efforts that proved immensely beneficial long after SENTINEL passed into history. Most notably, the Postal Bulk Mail Centers procurement mission of 1973-1975 was assigned to, and successfully negotiated by, Huntsville Division largely on the basis of its earlier experience with the SENTINEL (and later SAFEGUARD) GFP program.

While the power units contract was being adjudicated during the early fall, the Division staff launched several other procedures connected with contractual buying or financial savings in contracting. In August, the policy of prequalifying bidders on cirtical construction contracts was instituted. This procedure was covered in ASPR 18-209 and ECI 2-270, and it was recognized as valid by U.S. Comptroller General decision B-135504 made on 2 May 1958. Within the Division, a Prequalification Board was appointed to review the qualifications of all interested bidders, maintain a registry, and administer the local procedures.[40] On the one hand, prequalification would ensure that prospective bidders were fully apprised of bid conditions and specifications, while on the other it gave the Division an opportunity to examine the bidder's construction capacity and capability, financial condition, management, and potential performance without seriously infringing free competition in the marketplace. Contracts of lesser criticality or complexity continued to be advertised across the construction industry, as did those originating with cooperating districts. About the same time, the Division was also granted authority by the Armed Services Procurement Regulation (ASPR) Committee to implement default clauses in constuction and supply contracts, in effect preventing the prime contractor from divorcing himself from liability for delays caused by subcontractors at lower tiers.[41]

Based on past experience with critical projects, it was apparent that for SENTINEL the services of an area counsel and area labor relations officer at the jobsite would be necessary as full time assignments. Although controls and procedures were devised for coordination with the Hunstville office, the policy for SENTINEL (and later SAFEGUARD) was to streamline by delegating field authority to the utmost. Because Huntsville Division was an operating division and lacked at its inception the contractual authorities normally delegated to district engineers as contracting officers, extra ordinary authorities for the Division's contracting officers and their field representatives (area engineers) were obtained from OCE. Under the SENTINEL program, these special authorities gave Huntsville contracting officers the same authority as district engineers, plus increased authority from none to as much as $500,000 for approval of change orders under "Differing Site Conditions." The authority of the area engineer in change orders was also substantially increased. For the first construction contract award (Boston, Massachusetts), the actual authority delegated from the contracting officer to the area engineer was a maximum of $50,000. Some of these limits were later reduced in the course of the SAFEGUARD program.[42]

Supervision and coordination over contractual legal matters were retained at the Huntsville Division office because of the need for uniformity in decisions made for various SENTINEL job sites and because the extraordinary authorities granted by OCE were contingent upon assurance of such uniformity. Award of basic contracts was at Division headquarters; the same was planned for the conduct of trial of appeals under the disputes clause, should any develop. To enable the Huntsville Division and its area offices to concentrate on construction, arrangements were made with supporting districts for services in processing of claims in the real estate and noncontractual categories.[43]

In addition to contractual and legal procedures, during the fall and summer of 1968 consideration began to be given to initiation of value engineering concepts. During the week of 4-8 November, twenty-five Division employees attended a forty-hour OCE-sponsored course on value engineering concepts, but implementation was limited under the brief period of the SENTINEL program. Value engineering really came into its own under the SAFEGUARD and later programs, where it resulted in extensive savings.

The second and more mundane of Huntsville's major SENTINEL responsibilities was to assist SENSCOM in selecting suitable sites on which to locate installations. On 3 November 1967, the Department of Defense publicly revealed the first ten SENTINEL site locations as Boston, Massachusets; Chicago, Illinois; Detroit, Michigan; New York, New York; Dallas, Texas; Seattle, Washington; Albany, Georgia; Grand Forks AFB, North Dakota; Oahu, Hawaii; and Salt Lake City, Utah. Six months later, on 27 May 1968, three further sites at San Francisco and Los Angeles, California, and Sedalia, Missouri, were added to the list, while sites for Warren AFB, Wyoming, and Malmstrom AFB, Montana, were announced later in the year. Washington, D.C., and Fairbanks, Alaska, were not revealed before SENTINEL was suspended in February 1969.

Immediately after activation, members of Huntsville Division teamed with representatives of ARADCOM and local Corps districts to begin exploratory probes of potential sites in four of the first ten locations, and these explorations multiplied and accelerated throughout 1968. Prime attention centered on finding suitable land in the Boston area, since the Department of Defense had scheduled the first construction to take place there, but most of the first ten sites received some attention's before year's end. The early work progressed smoothly, but during the fall a great deal of confusion arose as the Corps and ARADCOM backed and filled in trying to find qualified sites that did not arouse the ire of local residents and their Congressmen. A very vocal anti-BMD movement emerged after November, and some citizens and municipalities denied rights-of-way access or manifested other acts of antagonism towards the military. When SENTINEL was finally suspended in February 1969, only the Boston PAR and MSR sites had been nailed down with finality.

The 300 or so acres sought for each facility at Boston and other places had to meet rigorous criteria laid down by the Corps in a sixty page "Anti-Ballistic Missile Engineering Criteria Manual for Tactical Site Selection" published by the Huntsville Division in November 1967.[44] This manual outlined a

POTENTIAL SITES FOR SENTINEL DEPLOYMENT IN THE BOSTON AREA.

comprehensive three phase game plan for conducting the selection and validation of sites prior to construction, together with sample reports to be filed and laboratory procedures to be conducted in each area. Phase I was intended to produce general data to enable the System Manager to chose a primary site from among several candidates for each location in the national deployment plan. At Boston, eight potential sites stretched in a rough crescent from Burlington, Camp Curtis Guild, and Peabody northwest of the city northeastward to Swan Pond, Sharpner's Pond, and Hood Pond across the Ipswich and Gloucester on Cape Cod. Here, as elsewhere, the Corps of Engineers was expected to recommend a best site after a visual reconnaissance and study of local land descriptions, climatological factors, utility services, geological data, local construction materials and labor, and transportation and communication lines. These studies even reported typical hourly wage rates, the color and grade of local sand and gravel, airline service, and public radio stations in the area. Most-favored status went to land already in Government hands if conditions were found suitable there.

Phase II was a progressive development from Phase I as concentration on one site evolved. During this period of about three months, exact topographical maps were prepared in two scales and investigations made to determine foundation conditions. Corings, drillings, soundings, and soil samples were subjected to meticulous laboratory analysis to determine porosity, density, geological faults, water tables, and other subsurface conditions. With the completion of Phase II and the approval of the System Manager, acquisition procedures then began. Phase II for Boston was completed in July of 1968, but great difficulty was encountered at Detroit because of ground water. This site had to be changed several times, as did the Chicago sites.

Under Phase III, acquisition of real estate began with the establishment of fee line boundaries and such additional investigations as might prove necessary because of criteria or design changes in the facilities. Actual purchases of land had to conform with Title X of U.S. Code 2662, which specified that Congressional approval was needed to acquire land for defense purposes. In Title X actions, the Corps of Engineers submitted its request to the Secretary of the Army who presented it to the Real Estate Subcommittees of the Armed Services Committees of the Senate and House. The Congressional submission had to include the amount and precise location of the real estate, the last known owners, and its current estimated value, along with justification for the purchase. Thirty days then had to elapse, during which time Congress might hold public hearings or request additional time to consider the Army's needs. If at the end of thirty days Congress had not said otherwise, the Secretary of the Army could take steps to buy the land.

The conduct of real estate transactions was carried out by the local Corps district concerned, with representatives of the district acting as agents for the Secretary of the Army. The Corps was expected to appraise the land through a private appraiser and make an offer to buy at fair market value. Eminent domain was held in last resort, for use only after no reasonable accord could be reached between the Army and landowners.

Finally, before construction could begin community impact studies had to assess the effects of construction and SENTINEL operations on area schools, housing, economics, utilities, local radio, and particularly water supplies. Drawing on past experience with the ICBM construction program, the Corps took two other preliminary steps worthy of note. To avoid the kind of labor troubles that had obstructed the building of ICBM silos, a meeting was held at Boston on 19 November at which the Corps of Engineers and the Department of Labor briefed sixty-four national, regional, and local labor leaders on the forth-coming construction work and the handling of any disputes that might arise.

The same precautions were taken to preclude the possibility of complaints about damages caused to Massachusetts roads that had almost closed down some earlier ICBM work in the Midwest. Alerted by the ICBM experience, Huntsville Division devised an important improvement for the BMD program regarding the use of public roads. In the usual situation a construction contractor had to get to the work site over public roads at his own risk and expense. Any road damage thus created was entirely a matter between himself and the local road authorities. Naturally, accelerated heavy traffic on a large, high priority construction project would invariably lead to premature deterioration of public roads and complaints from taxpayers and local agencies. This could result in an impasse, a slowdown, or even stopping of the work by protective action on the part of local road authorities. The construction of missile sites was of such urgency that in 1961 Congress provided a remedy for reimbursement for excessive damage caused by contractor-generated traffic at missile sites. This legislation was known as the "Fulbright Amendment" and was codified as 23 U.S.C. 210(h). To implement this statute for the BMD program, it was necessary to establish a procedure between the Secretary of Transportation, Bureau of Public Roads, Military Traffic Management and Terminal Service (MTMTS), and the Corps of Engineers. A special road damage clause was devised and utilized in construction contracts which differentiated between contractor responsibility for normal wear and tear and Government responsibility for excessive damage. The result was highly successful in assuaging the concerns of local public officials about damage to their roads and thus alleviating any need for restrictive actions on their part.[45]

The kinds of activities just outlined obviously depended on close cooperation between Huntsville Division and Corps districts touched by SENTINEL. Site survey and validation was only the beginning of their association--policies and procedures also had to be coordinated for the massive construction to follow, particularly in the constitution and operation of field offices for each job site. The "NIKE-X Mobilization Plan" had forecast a joint relationship between Huntsville and other districts but said little about defining it. This ambiquity persisted until April 1968, when steps were taken to draft a working relationship between Huntsville Division and geographic districts. At a conference hosted by Huntsville Division on 17-18 April, a basic agreement was hammered out concerning the SENTINEL program by representatives from OCE, Huntsville Division, and eight divisions and their subordinate districts. During all-day briefings and discussion on 18 April, a five page "Concept of District Participation" was drawn up providing for command and control, district support of field offices, and other interfaces with the Huntsville Division.

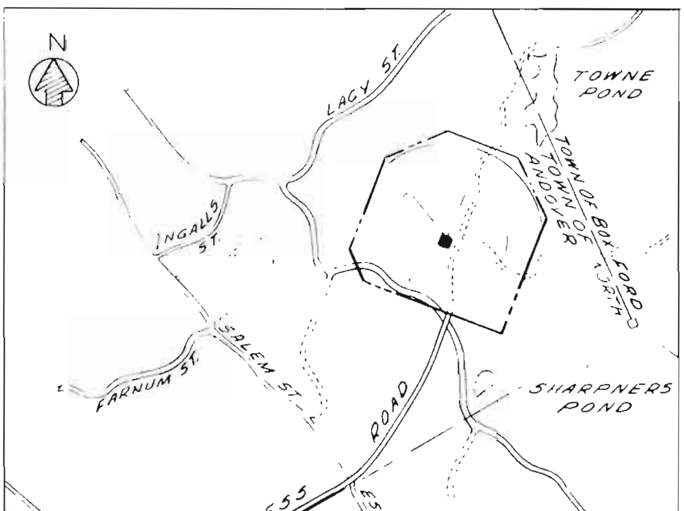
The essence of the April pact was that Huntsville Division would establish a field office headquarters at each SENTINEL site, with the district to dispatch the field office staff to the site. These men would have reemployment rights in their district. The field office slots and funding for them would come from Huntsville and the personnel involved would be responsible to Huntsville Division for the job performance. The districts were asked to administratively and logistically support the field offices and furnish real estate expertise and site exploration services. As site construction progressed, the districts might be solicited for other contributions such as assistance with SENTINEL staff family housing.

Preliminary site activities for the first SENTINEL construction at Boston entered their final stage after 16 August with solicitation of Congressional approval for Title X acquisition of land near Sharpner's Pond for PAR and a plot on Massachusetts National Guard Camp Curtis Guild not far away for the first MSR. On 11 September the Department of Defense confirmed the choice of these sites in a public annoucement, and Congressional approbation under Title X came soon after. The Sharpner's Pond location where ground was first broken two weeks later was a heavily wooded, undeveloped plot close to North Andover. The access road cut into the area ran northeast for one and three-quarter miles off the Salem Turnpike (Massachusetts State Road 114) about four miles southeast of the junction with State Road 125.

The construction undertaken at Sharpner's Pond was scheduled for three stage execution for maximum convenience and flexibility under the tight deadlines prevailing in the PAR design. Each stage entailed a separate contract. Phase I called for cutting the access road, rooting and clearing, and some excavation for the PAR and its power plant. Rock removal, pouring of concrete foundations, some backfill, and connection with related utilities would begin under Phase II later in the winter, with mainstream construction planned for Phase III after the spring of 1969.

Advance notice for Phase I Contract DACA87-69-C-0007 was issued on 22 August, and Invitations for Bids followed on 4 September. The eight bids tendered for first SENTINEL construction were opened uneventfully at New England Division headquarters in Waltham, Massachusetts, at 3:00 PM on 19 September. The low bid of $767,242.50 submitted by George Brox, Inc., of Dracut, Massachusetts, was some $4,500 above Government estimates but was accepted. Brox quickly moved heavy equipment to the site and commenced clearing upon receiving formal contract award and notice to proceed on 24 September.[46] On 15 October, the first SENTINEL area

AERIAL OF SHARPNERS POND PAR SITE



PERIMETER ACQUISITION RADAR

VICINITY MAP

Scale: 1":2000'

CONTRACT SIGNING

MISSILE SITE CONTRACT SIGNED--Contract for initial work in North Andover, Massachusetts on Nation's first SENTINEL Ballistic Missile Defense site is signed by Corps of Engineers and George Brox Inc., Dracut, MA. Colonel Lochlin Caffey (seated, left) and George Brox, president-treasurer, ink $767,242 contract. Standing (left to right) George C. Brox, assistant treasurer; Colonel Roy P. Beatty, Deputy Division Engineer for SENTINEL, New England Division, and Frank R. Brox, vice president. Colonel Caffey, Assistant Division Engineer, Eastern Region, Huntsville Division Corps of Engineers, is contracting officer for the Army.

office was opened to administer the contract, with Col. Roy Beatty of New England Division as area engineer. Phase II was begun on 22 January 1969 when Morrison-Knudsen, Inc., of Boise, Idaho, was awarded a construction contract for $2,213,857.00.[47]

The initiation of SENTINEL work in the Boston area was at first received with calm indifference by the local populace. On 25 September, the day after ground-breaking, the Corps conducted a three hour public relations meeting in the auditorium of North Andover High School. About one hundred people and two North Andover selectmen attended. Some resentment at the military's intrusion was manifested, but in general the gathering seemed to go off smoothly. The proceedings were video-taped for later presentation by the National Education Television Network.[48]

The relative tranquility evidenced at North Andover did not prove very durable. Presidential elections were forthcoming in November, and the issue of BMD had been thoroughly aired during late summer and early fall. Concurrent with national electioneering came wide attention and publicity at many locales where BMD sites were to be placed. Some communities took the news that BMD was coming into their backyards with equanimity, but others began to express a smouldering antagonism that grew into outright hostility after October. The causes of this feeling were deeply rooted in the contemporary climate of opinion prevailing in the American public, particularly in intellectual centers and among urban areas of the central and northeastern states. Citizens here and elsewhere were often convinced of the dangers of nuclear warheads in their proximity and were equally adamant that the risks were disproportionate by comparison with the protection obtained. The debate on both sides was sharpened into a raging national issue because of the escalating Vietnam War, military spending, and the sociological currents in the country during this time. In fact, it was an era of suspicion of government in general and of the military in particular.

The rising tide of BMD opposition was grounded in grass roots feeling and stimulated by a small group of scientists and engineers in the academic-research community. Members of the Federation of American Scientists, a national group of about 2,500 members which had criticized BMD deployment since 1964, were among the foremost spokesmen for the opposition. Soon after the presidential election in November, five Federation scientists formed a "West Suburban Concerned Scientists Group" to fight BMD in the Chicago area. Utilizing the chapter network of the Federation of American Scientists and appeals to Congressmen, the Chicago group took the BMD issue into the public arena, where it gathered momentum in November and December. The focus of the debate shifted to the New England area with the advent of SENTINEL construction there, and the acrimony that ensued soon began to cast uncertainty on the future of the entire program.

Thus it was that 1968 closed with a storm cloud gathering over the SENTINEL deployment. But controversy notwithstanding, the BMD deployment had made great strides in the fifteen months since its announcement. The Army's weapon system contractors had brought the SENTINEL's major radar components from development to production and significantly advanced the data processing equipment. Operation of the prototype MSR on Meck Island began in May 1968, and it later participated in several successful flight tests of SPARTAN and SPRINT missiles. Plans were being laid to push this progress during 1969, along with further site investigations and ground-breakings beyond the Boston installations.

At Huntsville Division, the old year slipped away with a sense of accomplishment about the past and anticipation for the future, all tempered by a growing awareness that SENTINEL's future did not look quite so bright as it had some months before. The Division could take pride in the fact that it had been mobilized, moved to Huntsville, set up shop, and made tremendous progress despite omnipresent pressures of time and fitful shifts of direction. The Division could look with satisifaction on the development of solutions for such challenges as the NEMP and PAR Power Plant placement problems, and it could legitimately anticipate that more such difficulties might be resolved with the completion of shock testing and hardness evaluation during the coming year. Corps personnel at Huntsville Division and its sister divisions had also resolved a mutual plan of action for site work and implemented it at a dozen localities across the nation. If the citizenry's reponse to the arrival of BMD in their neighborhood was not always enthusiastic, hospitable, or even indifferent, the real causes lay in the context of the times and not in the performance of the Corps of Engineers.

CHAPTER I FOOTNOTES

[1]The "Corps of Engineers NIKE-X Mobilization Plan" of May 1967 was actually the product of the four men then making up the NIKE-X Cadre and Planning Group at the Office of the Chief of Engineers. Those four men were: George Fellers, Chief; Richard Malm, Data Processing; Bill McCormick, Engineering; John Kennedy, Construction. In authoring the plan, the NIKE-X Cadre was supported by OCE staff, the Mobile District, and a representative from the Baltimore Distrist. For this information I am indebted to Walter R. Peterson, Mechanical-Electrical Branch, Engineering Division, USAEDH. Peterson was on the staff of the Directorate of Military Construction, OCE, during the 1965-1967 period.

[2]OCE, "NIKE-X Mobilization Plan," p.3.

[3]OCE, "NIKE-X Mobilization Plan," pp. 35-42.

[4]USAEDH-PAO, "Historical Summary FY 1968," II, Documents, pp. 44-45. Because the bulk of material for this chapter has been drawn from the Division's "Historical Summary FY 1968" and "Historical Summary FY 1969," individual citations have been made only for direct quotations and for materials that are not drawn from the "Historical Summary."

[5]Draft Regulation No. 10-1-, Organization and Functions, U.S. Army Engineer Division, Huntsville, OCE for USAEDH, n.d., attached to ltr, OCE to Division Engineer, Huntsville, 26 Dec. 67, sub: Organization and Functions; ltr, USAEDH to Chief of Engineers, 17 Jan 68, sub: Control of Organization and Functions; ltr, OCE to DivisionEngineer, Huntsville, 16 Aug 68. Historical Records File, Management Analysis Branch, USAEDH.

[6]Text of the Memorandum of Agreement is in USAEDH-PAO, "Historical Summary FY 1968," II, Documents, pp. 81-82.

[7]I am greatly indebted to Dewey Rhodes, Chief of the Manpower Management Branch, Personnel Office, USAEDH, for providing much valuable information about the manpower aspects of the Division's history. Much of this information clarified and elaborated the information available in the "Historical Summary" for 1968 and 1969.

[8]A brief vita on John Coony can be found in USAEDH-PAO, "Information Bulletin," I, No. 5 (23 Dec. 1968), p.2.

[9]A brief vita on Joe Harvey can be found in USAEDH-PAO, "Information Bulletin," II, No. 3 (9 June 1969), p.2.

[10]A brief vita on Bernard Trawicky can be found in USAEDH-PAO, "Information Bulletin," II, No. 2 (9 May 1969), p.2.

[11]A brief vita on Emil Vuch can be found in USAEDH-PAO, "Information Bulletin," I, No. 1 (19 Aug. 1968), pp. 1-2.

[12]BMDSCOM, **Bell ABM Project History,** pp. 1/44-1/45.

[13]Ibid.

[14]This is inferred from the Soviet threat capability mentioned in BMDSCOM, **Bell ABM Project History,** pp. 1/44-1/45, and definitively stated to the author in an interview with R.L. Phillips, Project Management Branch, USAEDH-ED, on 2 May 1977.

[15]The reader should again be reminded that the hardness criteria for the SENTINEL facilities remains secret. This includes such features as overpressure and survival in "button-up" mode after nuclear attack.

[16]See, for example, the figures mentioned by Michael London, Associate Editor of **Space/Aeronautics** magazine, in "Safeguard: Is There a Choice?," **Space/Aeronautics**, November 1969, pp.48-55.

[17]The best unclassified source of information on both SENTINEL and SAFEGUARD facilites is "SAFEGUARD: A Step Towards Peace," published by USAEDH in 1973. The Wyle Laboratories contract of November 1969 was DACA87-69-C-0003 in the amount of $59,158 and closed at $71,560.

[18]USAEDH-PAO, "SAFEGUARD: A Step Toward Peace," p. 21.

[19]Ibid., pp. 21-22.

[20]Ibid., pp. 22-23.

[21]Ibid,. pp. 22-23. Also see "Historical Summary FY 1968," I, Narrative, for the development of these solutions during 1968.

[22]USAEDH-PAO, "SAFEGUARD: A Step Toward Peace," pp. 22-23.

[23]Interview with R.L. Phillips, AE Contracts Section, USAEDH-ED, 2 May 1977.

[24]Contract DACA01-67-C-0010 in the amount of $332,746.00. Closed after thirty modifications on 14 August 1972 for $8,270,712.50.

[25]A list of the major design studies and reports in this line of NIKE-X research back to 1964 can be found in the "Historical Summary FY 1968," II, Documents, xiv-xxi.

[26]Contract DACA87-68-C-0001 was closed in June 1971 for a total of $18,248,706.78.

[27]This was Contract DACA73-68-C-0006, closed in October 1971 after seventeen modifications for $5,566,448.25.

[28]On the design of the MSR and MSR Power Plant as they were incorporated in the SAFEGUARD System, see USAEDH-PAO, "SAFEGUARD: A Step Toward Peace," pp. 9-11, 14-17.

[29]USAEDH-PAO, "Historical Summary FY 1968," I, Narrative, pp. 24-25.

[30]Interview with R.L. Phillips, AE Contracts Section, USAEDH-ED, 2 May 1977.

[31]This was Contract DACA87-68-C-0011, closed after twenty modification on 30 August 1972 for $12,531,049.

[32]This was Contract DACA87-68-C-0012, closed after twenty-two modifications on 27 June 1973 for $5,689,838.19.

[33]USAEDH-PAO, "Historical Summary FY 1969," I, Narrative, p. 41.

[34]USAEDH-PAO, "SAFEGUARD: A Step Towards Peace," pp. 5-8, 14-17, 20-23.

[35]USAEDH-PAO, "HND Liaison Bulletin," I, No. 1, p. 2.

[36]USAEDH-PAO, "Government Furnished Property (GFP) After Action Report: SAFEGUARD Ballistic Missile Defense Program," April 1977, pp. 3-7; Memo to the author from Thor S. Anderson, Chief USAEDH-PS, 20 June 1978, concerning specifics of SAFEGUARD GFP program.

[37]Memo to the author from Thor S. Anderson, Chief, USAEDH-PS, 20 June 1978.

[38]USAEDH-PAO, "Historical Summary FY 1969," I, Narrative, p. 47.

[39]Ibid., pp. 47-48.

[40]USAEDH-OC, "History of the Office of Counsel," First Year (Oct. 1967- Oct. 1968), p. 8.

[41]USAEDH-PAO, "HND Liaison Bulletin," I, No. 2 (6 Sept. 1968), pp. 2-3; USAEDH-OC, "History of the Office of Counsel," First Year (Oct. 1967- Oct. 1968), pp. 12-15.

[42]Memo to the author from Emil Vuch, USAEDH General Counsel, 25 Oct. 1977.

[43]Ibid.

[44]USAEDH-ED, "Anti-Ballistic Missile Engineering Criteria Manual for Tactical Site Selection," Huntsville, Alabama, November 1967.

[45]USAEDH-PAO, "HND Liaison Bulletin," I, No. 2 (6 Sept. 1968), p. 2; Memo to the author concerning special SENTINEL and SAFEGUARD legal actions on the problem of contractor traffic from Emil Vuch, USAEDH General Counsel, 25 Oct. 1977.

[46]USAEDH-PAO, "Historical Summary FY 1969," II, Documents, p. 42.

[47]Ibid., pp. 10 and 42.

[48]This meeting and SENTINEL activities in general were widely reported in local newspapers such as the **Boston Globe,** Lawrence **Eagle-Tribune,** Lynn **Item,** and Wakefield **Item.** The author's studies have been greatly facilitated by a mammoth eight-inch thick scrapbook of newspaper clippings maintained by the office of Col. Roy P. Beatty, area engineer for the Boston PAR job. This scrapbook is currently held in the Historical Records File, Public Affairs Office, USAEDH.