

COMMUNICATIONS AND TRACKING DEVELOPMENT  
LABORATORY/ BUILDING 44  
HISTORICAL DOCUMENTATION

Prepared for:  
National Aeronautics and Space Administration  
Lyndon B. Johnson Space Center  
Houston, Texas

Prepared by:  
Archaeological Consultants, Inc.  
Sarasota, Florida

August 2010

## PREFACE

In response to President George W. Bush's announcement in January 2004 that the Space Shuttle Program (SSP) would end in 2010, the National Aeronautics and Space Administration (NASA) completed a nation-wide historical survey and evaluation of NASA-owned facilities and properties (real property assets) at all its Centers and component facilities. The buildings and structures which supported the SSP were inventoried and assessed as per the criteria of eligibility for listing in the National Register of Historic Places (NRHP) in the context of this program. This study was performed in compliance with Section 110 of the National Historic Preservation Act (NHPA) of 1966 (Public Law 89-665), as amended; the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190); Executive Order (EO) 11593: Protection and Enhancement of the Cultural Environment; EO 13287, Preserve America, and other relevant legislation.

As part of this nation-wide study, in September 2006, historical survey and evaluation of NASA-owned and managed facilities was conducted by NASA's Lyndon B. Johnson Space Center (JSC) in Houston, Texas. The results of this study are presented in a report entitled, "Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, Lyndon B. Johnson Space Center, Houston, Texas," prepared in November 2007 by NASA JSC's contractor, Archaeological Consultants, Inc. As a result of this survey, the Communications and Tracking Development Laboratory (Building 44) was determined eligible for listing in the NRHP, with concurrence by the Texas State Historic Preservation Officer (SHPO). The survey concluded that Building 44 is eligible for the NRHP under Criteria A and C in the context of the U.S. Space Shuttle Program (1969-2010). Because it has achieved significance within the past 50 years, Criteria Consideration G applies.

At the time of this documentation, Building 44 was still used to support the SSP as an engineering research facility, which is also sometimes used for astronaut training. This documentation package precedes any undertaking as defined by Section 106 of the NHPA, as amended, and implemented by 36 CFR Part 800, as NASA JSC has decided to proactively pursue efforts to mitigate the potential adverse affects of any future modifications to the facility. It includes a historical summary of the Space Shuttle Program; the history of JSC in relation to the SSP; a narrative of the history of Building 44 and how it supported the SSP; and a physical description of the building. In addition, photographs documenting the construction and historical use of Building 44 in support of the SSP, as well as photographs of the facility documenting the existing conditions, special technological features, and engineering details, are included. A contact sheet printed on archival paper, and an electronic copy of the work product on CD, are also provided.

## **ACKNOWLEDGEMENTS**

Archaeological Consultants, Inc. (ACI) of Sarasota, Florida extends its gratitude to Perri E. Fox, NASA JSC's Shuttle Transition Manager, and Sandra J. Tetley, NASA JSC's Real Property Officer and Historic Preservation Officer (HPO), for making all arrangements for access and information gathering in support of this documentation. We also thank the staff of the JSC Imagery Repository for their cooperation in providing historical photographs; and the staff of the Engineering Drawing Control Center for their assistance in locating architectural drawings of the facility. We deeply appreciate the efforts of Ned Robinson, for serving as ACI's point of contact at the facility and for providing valuable information on the use of the Communications and Tracking Development Laboratory in support of the Space Shuttle Program. Finally, we would like to thank Rebecca Wright and Jennifer Ross-Nazzal of Tessada & Associates, for conducting oral histories, which greatly enhanced our discussion of the building.

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COMMUNICATIONS AND TRACKING DEVELOPMENT LABORATORY  
BUILDING 44  
JOHNSON SPACE CENTER,  
HOUSTON, TEXAS

**Basic Information**

Location: At the west end of Avenue C, to the south  
Johnson Space Center  
Houston  
Harris County  
Texas

U.S.G.S. 7.5. minute League City, Texas, quadrangle,  
Universal Transverse Mercator coordinates:  
15.297298.3271976

Date of Construction: 1965-1966

Architect/Engineer: Alexander, Rice and Associates, Houston, Texas

Builder: Baxter Construction Company, Inc., Houston, Texas

Present Owner: National Aeronautics and Space Administration  
Johnson Space Center, Houston, Texas

Present Use: Used to test spacecraft flight equivalent communication systems, from Apollo-era to present.

Significance: The Communications and Tracking and Development Laboratory (Building 44) is considered eligible for listing in the National Register of Historic Places (NRHP) in the context of the U.S. Space Shuttle Program (1969-2010) under Criteria A and C in the areas of Space Exploration and Engineering, respectively. Because it has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Building 44 is a unique NASA facility used for the testing of Space Shuttle communications systems and its interfaces. It also supports real-time communications trouble-shooting. Under Criterion C, the equipment housed in this facility was uniquely designed and engineered to perform its specialized functions.

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DEVELOPMENT LABORATORY /  
BUILDING 44  
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## The U.S. Space Shuttle Program

On January 5, 1972, President Nixon delivered a speech in which he outlined the end of the Apollo era and the future of a reusable space flight vehicle, the Space Shuttle, which would provide “routine access to space.” By commencing work at this time, Nixon added, “we can have the Shuttle in manned flight by 1978, and operational a short time after that.”<sup>1</sup> The Space Task Group (STG), previously established by President Nixon in February 1969, to recommend a future course for the U.S. Space Program, presented three choices of long-range plans. All included an Earth-orbiting space station, a space shuttle, and a manned Mars expedition.<sup>2</sup> Although none of the original programs presented was eventually selected, the National Aeronautics and Space Administration (NASA) implemented a program, shaped by the politics and economic realities of the time, which served as a first step toward any future plans for implementing a space station.<sup>3</sup>

On January 5, 1972, President Richard Nixon instructed NASA to proceed with the design and building of a partially reusable space shuttle consisting of a reusable orbiter, three reusable main engines, two reusable solid rocket boosters (SRBs), and one non-reusable external liquid fuel tank (ET). NASA’s administrators vowed that the shuttle would fly at least fifty times a year, making space travel economical and safe. NASA gave responsibility for developing the shuttle orbiter vehicle and overall management of the Space Shuttle Program (SSP) to the Manned Space Center (MSC, now the Johnson Space Center [JSC]) in Houston, based on the Center’s experience. The Marshall Space Flight Center (MSFC) in Huntsville, Alabama, was responsible for development of the Space Shuttle Main Engine (SSME), SRBs, the ET, and for all propulsion-related tasks. Engineering design support continued at MSC, MSFC and NASA’s Langley Research Center (LaRC), in Virginia, and engine tests were to be performed at NASA’s Mississippi National Space Technology Laboratories (NSTL, later named Stennis Space Center [SSC]) and at the Air Force’s Rocket Propulsion Laboratory in California, which later became the Santa Susana Field Laboratory (SSFL).<sup>4</sup> NASA selected the Kennedy Space Center (KSC) in Florida, as the primary launch and landing site for the SSP. KSC, responsible for designing the launch and recovery facilities, was to develop methods for shuttle assembly, checkout, and launch operations.<sup>5</sup>

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<sup>1</sup> Marcus Lindroos. “President Nixon’s 1972 Announcement on the Space Shuttle.” (NASA Office of Policy and Plans, NASA History Office, updated April 14, 2000).

<sup>2</sup> NASA, History Office, NASA Headquarters. “Report of the Space Task Group, 1969.”

<sup>3</sup> Dennis R. Jenkins. *Space Shuttle, The History of the National Space Transportation System. The First 100 Missions*. (Cape Canaveral, Florida: Specialty Press, 2001), 99.

<sup>4</sup> Jenkins, 122.

<sup>5</sup> Linda Neuman Ezell. *NASA Historical Databook Volume III Programs and Projects 1969-1978*. The NASA History Series, NASA SP-4012, (Washington, D.C.: NASA History Office, 1988), Table 2-57; Ray A. Williamson. “Developing the Space Shuttle.” *Exploring the Unknown: Selected Documents in the History of the U.S. Civil Space Program, Volume IV: Accessing Space*. (Edited by John M. Logsdon. Washington, D.C.: U.S. Printing Office, 1999), 172-174.

On September 17, 1976, the full-scale orbiter prototype, *Enterprise* (OV- 101), was completed. Designed for test purposes only and never intended for space flight, structural assembly of this orbiter had started more than two years earlier in June 1974 at Air Force Plant (AFP) 42 in Palmdale, California. Although the *Enterprise* was an aluminum shell prototype incapable of space flight, it reflected the overall design of the orbiter. As such, it served successfully in 1977 as the test article during the Approach and Landing Tests (ALT) aimed at checking out both the mating with the shuttle carrier aircraft (SCA) for ferry operations, as well as the orbiter's unpowered landing capabilities.

The first orbiter intended for space flight, *Columbia* (OV-102), arrived at KSC from the shuttle assembly facility in Palmdale in March 1979. Originally scheduled to lift off in late 1979, the launch date was delayed by problems with both the SSME components, as well as the thermal protection system (TPS). *Columbia* spent 610 days in the Orbiter Processing Facility (OPF), another thirty-five days in the Vehicle Assembly Building (VAB), and 105 days on Pad 39A before finally lifting off on April 12, 1981. STS-1, the first orbital test flight and first Space Shuttle Program mission, ended with a landing on April 14 at Edwards Air Force Base (AFB) in California. This launch demonstrated *Columbia's* ability to fly into orbit, conduct on-orbit operations, and return safely.<sup>6</sup> *Columbia* flew three additional test flights in 1981 and 1982, all with a crew of two. The Orbital Flight Test Program ended in July 1982 with 95% of its objectives completed. After the end of the fourth mission, President Ronald Reagan declared that with the next flight the Shuttle would be "fully operational."

A total of 129 Space Shuttle missions have been launched from the KSC between April 1981 and December 2009. From April 1981 until the *Challenger* accident in January 1986, between two and nine missions were flown yearly, with an average of four to five per year. The milestone year was 1985, when nine flights were successfully completed. The years between 1992 and 1997 were the most productive, with seven or eight yearly missions. Since 1995, in addition to its unique responsibility as the shuttle launch site, KSC also became the preferred landing site.

Over the past two decades, the SSP has launched a number of planetary and astronomy missions including the Hubble Space Telescope (HST), the Galileo probe to Jupiter, Magellan to Venus, and the Upper Atmospheric Research Satellite. In addition to astronomy and military satellites, a series of Spacelab research missions were flown, which carried dozens of international experiments in disciplines ranging from materials science to plant biology. Spacelab was a manned, reusable, microgravity laboratory flown into space in the rear of the Space Shuttle cargo bay. It was developed on a modular basis allowing assembly in a dozen arrangements depending on the specific mission requirements.<sup>7</sup> The first Spacelab mission, carried aboard *Columbia* (STS-9), began on November 28, 1983. Four Spacelab missions were flown between 1983 and 1985. Following a hiatus in the aftermath of the *Challenger* disaster, the next Spacelab mission was not launched until 1990. In total, twenty-four Space Shuttle missions carried Spacelab

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<sup>6</sup> Jenkins, 268.

<sup>7</sup> NASA. *NASA Shuttle Reference Manual*. (1988).

hardware before the program was decommissioned in 1998.<sup>8</sup> In addition to astronomical, atmospheric, microgravity, and life sciences missions, Spacelab was also used as a supply carrier to the HST and the Soviet space station *Mir*.

In 1995, a joint U.S./Russian Shuttle-*Mir* Program was initiated as a precursor to construction of the International Space Station (ISS). *Mir* had been launched in February 1986 and remained in orbit until March 2001.<sup>9</sup> The first approach and flyaround of *Mir* took place on February 3, 1995 (STS-63); the first *Mir* docking was in June 1995 (STS-71). During the three-year Shuttle-*Mir* Program (June 27, 1995 to June 2, 1998) the Space Shuttle docked with *Mir* nine times. All but the last two of these docking missions used the Orbiter *Atlantis*. Many of the activities carried out were types they would perform on the ISS.<sup>10</sup>

On December 4, 1999, *Endeavour* (STS-88) launched the first component of the ISS into orbit. As noted by Williamson, this event marked, “at long last the start of the Shuttle’s use for which it was primarily designed – transport to and from a permanently inhabited orbital space station.”<sup>11</sup> STS-96, launched on May 27, 1999, marked the first mission to dock with the ISS. Since that time, most Space Shuttle missions have supported the continued assembly of the space station. As currently planned, ISS assembly missions will continue through the life of the Space Shuttle Program.

The SSP suffered two major setbacks with the tragic losses of the *Challenger* and *Columbia* on January 28, 1986, and February 1, 2003, respectively. Following the *Challenger* accident, the SSP was suspended, and President Ronald Reagan formed a thirteen-member commission to identify the cause of the disaster. The Rogers Commission report, issued on June 6, 1986, which also included a review of the SSP, concluded “that the drive to declare the Shuttle operational had put enormous pressures on the system and stretched its resources to the limit.”<sup>12</sup> In addition to mechanical failure, the Commission noted a number of NASA management failures that contributed to the catastrophe. As a result, among the tangible actions taken were extensive redesign of the SRBs; an upgrade of the Space Shuttle tires, brakes, and nose wheel steering mechanisms; the addition of a drag chute to help reduce speed upon landing; the addition of a crew escape system; and the requirement for astronauts to wear pressurized flight safety suits during launch and landing operations. Other changes involved reorganization and decentralization of the SSP. NASA moved the management of the program from JSC to NASA Headquarters, with the aim of preventing communication deficiencies.<sup>13</sup> Experienced astronauts were placed in key NASA management positions, all documented waivers to existing flight

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<sup>8</sup> STS-90, which landed on May 3, 1998, was the final Spacelab mission. NASA. “Shuttle Payloads and Related Information.” *KSC Factoids*. Revised November 18, 2002.

<sup>9</sup> Tony Reichhardt (editor). *Space Shuttle, The First 20 Years*. (Washington, D.C.: Smithsonian Institution, 2002), 85.

<sup>10</sup> Judy A. Rumerman, with Stephen J. Garber. *Chronology of Space Shuttle Flights 1981-2000*. HHR-70. (Washington, D.C.: NASA History Division, Office of Policy and Plans, October 2000), 3.

<sup>11</sup> Williamson, 191.

<sup>12</sup> Columbia Accident Investigation Board (CAIB). *Report Volume I*. (August 2003), 25.

<sup>13</sup> CAIB, 101.

safety criteria were revoked and forbidden, and a policy of open reviews was implemented.<sup>14</sup> In addition, NASA adopted a Space Shuttle flight schedule with a reduced average number of launches, and discontinued the long-term practice of launching commercial and military payloads.<sup>15</sup> The launch of *Discovery* (STS-26) from KSC Pad 39B on September 29, 1988, marked a Return to Flight after a 32-month hiatus in manned spaceflight following the *Challenger* accident.

In the aftermath of the 2003 *Columbia* accident, a seven month investigation ensued, concluding with the findings of the Columbia Accident Investigation Board (CAIB), which determined that both technical and management conditions accounted for the loss of the orbiter and crew. According to the CAIB Report, the physical cause of the accident was a breach in the TPS on the leading edge of the left wing, caused by a piece of insulating foam, which separated from the ET after launch and struck the wing.<sup>16</sup> NASA spent more than two years researching and implementing safety improvements for the orbiters, SRBs and ET. Following a two-year hiatus, the launch of STS-114 on July 26, 2005, marked the first Return to Flight since the loss of *Columbia*.

On January 14, 2004, President George W. Bush outlined a new space exploration initiative in a speech given at NASA Headquarters.

*Today I announce a new plan to explore space and extend a human presence across our solar system . . . Our first goal is to complete the International Space Station by 2010 . . . The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station. In 2010, the Space Shuttle – after nearly 30 years of duty – will be retired from service...*<sup>17</sup>

Following the President's speech, NASA released The Vision for Space Exploration, which outlined the Agency's approach to this new direction in space exploration.<sup>18</sup> As part of this initiative, NASA will continue to use the Space Shuttle to complete assembly of the ISS. The Shuttle will not be upgraded to serve beyond 2010 and, after completing the ISS, the Space Shuttle Program will be retired.

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<sup>14</sup> Cliff Lethbridge. "History of the Space Shuttle Program." (2001), 4.

<sup>15</sup> Lethbridge, 5.

<sup>16</sup> CAIB, 9.

<sup>17</sup> The White House. "A Renewed Spirit of Discovery – The President's Vision for Space Exploration." (January 2004).

<sup>18</sup> NASA Headquarters. "The Vision for Space Exploration." (February 2004).

## Johnson Space Center

The Lyndon B. Johnson Space Center (JSC) officially opened on-site in June 1964 as the Manned Spacecraft Center (MSC).<sup>19</sup> This approximately 1,620-acre facility is located near Clear Lake, Texas, about 25 miles from downtown Houston, in Harris County. Many of the approximate 140 buildings are specialized facilities devoted to spacecraft systems, materials research and development, and/or astronaut training. JSC also includes the Sonny Carter Training Facility, located roughly 4.5 miles to the northwest of JSC, close to Ellington Field. Opened in 1997, this facility is situated on land acquired through a lease/purchase agreement with the McDonnell Douglas Corporation. In addition, NASA JSC owns some of the facilities at Ellington Field, which are generally where the aircraft used for astronaut training are stored and maintained.

The origins of JSC can be traced to the summer of 1958 when three executives of the National Advisory Committee for Aeronautics (NACA), Dr. Hugh L. Dryden, Dr. Robert R. Gilruth, and Dr. Abe Silverstein, began to formulate a space program.<sup>20</sup> Almost immediately, Gilruth began to focus on manned spaceflight, and subsequently convened a group of his LaRC associates, who compiled the basics of what would become Project Mercury, the first U.S. manned space program. Eight days following the activation of NASA, with the approval of NASA's first administrator, Dr. T. Keith Glennan, the Space Task Group (STG) was created to implement this program. The group was formally established on November 3, 1958, with Gilruth named as Project Manager. The initial staff of the STG came from LaRC, but was soon supplemented with engineers from the Lewis Flight Propulsion Laboratory (now Glenn Research Center) and AVRO Aircraft, Ltd. of Canada.<sup>21</sup>

At first, the STG offices were located at LaRC. With the establishment of the Goddard Space Flight Center in Greensbelt, Maryland, in May 1959, plans were made to incorporate the STG into it, creating a new "space projects center."<sup>22</sup> It was later decided to leave the STG at LaRC until the completion of Project Mercury; however, by January 1961, it was obvious that the STG would need to develop into an autonomous center, and on January 3, it was designated as such.<sup>23</sup>

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<sup>19</sup> Following the death of former President Lyndon B. Johnson, the U.S. Senate passed a resolution to rename the Manned Spacecraft Center in his memory. "MSC Is Renamed 'JSC'." *Roundup* (12, 8), March 2, 1973, 1; "Capacity Crowd View Dedication Ceremonies." *Roundup* (12, 20), August 31, 1973, 1 and 3. For ease of reference, JSC will be used throughout the text, with the exception of direct quotations from sources.

<sup>20</sup> Dryden was the Director of NACA; Gilruth was the head of the flight research section of NACA's Langley Aeronautical Laboratory (now Langley Research Center) in Hampton, Virginia; and Silverstein was the Director of NACA's Lewis Flight Propulsion Laboratory (now Glenn Research Center) in Cleveland, Ohio. As part of NASA's establishment, NACA, was deactivated and all of its personnel and facilities were transferred to NASA. James M. Grimwood. *Project Mercury: A Chronology*. (Washington, D.C.: NASA, Office of Scientific and Technical Information, 1963); Roger D. Launius. *NASA: A History of the U.S. Civil Space Program*. (Malabar, Fla.: Krieger Publishing Company, 2001), 29.

<sup>21</sup> Grimwood; Loyd S. Swenson, Jr., James M. Grimwood and Charles C. Alexander. *This New Ocean: A History of Project Mercury*. (Washington, D.C.: NASA, Office of Technology Utilization, 1966), 153.

<sup>22</sup> Swenson, et al., 115.

<sup>23</sup> Swenson, et al., 251.

The May 25, 1961, announcement by President John F. Kennedy to send a man to the Moon by the end of the decade reinforced the idea that the STG needed its independence, and soon. Thus, in August 1961, John Parsons, Associate Director of the Ames Research Center (ARC), was charged with establishing a survey team to locate a site for the new center.<sup>24</sup>

On September 19, 1961, James Webb, NASA Administrator, announced that Houston, Texas, would be the site for NASA's new Center for manned spaceflight.<sup>25</sup> Numerous factors influenced the choice of Houston as the home of the new Center. First of all, Rice University was willing to donate 1000 acres of land for the Center. Additionally, Houston met all of the requirements set forth in the selection criteria. For example, Ellington Air Force Base was located nearby, as were Clear Lake and Galveston Bay; these facilities could support air and barge traffic, respectively. Houston also has a year-round moderate climate, and both Rice University and the University of Houston were in close proximity to the new site.<sup>26</sup>

On November 1, 1961, the STG officially became the "Manned Spacecraft Center," with Gilruth as its first Director.<sup>27</sup> The first JSC employees officially transferred to Houston from LaRC were Ed Campagna of the Facilities Division, John Powers, from Public Affairs, and Martin Byrnes, Site Manager; their first offices were two vacant dress shops in the Gulfgate Shopping Center, which were donated by its site manager, Marvin Kaplan.<sup>28</sup> The trio was assigned the responsibilities of procuring temporary office space, hiring new personnel, and meeting with local organizations to help facilitate the needs of those co-workers who would soon be joining them.<sup>29</sup> From November 1961 until April 1962, nearly 400 additional employees were transferred from LaRC to Houston; the new Center officially became operational in Houston on March 1, 1962, when Gilruth moved the JSC's headquarters there.<sup>30</sup>

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<sup>24</sup> Swenson, et al., 363-364.

<sup>25</sup> Glennan resigned effective January 22, 1961 when President Eisenhower left office. Webb was sworn into office on February 15, 1961. Grimwood.

<sup>26</sup> From a political viewpoint, Houston was located within the district of U.S. House Representative, Albert Thomas, chairman of the House Appropriations Committee, and Texas was the home state of Vice President Lyndon B. Johnson. Dr. Robert Gilruth Oral History Interview, February 27, 1987, 273-275, *The Glennan-Webb-Seamans Project*, National Air and Space Museum.

<sup>27</sup> "STG Renamed; Will Move." *Space News Roundup* (1, 1), November 1, 1961, 1.

<sup>28</sup> Martin A. Byrnes, Jr., interview by Robert Merrifield, December 12, 1967, (Houston, TX, Archives Department, Lyndon B. Johnson Space Center), 6.

<sup>29</sup> Temporary offices were located in buildings throughout the Houston area, including the Phil Rich Building, the Farnsworth-Chambers Building, the Lane-Wells Building, the Canada Dry Bottling Building, and a Veterans Administration Building; and at Ellington Field. "Houston Site Offices Move to Rich Building." *Space News Roundup* (1, 3), November 29, 1961, 1; "Move To Houston Area Is On Schedule." *Space News Roundup* (1, 6), January 10, 1962, 1; "Photo Captions." *Space News Roundup* (1, 18), June 27, 1962, 2.

<sup>30</sup> Henry C. Dethloff. *Suddenly, Tomorrow Came...A History of the Johnson Space Center*. (Houston: Lyndon B. Johnson Space Center, 1993), 48.

To supplement the 1000 acres of land promised by Rice University, NASA purchased an additional 620 acres, mainly to provide highway access for the estimated 4000 employees.<sup>31</sup> In September 1961, the Fort Worth Division of the U.S. Army Corps of Engineers (ACOE), under District Engineer, Colonel R. Paul West, was designated the construction agency for the new Center. Their first task was to hire an architecture/engineering (A/E) team to complete the initial design work for the new Center. Twenty teams were considered for the initial contract, and after three rounds of reviews and cuts, an A/E team headed by Brown & Root, Inc., of Houston, Texas, was selected. Partnered with them were master planners Charles Luckman Associates, Los Angeles, California; and the architectural firms of Brooks & Barr, Austin, Texas; Harvin C. Moore, Houston, Texas; MacKie & Kamrath, Houston, Texas; and Wirtz, Calhoun, Tungate, & Jackson, Houston, Texas.<sup>32</sup> The nearly \$1.5 million contract was officially awarded in December 1961, and included general site development; master planning; design of the flight project facility, the engineering evaluation laboratory and the flight operations facility; and various site utilities.<sup>33</sup>

Charles Luckman Associates developed the master plan of the JSC, and “did an outstanding job of meeting the functional requirements that had been set forth in developing a campus-like atmosphere for the facility.”<sup>34</sup> The central “quad” area, bounded by 2<sup>nd</sup> Street on the west, Avenue D on the south, 5<sup>th</sup> Street on the east, and Avenue C on the north, included three “lagoons” surrounded by small, man-made hills, as well as various walkways, trees, and shrubs.<sup>35</sup> Luckman Associates also advocated the use of a modular design system for the buildings with materials that could be manufactured off-site, which aided in the tight schedule for completion. Most of the buildings incorporated a poured concrete foundation, and skeletal steel walls faced with precast exposed aggregate facing (PEAF) panels. This allowed for the fabrication of the steel components while the foundation was being poured, and subsequently the manufacture of the PEAF panels while the steel skeleton was being erected.<sup>36</sup>

Initial construction of the JSC was completed in three main phases. The contract for the first phase, preliminary site development, was awarded on March 29, 1962, to a joint venture of Morrison-Knudsen Construction Company of Boise, Idaho, and Paul Hardeman of Stanton, California; it amounted to \$3,673,000. They began the work in early April; it was completed on July 18, 1963.<sup>37</sup> The task included “overall site grading and drainage, utility installations

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<sup>31</sup> “Interview with I. Edward Campagna, Assistant Chief, Technical Services Division, Maintenance and Operations.” August 24, 1967, Box MERR1, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake; Dethloff, 48.

<sup>32</sup> “Photo Captions.” *Space News Roundup* (1, 12), April 4, 1962, 2.

<sup>33</sup> “Design Work Contract Is Let For Clear Lake.” *Space News Roundup* (1, 5), December 27, 1961, 8.

<sup>34</sup> “Interview with James L. Ballard, Jr.” August 1, 1968, Box MERR1, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake.

<sup>35</sup> Campagna, August 24, 1967.

<sup>36</sup> Ballard, August 1, 1968; Campagna, August 24, 1967.

<sup>37</sup> “First Construction Contract Work Underway at Clear Lake.” *Space News Roundup* (1, 13), April 18, 1962, 1; “Clear Lake Site Commitment Now Stands At \$38,911,458.” *Space News Roundup* (3, 4), December 11, 1963, 3.

including an electrical power system, a complete water supply and distribution system, sanitary and storm drainage systems, basic roads, security fence and street lighting.”<sup>38</sup>

The invitations to bid for the Phase II contract of the construction, which was the first to include actual buildings, were distributed in early July 1962. At first, the task included an office building, a shop building and warehouse, a garage, a central heating and cooling plant, a fire station, and a sewage disposal plant, as well as all necessary paving and utilities for these structures.<sup>39</sup> By the time bids were received and opened, the statement of work had been revised to exclude the office building, the shop building, and the warehouse, all of which were replaced by the Data Processing Center (Building 12). By the time the contract was let in October 1962, the task had changed a second time. In the end, the ACOE signed a contract with the joint venture of W.S. Bellows Construction Corporation and Peter Kiewit & Sons Corporation, both of Houston, in the amount of \$4,145,044, for the construction of Building 12, the sewage disposal plant, the central heating and cooling plant, the fire station, and a water treatment plant and associated building.<sup>40</sup> Of these facilities, the fire station was the first to be completed in September 1963; the central heating and cooling plant was last, finished in December 1963.<sup>41</sup>

Phase III of JSC’s construction incorporated the largest grouping of buildings under one contract. The invitations to bid on this phase were issued on September 25, 1962, and listed ten buildings with an approximate total area of 760,000 square feet.<sup>42</sup> Similar to Phase II, the statement of work was revised prior to the submittal of the bids to include eleven office and lab buildings, and the temperature and humidity control machinery for the entire site. Interested firms were also asked to submit alternate proposals that incorporated additional facilities, which NASA was hoping to add to the contract if funding became available.<sup>43</sup> On December 3, 1962, Colonel Francis P. Koish, the new ACOE District Engineer, signed the official contract, which amounted to roughly \$19 million, with the joint venture of C.H. Leavell and Company of El Paso, Texas, Morrison-Knudsen Construction Company, and Paul Hardeman. Eleven major facilities were part of this contract, including the project management building, the cafeteria, the flight operations and astronaut training facility, the crew systems laboratory, the technical services office and shop buildings, the systems evaluation laboratory, a spacecraft research lab and office building, and a data acquisition building. Funding for the additional facilities had become available by this time, so additional support buildings, such as the shop building and warehouse,

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<sup>38</sup> “Interview with Jack P. Shields.” August 1, 1968, Box MERR4, Oral History Series. Johnson Space Center History Collection, University of Houston-Clear Lake; “First Construction Contract Work.”

<sup>39</sup> “Second Major Clear Lake Building Contract Awarded.” *Space News Roundup* (1, 17), June 13, 1962, 8.

<sup>40</sup> “Bids Open On Phase Two Of Clear Lake Work.” *Space News Roundup* (1, 23), September 5, 1962, 1; “Phase II Contract Goes to Bellows, Peter Kiewet, Sons.” *Space News Roundup* (1, 25), October 3, 1962, 8; Shields, August 1, 1968.

<sup>41</sup> “Photo Captions.” *Space News Roundup* (2, 23), September 4, 1963, 3; “Central Heating and Cooling Plant Completed.” *Space News Roundup* (3, 5), December 25, 1963, 8.

<sup>42</sup> “First Building Contract To Be Let In November.” *Space News Roundup* (1, 20), July 25, 1962, 8.

<sup>43</sup> “Bids Open On Phase 3 Of Center Construction.” *Space News Roundup* (2, 2), November 11, 1962, 1-2.

were also included. Per the contract, the buildings were to be ready for occupancy in 450 calendar days.<sup>44</sup>

In October 1963, the Logistics Division became the first to move into its complete facility, the Support Office (Building 419) and its shops and warehouse (Building 420). By the end of 1963, twelve additional buildings were certified as operational.<sup>45</sup> The major relocation to the new Center occurred between February and April 1964, and included the occupation of facilities such as the Auditorium and Public Affairs Building (Building 1), the Flight Crew Operations Office (Building 4), the Flight Crew Operations Lab (Building 7), the Systems Evaluation Lab (Building 13), and the Spacecraft Technical Lab (Building 16). The Director's office officially moved on March 6, 1964. During May, the Instrument and Electronics Lab (Building 15) was occupied, followed by the Manned Spaceflight Control Center, Houston (Building 30) at the end of June, when all leases on the temporary facilities expired.<sup>46</sup>

Since its beginnings as the STG, JSC has had four main tasks with regard to manned spaceflight: spacecraft development; mission control; research and development; and astronaut selection and training.<sup>47</sup> The basic design guidelines for each space vehicle used during the Mercury, Gemini, Apollo, and Space Shuttle programs were developed by JSC engineers. JSC subsequently managed the contracts with private firms for spacecraft manufacture. It was also the responsibility of JSC engineers to develop the proper interfacing between the spacecraft and its respective launch vehicle, which was developed separately by NASA's MSFC (Mercury-Redstone, Apollo-Saturn, Shuttle SRBs, ET, and SSMEs) or the U.S. Air Force (Mercury-Atlas, Gemini-Titan).<sup>48</sup>

In addition to spacecraft development and astronaut training, JSC is also responsible for mission control. Mission control begins once the space vehicle has cleared the launch pad, and ends when the vehicle lands.<sup>49</sup> The key figure of mission control is the Flight Director, who makes all final decisions with regards to the proceedings. All communication between the ground and the spacecraft is coordinated through the Spacecraft Communicator. The mission control team also includes personnel who monitor all aspects of the space vehicle, such as flight dynamics,

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<sup>44</sup> "19 Million Dollar Construction Contract Signed." *Space News Roundup* (2, 4), December 12, 1962, 1; "MSC 'Site' Three-Fourths Complete, First Move Scheduled Next Month." *Space News Roundup* (2, 24), September 18, 1963, 1; Shields, August 1, 1968.

<sup>45</sup> "MSC 'Site' Three-Fourths Complete;" "Major Move To Clear Lake Begins February 20." *Space News Roundup* (3, 6), January 8, 1964, 1.

<sup>46</sup> "Majority of MSC Personnel Relocated At New Site." *Space News Roundup* (3, 11), March 18, 1964, 2; "Final Relocation Of Center Employees Begins Today." *Space News Roundup* (3, 18), June 24, 1964, 1.

<sup>47</sup> "Gilruth Cites MSC Progress Despite Difficult Relocation." *Space News Roundup* (1, 19), July 11, 1962, 1.

<sup>48</sup> Archaeological Consultants, Inc. (ACI). *Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program. Lyndon B. Johnson Space Center, Houston, Texas.* November 2007, Section 4.3.1.

<sup>49</sup> Likewise, those who designed the launch vehicle generally handled the actual launch process. It should be noted that the Kennedy Space Center, which has conducted all launches for Apollo and Space Shuttle, grew from MSFC's Launch Operations Directorate, which controlled the initial Mercury-Redstone launches.

communications links, data processing, and instrumentation. Between missions, the controllers plan for the next flight, conduct various in-house training exercises, and aid with astronaut training.<sup>50</sup>

In conjunction with vehicle design, JSC has historically conducted related research and development, which generally falls into four categories: materials, electrical systems, life systems, and life sciences. The materials category includes development and testing of active thermal control systems as well as spacecraft structure testing. Electrical systems includes testing of the various interfaces with spacecraft hardware and software, ensuring there are no anomalies within the wiring and electronics systems, and confirming the ability of the spacecraft's communications systems to connect to relay satellites and ground stations. Life systems and life sciences are inherently connected to one another and include the astronauts' spacesuits and backpacks, as well as ensuring that their meals meet nutritional guidelines, taste good and store well.<sup>51</sup>

The last major task of JSC, and probably the most well-known besides mission control, is astronaut selection and training. From the original "Mercury 7," JSC has determined the criteria for astronaut selection and handled all interviews and examinations during the selection procedure. Additionally, the Center has established all training curricula, which provide astronauts with the basic knowledge needed to fly a mission and survive in emergency circumstances, as well as more specific training for tasks associated with a particular mission. Since Project Gemini, program-specific spacecraft simulators and trainers have been located within various buildings at JSC for astronaut training.<sup>52</sup>

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<sup>50</sup> All Mercury missions and the first four Gemini missions were controlled from the old Mercury Control Center at Cape Canaveral, Florida. The Mission Control Center at Houston took over starting with Gemini IV. ACI, Section 4.3.3.

<sup>51</sup> ACI, Section 4.3.4.

<sup>52</sup> ACI, Section 4.3.2.

## **Communications and Tracking Development Laboratory (CTDL)**

### *Construction*

In 1965, the architecture and engineering firm of Alexander, Rice and Associates, of Houston, Texas, designed what was then referred to as the Electronic Systems Compatibility Facility, Building 440. Under the direction of the ACOE, this facility was built by the Baxter Construction Company, Inc., also from Houston, between April 1965 and June 1966, for an approximate cost of \$1.5 million. At the time of construction, the facility consisted of a north wing, which contained laboratories and testing facilities on the first floor and offices on the second floor; and a south wing that was comprised of a high bay area with electronics testing equipment.<sup>53</sup>

The first modification to the CDTL occurred in 1976, when a 1721 square foot mezzanine area was constructed in the high bay; a second mezzanine space, at roughly 1383 square feet, was built in 1980. The high bay area later received two additional mezzanine enlargements, one in 1985 (1056 square feet) and the other in 1991 (approximately 1710 square feet). This latter mezzanine area occurred at the same time as the construction of an annex to the south of the high bay.<sup>54</sup> Other alterations to the facility have included modifications to individual rooms and upgrades to various pieces of testing equipment.

### *Electronics Systems Test Laboratory (ESTL)*

Established ca. 1964, the ESTL served the Apollo Program, the Skylab Program, and the Apollo-Soyuz Test Project prior to focusing on the Space Shuttle Program. Originally, the facility encompassed the south center portion of the CDTL's north wing, but it expanded into the high bay area ca. 1980, when it was decided to place additional shielded enclosures into the lab.<sup>55</sup> When the ESTL began supporting the Space Shuttle Program, it consisted of one Test Control Center (TCC; Room 121); an area devoted to the Tracking and Data Relay Satellite System (TDRSS; Room 122); the Orbiter Communications Room (OCR; Room 126); a space devoted to the Spaceflight Tracking and Data Network (STDN; Room 127); and various support and general work areas (Rooms 120, 123, 124, and 125). In 1993, in preparation for the ISS program, the ESTL was renovated into its current configuration (compare Photo No. 75 with Photo Nos. 98 and 100). These modifications added a second TCC (which became Room 123), expanded Room 122, and combined Rooms 124 and 125 (now Room 125) to create a larger area for the facility's computer servers.<sup>56</sup>

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<sup>53</sup> Alexander, Rice and Associates. "Building No. 440, Electronic Systems Compatibility Facility." February 1965. On file, JSC EDCC; NASA JSC. "Real Property Record-Building 44." On file, JSC, JSC Real Property Office, Center Operations Directorate. The date of the change in the building name and number could not be verified.

<sup>54</sup> NASA JSC. "Real Property Record-Building 44."

<sup>55</sup> Ned Robinson. Interview by Jennifer Ross-Nazzal, October 7, 2009, Houston, TX, Manuscript on file, Tessada & Associates, Houston, TX, 1 and 16.

<sup>56</sup> See the Physical Description for a more complete discussion of the lab's current layout.

Throughout its involvement in the Space Shuttle Program, the ESTL has been used to test nearly all of the vehicle's communications systems. Typically, the tests occurred in a "controlled, calibrated, realistic RF [radio frequency] environment," allowing engineers to subject the equipment to planned and potentially interfering radio links.<sup>57</sup> The earliest tests, begun in the mid-1970s, concentrated on the orbiter's Ku-band system. The focus then shifted to the other communications systems, such as the phase modulation system, the frequency modulation system, the audio system, and the recording system. Testing was conducted on what were referred to as "engineering or qualification units," in order to confirm whether the equipment would meet the mission requirements. These tests also evaluated how well the apparatus worked and aimed to find any problems prior to the assembly of the actual flight units. All of the test results were shared with the Mission Operations Directorate so they could familiarize themselves with the systems and create contingency plans should there be any failures.<sup>58</sup>

Between 1978 and 1981, after all of the systems, and their equipment, were further developed, each went through a roughly six-week verification process. After this was completed, all of the systems were then interfaced with one another, and twenty-four months of verification testing was conducted on the entire communications system. As the Space Shuttle Program evolved and new equipment came on-line, such as the TDRSS, a similar process was followed to check that all of the equipment was operating as an individual unit, and properly interfacing with all of the other equipment. The overall goal of the ESTL was to have the equipment and systems tested and verified two to three years before the changes were made to the orbiter.<sup>59</sup>

Aside from these larger developments, the ESTL has supported each of the program's missions, through pre-mission testing, real-time mission support, and post-flight anomaly testing. Prior to each mission, the lab plays a large role in verifying that all of the shuttle's communications equipment was functioning individually as well as interfacing properly with all other systems. Similarly, the ESTL conducts tests on the communications systems for individual payloads. Since the different payloads were typically assembled by outside vendors, these tests allowed the lab to confirm that its equipment was compatible with the shuttle's systems, and that all data would properly transfer from the payload to the shuttle; from the shuttle to the MCC; and from the MCC to the Payload Operations Control Center, which is located at the MSFC.<sup>60</sup> The general procedure for these tests would be to connect the payload's equipment to the ESTL's systems, which would then transmit a signal to one of the TDRSS satellites. The satellite then relayed the signal to the TDRSS Ground Station at White Sands, New Mexico, which in turn routed the

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<sup>57</sup> NASA JSC. "Electronics Systems Test Laboratory." No date.

<sup>58</sup> Ned Robinson, Interview, 1-4. The Mission Operations Directorate, an organizational group of JSC, "plans, directs, manages and implements overall mission operations including the space shuttle and space station programs." NASA JSC. "JSC Organizations." April 29, 2010.

<sup>59</sup> Robinson, Interview, 7-9, 16.

<sup>60</sup> The individual payload tests could have been conducted years prior to the mission on which it was scheduled to fly. Robinson, Interview, 12. Ned Robinson. Personal communication with Patricia Slovinac and Christine Newman, September 14, 2009.

information to the flight controllers in the MCC, who then patched the data back to the ESTL for evaluation.<sup>61</sup>

Another critical pre-mission task of the ESTL occurs roughly ten days before a mission. At this time, the ESTL works with the TDRSS network, Goddard Space Flight Center, and the MCC, to conduct a verification and validation test of the ground-based communications systems equipment. For this particular test, the ESTL acts as the orbiter to “flow all the data rates they [MCC, Goddard, TDRSS network] expect to see during the mission. If there was a payload, we [ESTL] would try to get the payload people back, even though we may have tested them two years before, so they could flow their data, and it would be just like it would be during a mission.”<sup>62</sup> The timing of this test enabled the ground technicians to replace any problematic apparatus and then test the new equipment before the mission.<sup>63</sup> Also as part of this testing procedure, the ESTL would simulate various contingency scenarios that mission control may encounter during a flight, helping to train the controllers in anomaly resolution.<sup>64</sup>

During a Space Shuttle mission, the ESTL has two distinct functions. The first is to act as the Merritt Island Launch Annex (MILA) ground station for the orbiter’s first pass over Houston.<sup>65</sup> At this time in the flight, the orbiter’s payload doors are still closed, and therefore, its Ku-band antenna is not operational. Instead, the vehicle’s S-band frequency modulation system is in use, which sends information to a satellite dish on the roof of the CTDL. The ground station equipment inside the ESTL processes this information, and then directs it over to the MCC. The orbiter’s crew also uses the duration of this direct communications link to open the payload doors, which allows the operation to be monitored by the flight controllers in the MCC, via the S-band data stream.<sup>66</sup>

The second function of the ESTL during a flight is to provide real-time mission support should a complication arise. If such a situation occurs, the flight controllers at the MCC describe the situation to the lab’s engineers, who in turn, investigate the problem by simulating it in their equipment. Once the test is completed and the data analyzed, the engineers can develop a solution to the problem, if possible. The solution is then relayed to the MCC flight controllers, who forward the instructions to the astronauts. If the problem cannot be replicated or resolved, the lab’s engineers will help the flight controllers devise a temporary solution, such as using an

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<sup>61</sup> Linda Copley. “German engineers participate in space radar testing at JSC.” *Space News Roundup*. (28, 8), February 24, 1989, 4.

<sup>62</sup> Robinson, Interview, 12.

<sup>63</sup> The ESTL/TDRSS network is critical to the success of a mission; therefore, if any piece of the network is not ready, “the Shuttle can’t launch.” Robinson, Interview, 26.

<sup>64</sup> Roger Roberts. “Loud and clear: JSC lab tests spacecraft communications.” *JSC Features*. October 11, 2005.

<sup>65</sup> MILA is a Spaceflight Tracking and Data Network Station located at KSC and operated by Goddard Space Flight Center in Maryland. The MILA station “serves as the primary voice, data, and telemetry communications link between the shuttle and the ground from launch until 7-1/2 minutes into the flight,” and is also used during landing operations. To accomplish its mission, MILA has two 30-foot diameter S-band steerable dish antennas. NASA KSC. “NASAfacts: The MILA spaceflight tracking and data network station.” rev. 2006.

<sup>66</sup> Robinson, Interview, 28.

alternate system to transmit data from the orbiter to the ground, which enables the astronauts to complete the mission.<sup>67</sup> In such an event, or if a minor anomaly is experienced that does not require immediate attention, the ESTL will conduct post-flight anomaly resolution testing on the system and the specific equipment involved. Post-flight anomaly resolution testing generally follows the same procedures as real-time mission support investigations. In the more difficult cases, the actual flight unit in which the problem occurred is sent to the ESTL, where it could be incorporated into the systems and tested.<sup>68</sup>

A typical ESTL test team has historically consisted of between fifteen and twenty people. The team is led by the Test Director, the Test Conductor, and the Test Project Engineer. The Test Director, typically a NASA employee, is the overall director of the test, while the Test Conductor, typically a contractor, coordinates and conducts the test. The Test Project Engineer's job is to prepare for the test by getting all necessary information from the customer and then meeting with the test team. After the test, it is the Project Engineer's job to ensure that sure all of the test data is properly documented, and to organize the results into a document for publishing. Other participants of the test team include "data takers" and various area engineers. "Data takers" are engineers who are tasked with recording the data from the test and subsequently formulating data sheets; there were typically one or two data takers on a team. Area engineers are those who specialize in a specific set of equipment, such as the ground station or the orbiter. During a test, they are responsible for maintaining and operating the system if it is to be used during the test sequence. As such, the number of area engineers on a test team varies depending on the systems being used.<sup>69</sup>

To conduct all of these activities, the ESTL maintains a large amount of equipment, which is generally grouped together by function and distributed throughout the facility's rooms. Rooms 121 and 123 serve as the Test Control Centers, No. 1 and No. 2, respectively. These rooms are where the test team gathers to run a particular testing sequence. The Test Director, the Test Conductor and the Test Project Engineer sit in the back of the room at consoles that are interfaced with the MCC, the TDRSS network, and the ISS Software Integration Lab. Data entry computers are also located in the back of the room. In the front of the room are video generation consoles to receive and send data, and ultimately project that data on the large screen at the front of the room. Other activities that occur in the Test Control Centers are data gathering, measurements of data and radio frequency performance, and evaluations of the video and audio data. When the second Control Center was furnished in the early 1990s, the plan was to have one center (Room 121) for the shuttle and the other for the ISS; however, in the end, the two rooms have been used interchangeably.<sup>70</sup>

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<sup>67</sup> Harold Ferrese and Ned Robinson. Personal communication with Joan Deming and Patricia Slovinac. November 1, 2006; James Hartsfield. "Team efforts devised Discovery fixes." *Space News Roundup*. (27, 34), October 21, 1988, 4.

<sup>68</sup> This same type of support is provided for the TDRSS and STDN ground stations. Robinson, Interview, 14, 23.

<sup>69</sup> Robinson, Interview, 5-8.

<sup>70</sup> Robinson, Interview, 30; Ferrese and Robinson; Robinson, Personal communication.

Room 120, the Command, Telemetry, and Recording Area, is where simulated shuttle data for a particular testing sequence is generated. There are specific consoles to generate audio and telemetry data, as well as a replica of the MCC's processing equipment, which records test data, separates it by function, and then redistributes it. Supporting Room 120, as well as Rooms 121 and 123 is the Communication Distribution Center in Room 124. It is through this room that the ESTL connects to external facilities, such as the MCC, through fiber optic cables. Also included in this room are panels that route audio and video data throughout the lab. Another general support area is Room 125, which contains all of the laboratory's servers. This room also has an electrostatic discharge bench where flight units or ground station equipment that have been sent to the ESTL for testing can be packed or unpacked.<sup>71</sup>

Room 126 in the ESTL is the Orbiter Communications Room, a shielded enclosure that contains prototypes of all of the communications equipment found on the orbiter. It is here that actual flight units can be connected for anomaly testing. Through various consoles, engineers can program the correct parameters and monitor how the equipment functions. Because the room is shielded, the only radio frequency signals that can pass into and out of the room are through cables in the floor. Also included here are replicas of the shuttle's audio hardware and power systems.<sup>72</sup>

Room 127 contains the replica of the MILA STDN ground station. It is through this room that the orbiter communicates with the ground for its first pass over Houston through the S-band antenna. This system is also used during astronaut training sessions in the NASA KC-135A jet, and to collect data from some of the scientific experiments conducted during a mission. The replica of the TDRSS ground station is located in Room 122. This room also contains Space Loss Simulators for both the Ku-band and S-band antennas, as well as a Doppler Effect simulator. The equipment in this room is also used to patch the Ku-band and S-band signals throughout the entire ESTL.<sup>73</sup>

#### *Satellite Interface Test Area (SITA)*

Working in conjunction with the ESTL is the SITA. During the 1980s, SITA consisted of a small temporary shelter located along the south wall of the CTDL high bay area. Inside the shelter was a working, Ku-band antenna, which sat on a platform. The antenna and platform were raised by means of a "scissor jacks" lift, and the antenna was positioned within a geodesics radome situated on the roof.<sup>74</sup> In 1991, during the renovations for the ISS program, SITA received a permanent structure in the form of a three-room annex built to the south of the CTDL high bay.<sup>75</sup> The rooms were arranged so that the end rooms, Rooms 156 and 152, would contain antennas,

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<sup>71</sup> Robinson, Interview, 32-33; Robinson, Personal communication.

<sup>72</sup> Robinson, Interview, 29-30; Robinson, Personal communication.

<sup>73</sup> Robinson, Interview, 30-31; Ferrese and Robinson; Robinson, Personal communication.

<sup>74</sup> A radome is a structured dome faced with a weatherproof material that protects the antenna from the elements, while allowing it to transmit signals.

<sup>75</sup> See page 13.

while the middle space, Room 154, would serve as the control room. As with the original SITA, the roof area above each of the new antenna rooms was fitted with a geodesic radome to protect the antenna when raised, through the use of a hydraulic pit platform, into its operating position.

Since construction, Room 156 has been assigned to hold the Ku-band antenna for Space Shuttle communications; Room 152 is allocated to ISS communications. The Ku-band antenna in Room 156 is what the ESTL uses to transmit signals to the TDRSS network. In addition, it can receive signals from the orbiting spacecraft should there be a problem with the main TDRSS ground station at White Sands. This antenna is also used to train astronauts in manual stowage operations should there be a problem with the automatic control system while on orbit. Consoles in the control room monitor and measure the radio frequency signals and data streams from the antenna. In addition, this room contains the controls to allow the ground technicians to properly orient the antenna; this process is aided by a series of video cameras mounted in the protective radome.<sup>76</sup>

#### *Audio Development Laboratory (ADL)*

The ADL has been a part of the CTDL since the Apollo Program, although the actual date of installation is unknown.<sup>77</sup> It is located at the south end of the high bay area, and is comprised of five rooms (Rooms 143, 143A, 143B, 144, and 144C). Room 143 is the lab's entrance area, while Room 143 serves as a general office area and the Quiet Room; Room 143B is an Anechoic Chamber. Room 144 is the facility's main laboratory area and Room 144C is the Reverberation Chamber. The Quiet Room is capable of providing a low acoustic noise environment; the Anechoic Chamber has special absorption material on its wall surfaces to create an ultra-low ambient acoustic noise environment. The Reverberation Chamber is specially designed, with a pentagonal cross-section, to provide a uniform simulated acoustic environment.<sup>78</sup>

The ADL has been used throughout the Space Shuttle Program to test and develop personal audio communications and electro-acoustic systems equipment. It has provided an environment where equipment such as earphones, microphones, headsets, voice codecs,<sup>79</sup> and audio distribution systems could be researched and developed. These devices could then undergo engineering evaluation, acceptance, and flight qualification testing in this laboratory. Typically, the Quiet Room, Anechoic Chamber or Reverberation Chamber served as the testing stations, with a Head and Torso Simulator (see Photo No. 65) fitted with the apparatus; the main laboratory held all of the support equipment, including audio routing, recording, and analysis equipment; special electrostatic discharge workstations; and a thermal chamber.<sup>80</sup>

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<sup>76</sup> Robinson, Personal communication.

<sup>77</sup> Andy Romero. Personal communication with Patricia Slovinac. August 2, 2010, via email.

<sup>78</sup> NASA JSC. "Audio Development Laboratory." No date.

<sup>79</sup> A codec is a device that can encode and decode a digital data stream.

<sup>80</sup> The ADL is currently undergoing renovations. Andy Romero. Personal communication with Patricia Slovinac and Christine Newman. September 15, 2009.

## Physical Description

The CTDL has approximate overall dimensions of 277' in length (north-south) and 232' in width (east-west), and 43' in height. The entirety sits on a reinforced concrete foundation, and has a flat, built-up roof. The building is divisible into three sections, a north wing (Wing N), a south wing (Wing S), and the Wing S Annex.

Wing N, which has a "T"-shaped plan, measures approximately 234' in length (east-west) and 143' in width (north-south) overall, and stands 30' in height. It contains two floors with walls constructed of plate glass windows. The first floor walls are shaded by a 10'-6"-deep pre-cast exposed aggregate facing (PEAF) panel canopy that is supported by free-standing pillars, which sit roughly 10' from the glass wall and are spaced at 24'-3" on center. These pillars extend through this lower canopy to support the 5'-deep PEAF panel roof canopy that shades the second floor. It is constructed of window walls, with concrete bands and the second floor and roof levels. Openings to this wing include one pair of metal swing doors on the north elevation, and two pairs of metal swing doors on the south elevation. Internally, the first floor of this wing contains lab areas for data and communications systems, as well as support facilities for these labs. Additionally, portions of the ESTL are located within the south-central portion of Wing N. The second floor contains offices and conference rooms for the engineers and technicians.

Wing S has approximate dimensions of 102' in length (east-west), 72' in width (north-south), and 43' in height. Its walls are composed of a steel skeleton faced with aluminum siding and insulated aluminum panels. This wing has two metal swing doors on the north elevation, one on either side of Wing N, and a metal rolling door on the east elevation. Internally, this portion of the facility contains the extensions of some of the ESTL rooms on the first floor, as well as the ADL area; the second floor has additional facility support areas. The Wing S Annex has rough dimensions of 65' in length (north-south), 30' in width (east-west), and 20' in height, excluding the geodesic domes on the roof. Similar to Wing S, it is constructed of a steel skeleton faced with aluminum wall panels. Exterior openings to this area include a pair of metal swing doors and a metal rolling door on the east elevation. Internally, the Wing S Annex contains the SITA.

As originally defined by the "Survey and Evaluation of NASA-owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program, Lyndon B. Johnson Space Center, Houston, Texas," the significance of the CTDL is derived from, "the Electronics Systems Test Laboratory, which consists of a group of 16 rooms on the first floor. The room numbers are 119, 120, 121, 122, 123, 124, 126, 127, 143, 143A, 143B, 144, 144C, 152, 154, and 156."<sup>81</sup> However, it should be noted that during the field work for this documentation package, the significant rooms that are part of the ESTL were further clarified by Ned Robinson as Rooms 120, 121, 122, 123, 124, 126, and 127. Rooms 143, 143A, 143B, 144, and 144C constitute the ADL; Rooms 152, 154, and 156 are referred to as the SITA.<sup>82</sup>

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<sup>81</sup> ACI, 6.2.6.

<sup>82</sup> Ned Robinson. Personal communication with Patricia Slovinac and Christine Newman of ACI, September 14, 2009, Houston, TX.

*Electronics Systems Test Laboratory*

The ESTL has rough overall dimensions of 141' in length (north-south) and 106' in width (east-west); the typical floor to ceiling height is 9'-4". It is comprised of ten individual rooms: Rooms 119, 120, 121, 122, 123, 124, 125, 126, 127, and 128; three of these, Rooms 119, 125, and 128, are generic support spaces, as discussed below. In general, all of the rooms that comprise the ESTL have gypsum board walls, acoustical tile ceilings, and raised tile floors, which allow all of the equipment cabling to be run underneath. The lab is spatially arranged so that Room 120 serves as the core, with the remainder of the rooms surrounding it. To the south of Room 120, from east to west, are Room 123, TCC No. 2; Room 121, TCC No. 1; and Room 122, TDRSS Ground System. To the west of Room 120 are Room 126, Orbiter Communications, at the south, and Room 127, STDN Direct Link RF System at the north; Room 125 sits to the north of Room 120. At the east end of the room is a partial-width wall that creates a small entrance corridor, to the east of which is Room 124 at the north and Room 128 at the south.

Room 120, the Command, Telemetry, and Recording Area (Photo Nos. 10, 11), has rough dimensions of 47' in length (east-west) and 35' in width (north-south). Its east, north, and west boundaries are all formed by rows of equipment racks; the south boundary is denoted by a line of workstations (Photo No. 18). The Computer Control Terminals for this room are situated near the center of the space, parallel to the workstations, but facing in the opposite direction (Photo No. 12). Within the north boundary of Room 120 are two groups of equipment panels. The group to the west, which houses the data generating equipment, contains nine racks (Photo Nos. 13, 14), while the line of five panels to the east holds the data decalming equipment (Photo No. 15). The row of seven panels that form the west boundary of this area encompasses the data conditioning equipment for the lab (Photo No. 16). Within the east boundary of this room are two groups of three panels. The set to the east contains a communications processing rack, a support rack, and the timing subsystem rack (Photo No. 17); the west group comprises the laboratory's front end processor. Other features of this room include numerous work tables positioned throughout the center area.

The two TCCs are nearly identical to one another. Room 121 (Photo Nos. 19, 20) has approximate dimensions of 36' in length (north-south) and 23' in width (east-west). It is entered through a pair of metal swing doors on its north wall; to the west of the door is a ribbon of three, one-light fixed windows that are slanted outward from the sill. The east and west walls of the room each have a metal swing door located roughly at the center point, with ribbons of windows to the north and south of the door. On the east wall, which is shared with Room 123, the windows are vertical; the windows on the west wall, which is shared with Room 122, are slanted like those on the north wall. Internally, TCC No. 1 is arranged so that the three control consoles (Photo No. 21) sit toward the north end of the room, facing south; to their west are the data entry consoles (Photo No. 22). At the front of the room (the south end) is a large projection screen that sits on a row of seven equipment panels (Photo Nos. 24, 25). Embedded within these panels are the various consoles for audio and video evaluation; a work desk projects from the center three racks. To the northeast of this group of panels, and perpendicular to it, is a row of five equipment

racks, which contain all of the fiber optics patching consoles; a work desk projects from the four northern panels (Photo No. 23). Opposite of these consoles is another set of five equipment panels that contain the video control consoles and a work desk (Photo No. 26).

The differences between TCC No. 1 and TCC No. 2 include the size of the rooms, the wall features, and the number of equipment racks. Room 123, TCC No. 2 (Photo Nos. 27-29), is slightly longer than TCC No. 1, with approximate overall dimensions of 44' in length (north-south) and 23' in width, and has a portion of its northeast corner carved out for Room 128. The shared walls between these two rooms are fitted with windows; the remainder of Room 123's east wall is void of openings.

To the west of Room 121 is Room 122, the TDRSS Ground System area (Photo Nos. 30, 33, 34). This room has an "L"-shaped plan with rough overall dimensions of 46' in length (north-south) and 32' in width (east-west), and is typically entered through a pair of metal swing doors at the west end of its north wall. To the east of the entrance is a row of fixed windows that are slanted outward from the sill. Internally, the room is spatially divided into different areas by rows of equipment panels (see Photo No. 30). Along the west wall in the north part of the room, there is a row of six racks containing the equipment for the ISS test set (Photo No. 31). Dividing the north part of the room from the southern area is a line of seven racks (Photo No. 32). This row of panels contains the equipment for the Space Loss Simulator for S-band communications. Directly to the south of these panels and facing in the opposite direction, is a group of five equipment racks that form the Space Loss Simulator for Ku-band communications (Photo No. 35). Forming the south and west boundaries of this area is a row of seven equipment racks and a row of four equipment racks, respectively. Together, these sets of panels contain a replica of one TDRS ground terminal, such as those found at the White Sands Test Facility in New Mexico (Photo Nos. 36, 37). The control consoles for this equipment sit perpendicular to the northern terminus of the west set of equipment racks (Photo No. 38).

At the northeast corner of the ESTL is Room 126, the Orbiter Communications Room (Photo No. 40), which has approximate dimensions of 33' in length (north-south) and 13' in width (east-west). The walls and ceiling of this room are faced with radio frequency shielding panels, as is the pair of metal swing doors at the north end of the east wall (Photo No. 41). The north wall of this room is the only one that does not contain any equipment. A three-shelf equipment rack sits along the east wall. The top shelf holds a power routing system that connects to the adjacent power supply console; the two lower shelves contain prototypes of the orbiter's communications boxes, each of which rests on a cold plate (Photo Nos. 42, 43). All of these boxes are connected to a thermal monitoring system that shuts them down if they reach a critically high temperature. Additionally, the boxes are tied in to the row of seven equipment panels along the west wall, which contain the control and monitoring system (Photo Nos. 44, 45). This equipment allows the engineers to set the parameters for a test and then monitor the conditions of the boxes. On the south wall of the Orbiter Communications Room is a line of three equipment racks, which contain replicas of the orbiter's audio hardware and power boxes and consoles (Photo No. 46).

To the north of Room 126 is Room 127, which contains the STDN Direct Link RF Systems area (Photo Nos. 47, 48). This room has rough dimensions of 23' in length (east-west) and 18' in width (north-south), and is entered through a pair of metal swing doors on its east wall. On either side of the entrance is a fixed window that slants outward from the sill; the east half of the south wall is fitted with power filters (Photo No. 49). This corresponds to the internal layout of the room, which contains all of the radio frequency equipment in the east half and storage cabinets in the west half (see Photo No. 47). The boundary between the two halves of the room is formed by a line of six equipment racks that contain a working ground support/communication station (Photo No. 50). The small control console (Photo No. 51) sits to the east of the panels. Along the south wall of Room 127, but set away from it, is a pair of racks (Photo No. 52) that holds the control and support equipment for the 16' satellite dish on the roof (see Photo No. 7) that communicates with the orbiter.

At the northeast corner of the ESTL is Room 124, known as the Communications Distribution Center (Photo No. 53). This room, which measures approximately 16' in length (north-south) and 14' in width (east-west), is accessed from the north end of the entrance corridor via a metal swing door. Within this space are two groups of three equipment racks, arranged in the form of an "L" in the northwest corner. It is through these panels that the ESTL is linked to other facilities as JSC; the group on the west wall holds the video, audio and data links (Photo No. 54), while the group on the north wall contains all of the fiber optics patches.

As noted above, the last three spaces included in the ESTL, Rooms 119, 125, and 128, are generic support rooms for the laboratory. Room 119 sits to the west of Room 122. This 26' x 9' space is used solely for equipment storage (Photo No. 55). Room 125, which houses the lab's data servers, is located to the north of Room 120. It has approximate dimensions of 41' in length and 21' in width, and is entered through a pair of metal swing doors on its south wall. This room is arranged in a similar fashion to Room 120, with all of the equipment panels located along the walls, and support desks and workspaces in the center (Photo No. 56). Finally, Room 128, with rough measurements of 14' x 14', sits to the north of Room 123 and serves as the ESTL's conference room.

#### *Satellite Interface Test Area*

The SITA is comprised of three rooms within the Wing S Annex, the southernmost of which is Room 156. This room (Photo No. 57) has rough overall dimensions of 28' in length (east-west) and 15' in width (north-south), and is accessed by a metal swing door at the east end of its north wall that opens into a corridor. It also has a pair of metal swing doors on the east wall that lead to the exterior of the building. In the center of the room, there is an approximate 8'-diameter, decagonal, open-grate metal, hydraulic pit platform, which supports a Ku-band antenna (Photo No. 58). The platform raises and lowers the antenna between its use and storage positions. When in the use position, the antenna is protected from the elements by a 14'-diameter geodesic radome; the platform fits snugly into its ceiling opening (Photo No. 59). In the case of severe weather, such as a hurricane, a ceiling-mounted rolling metal door seals off the radome's

opening (Photo No. 60). Other features of this room include video cameras within the radome, and equipment support consoles and panels along the north and south walls.

On the north side of Room 156 is Room 154, the SITA Control Room (Photo No. 61). This space has approximate overall dimensions of 20' in length (east-west) and 12' in width (north-south); the only opening is a pair of metal swing doors on the east wall that provides access to the room from the corridor. Against the south wall of the Control Room are workstations for the engineers and technicians, while along the west wall of this space is a pair of panels that holds RF signal monitoring and measuring equipment, as well as data gathering consoles. Additionally, there is a line of six equipment racks along the north wall, which contain monitors and controls for the video cameras in the Room 156 radome, as well as power system and data recording equipment.

At the north end of the annex is Room 152 (Photo No. 62), which has approximate dimensions of 20' in length (east-west) and 19' in width (north-south). Similar to Room 154, the only entrance to this room is a metal swing door on its east wall. Otherwise, it is very similar to Room 156 in that it contains a hydraulic pit platform in the center of the room, as well as a geodesic radome on its roof. However, the Room 152 versions of this equipment have diameters of 15' and 22', respectively. Likewise, the ceiling contains a rolling metal door to seal off the radome's opening in the case of severe weather. Due to the larger proportions of the platform to the overall room, there is little space for support equipment, although there is a small console along the west wall and a work desk along the north wall.

#### *Audio Development Laboratory*

The ADL sits in the southwest corner of the CTDL's Wing S and has rough overall dimensions of 62' in length (east-west) and 40' in width (north-south). It is divided lengthwise into two halves by a wall faced with RF shielding that dates to the original building; a pair of metal swing doors provides access between the two areas. The north half of the ADL consists of three rooms, Room 143, Room 143A, and Room 143B. Room 143, which measures approximately 16' in length (east-west) and 15' in width (north-south), sits in the center of the northern area (Photo No. 68). This room generally serves as an entrance/transition area for Room 143B, which holds the Anechoic Chamber, to its west and Room 143A, the Quiet Room, to its east. Room 143B has approximate dimensions of 23' in length (east-west) and 15' in width (north-south); it is entered through a metal swing door at the north end of its east wall. Within the western two-thirds of this room is the Anechoic Chamber (Photo No. 65), which roughly measures 15' in length (east-west) and 13' in width (north-south). Internally, the chamber features an open-grate metal floor and foam-covered walls and ceiling; additionally, the inner face of the metal swing entrance door on the east wall is faced with foam (Photo No. 66). A second door sits to the outer side of the entrance, providing a double seal for the chamber when it is closed. Room 143A, the Quiet Room, has rough overall dimensions of 16' in length (east-west) and 15' in width (north-south). This space is accessed from Room 143 through a pair of metal swing doors at the south end of its west wall. Within the room are metal storage cabinets along the north and east walls; the south

wall contains a workstation. In addition, a work table sits in the center of the room (Photo No. 67).

The south half of the ADL is comprised of one large room (Room 144), which contains a small Reverberation Chamber (Room 144C) in its west half. Room 144 has approximate overall dimensions of 62' in length (east-west) and 22' in width (north-south). Aside from the aforementioned pair of metal swing doors on its north wall, there is also a pair of metal swing doors along its east wall, which provides access to the room from a corridor. At the east end of Room 144, there is a moveable partition wall that separates that space into an office area (Photo No. 70); the north wall also contains workstations, as well as a few equipment panels. Along the central portion of the south wall is a line of four equipment racks that support the Reverberation Chamber, with the control console sitting perpendicular to the racks at their west end. The Reverberation Chamber (Room 144C; Photo No. 69) has rough overall dimensions of 20' in length (east-west) and 13' in width (north-south), and is entered through a metal swing door on its east wall. Internally, the chamber has a pentagonal cross section, and its floor, ceiling, and wall surfaces are lined with special shielding panels. Suspended from the ceiling are two small support beams for wires and other lightweight equipment.

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Photographs CTDL-1 through CTDL-70 were taken by Patricia Slovinac, ACI; September 2009. Historic photographs (CTDL-71 through CTDL-90) are courtesy of the NASA JSC Imaging Center (Building 424), Houston, Texas; the negative number is given in parentheses.

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Photograph Nos. CTDL-91 through CTDL-105 are photocopies of engineering drawings. Original drawings are located at the Engineering Drawing Control Center, JSC, Houston, Texas.

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FACILITY  
NASA, Manned Spacecraft Center, Texas  
Drawing A-440-2, Alexander, Rice and Associates, 1965  
FIRST FLOOR PLAN-NORTH WING  
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FACILITY  
NASA, Manned Spacecraft Center, Texas  
Drawing A-440-3, Alexander, Rice and Associates, 1965  
SECOND FLOOR PLAN-NORTH WING  
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NASA, Manned Spacecraft Center, Texas  
Drawing A-440-30, Alexander, Rice and Associates, 1965  
R.F. SHIELDING AND GLARE PROOF GLAZING DETAILS  
Sheet 31 of 36
- CTDL-98      Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-2, NASA JSC, 2007  
FIRST FLOOR PLAN-NORTH WING
- CTDL-99      Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-3, NASA JSC, 2008  
SECOND FLOOR PLAN-NORTH WING
- CTDL-100     Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-4E, NASA JSC, 2007  
PARTIAL FIRST FLOOR PLAN AND DETAILS
- CTDL-101     Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-7, NASA JSC, 2004  
EXTERIOR ELEVATIONS

- CTDL-102      Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-8, NASA JSC, 2007  
EXTERIOR ELEVATIONS
- CTDL-103      Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-40, NASA JSC, 2004  
FLOOR PLAN
- CTDL-104      Photocopy of drawing  
BUILDING 44  
NASA, Lyndon B. Johnson Space Center, Texas  
Drawing A-44-41, NASA JSC, 2004  
BUILDING ELEVATIONS



**CTDL-1**



**CTDL-2**



**CTDL-3**



**CTDL-4**



**CTDL-5**



**CTDL-6**



**CTDL-7**



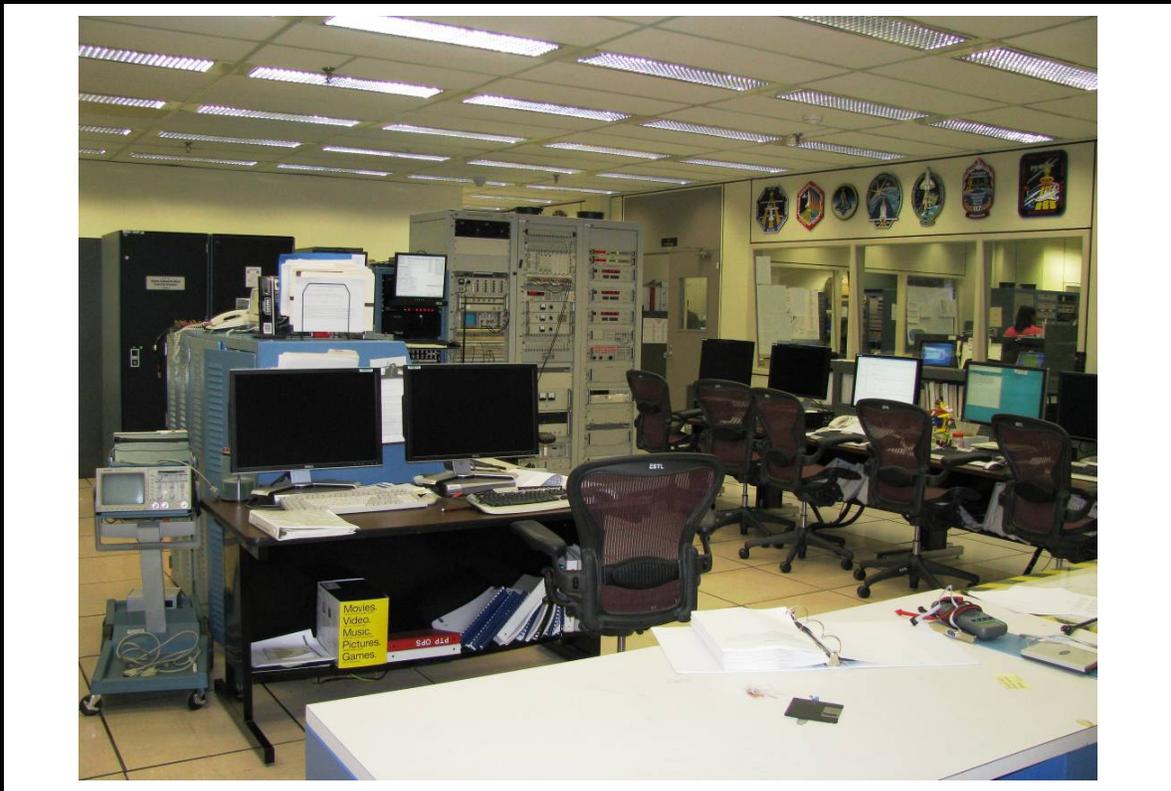
**CTDL -8**



**CTDL -9**



**CTDL -10**



**CTDL -11**



**CTDL -12**



**CTDL -13**



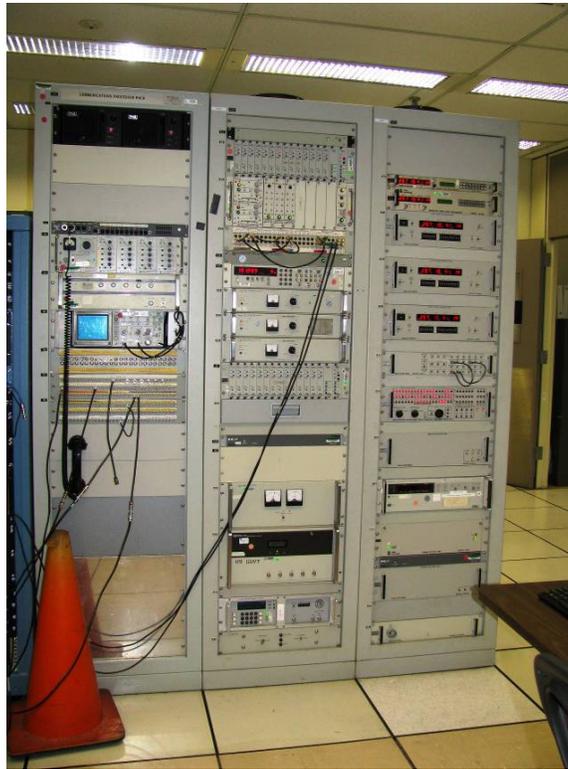
**CTDL -14**



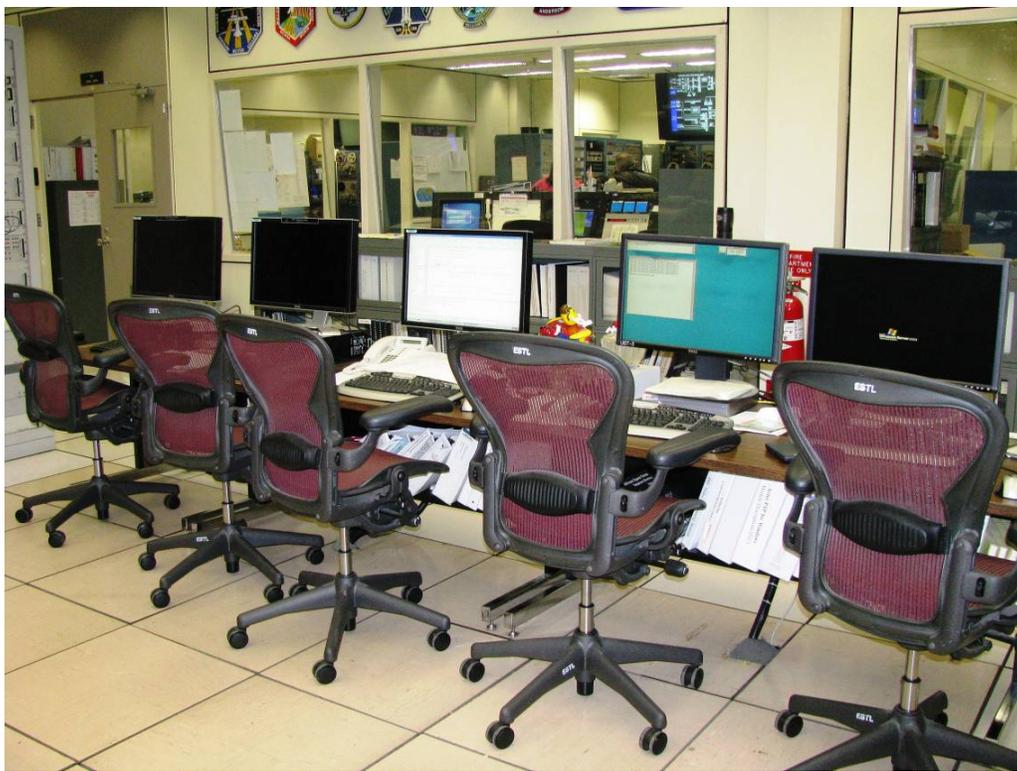
**CTDL -15**



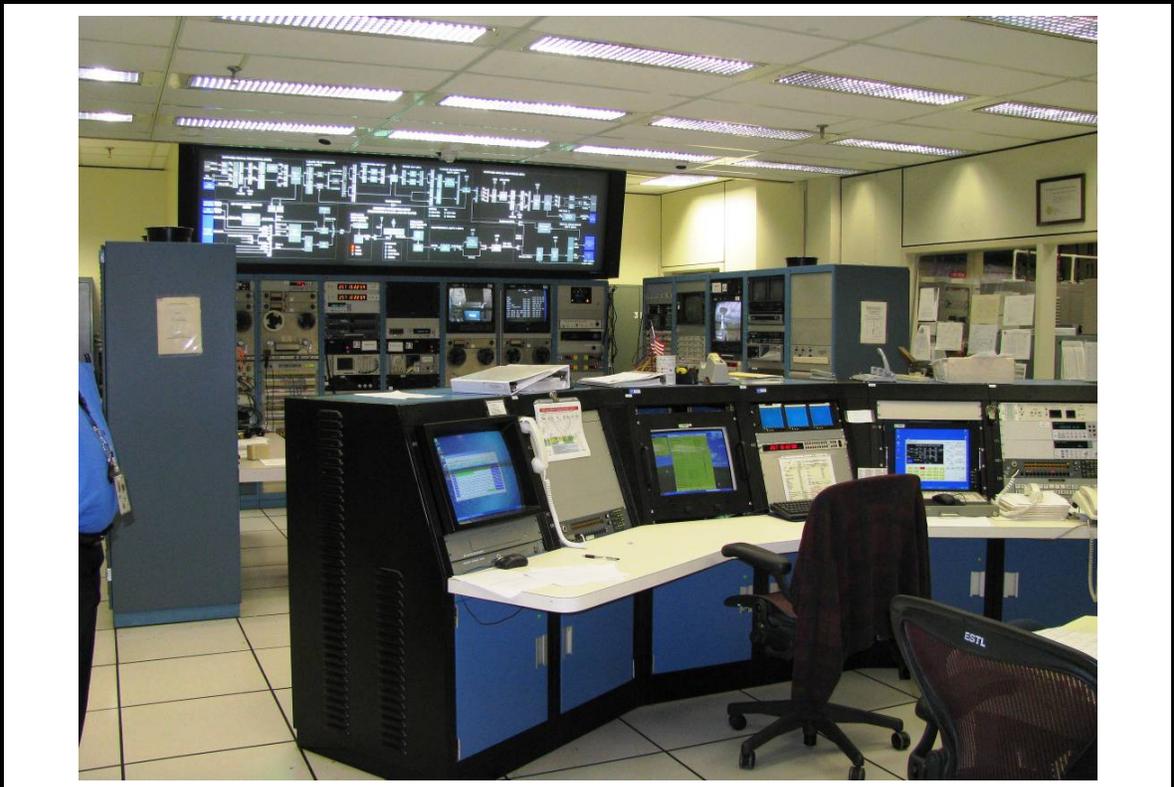
**CTDL -16**



**CTDL -17**



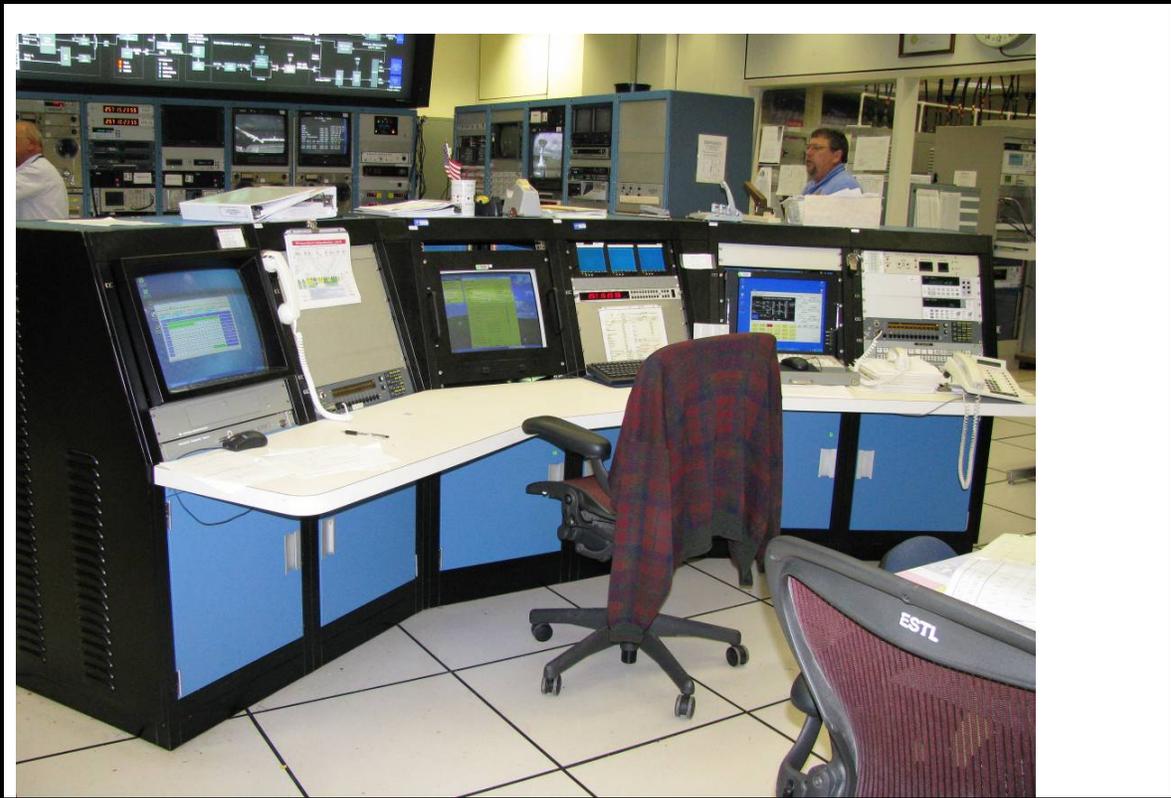
**CTDL -18**



**CTDL -19**



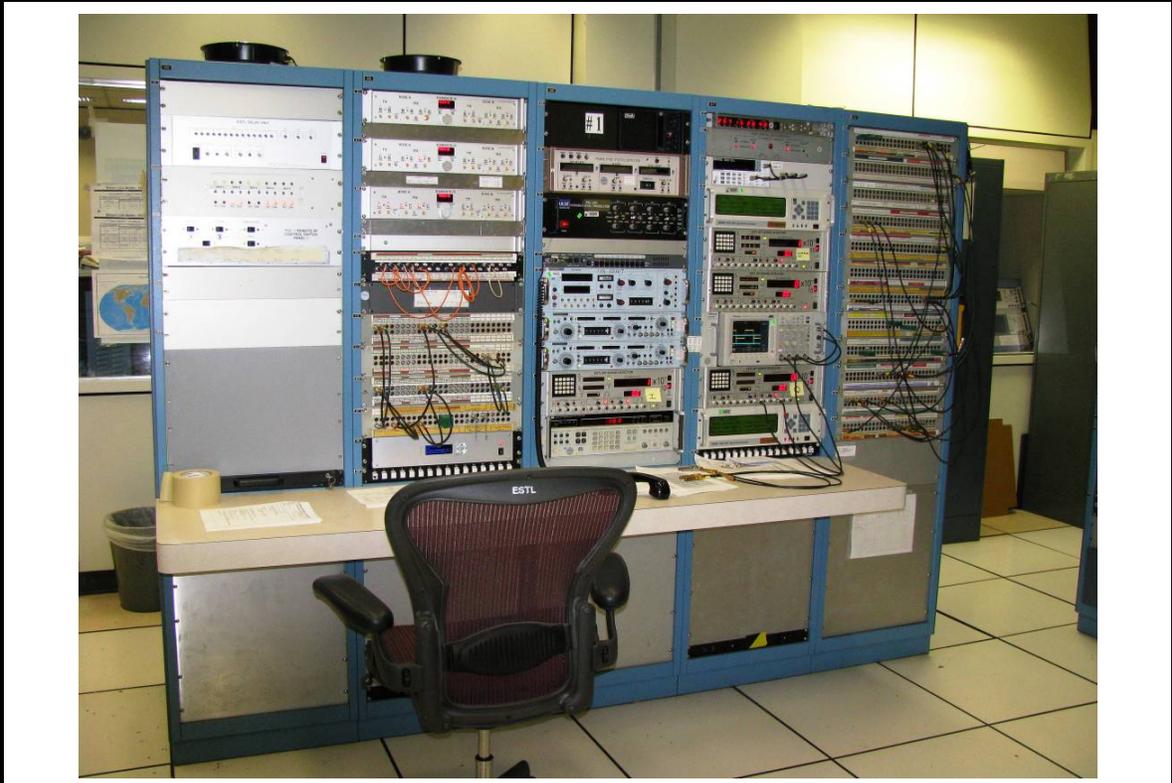
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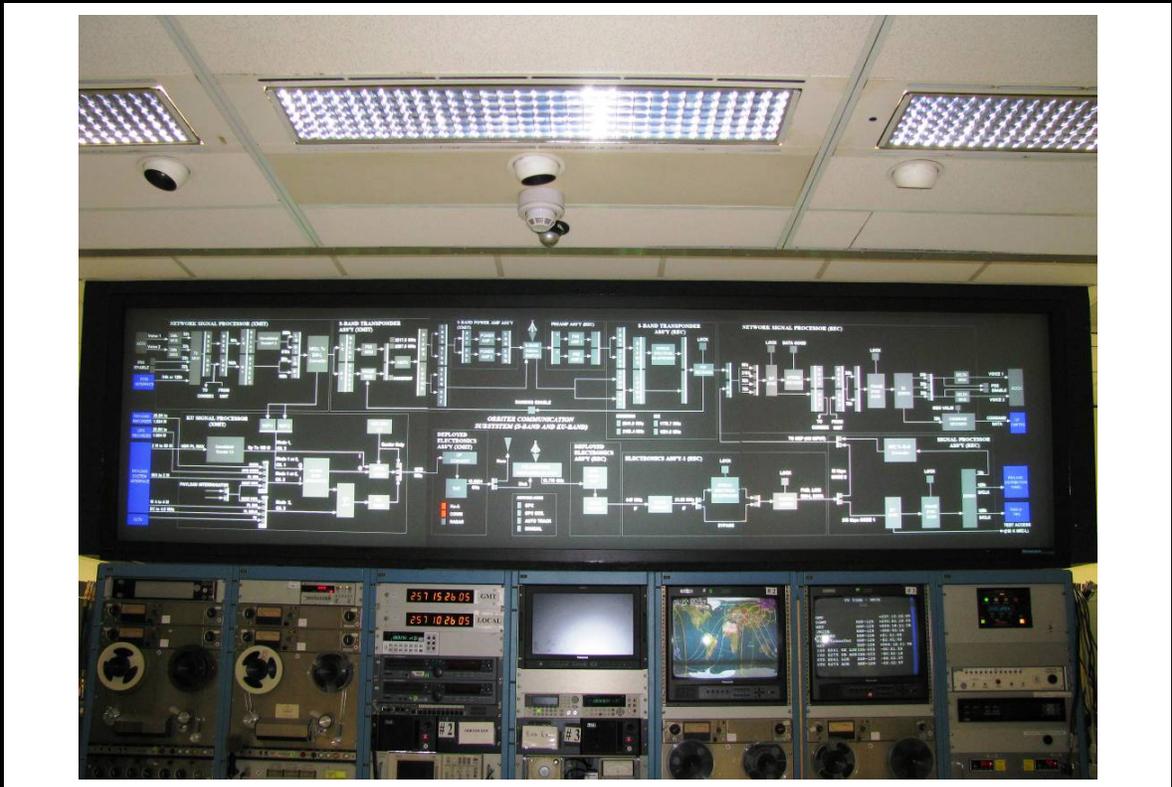
**CTDL -21**



**CTDL -22**



CTDL -23



CTDL -24



**CTDL -25**



**CTDL -26**



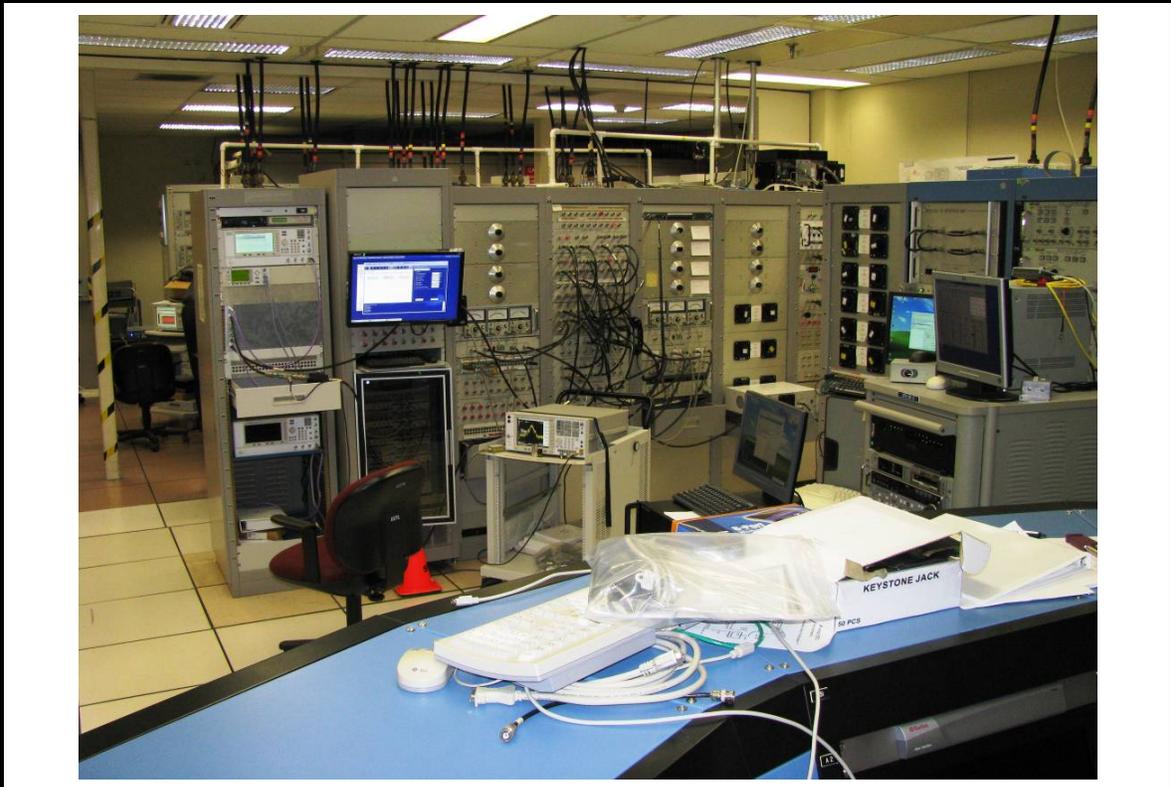
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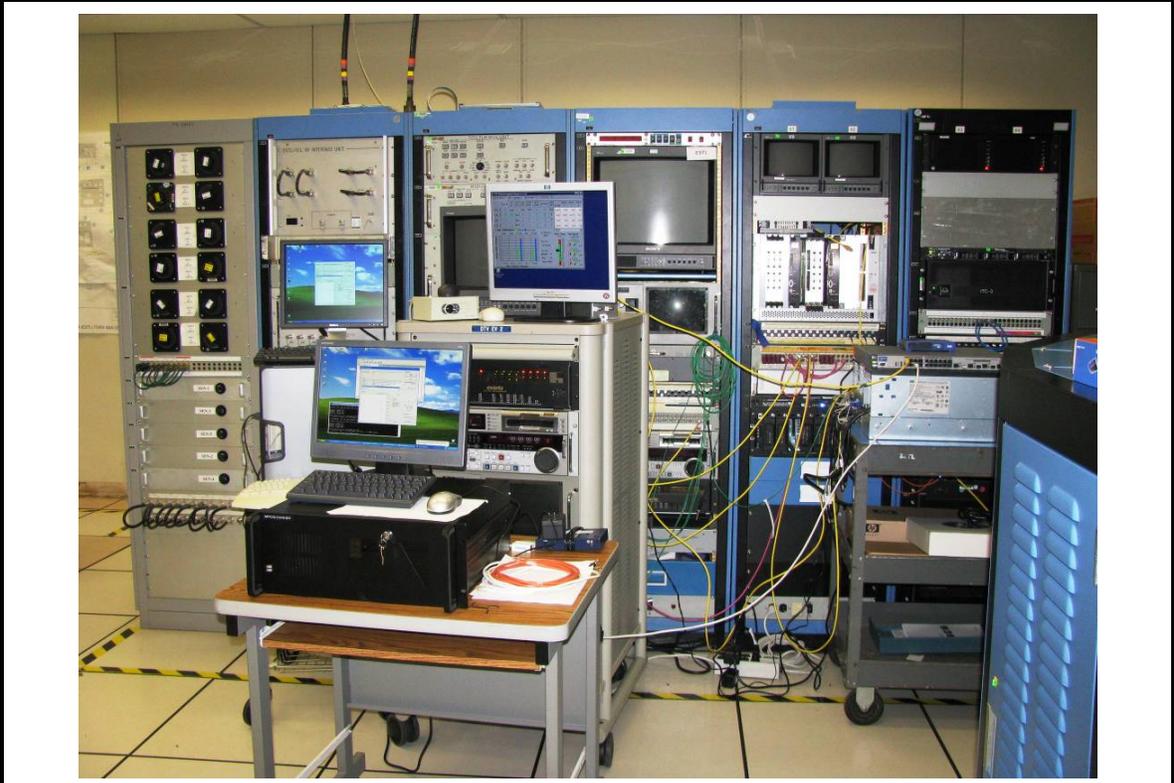
**CTDL -28**



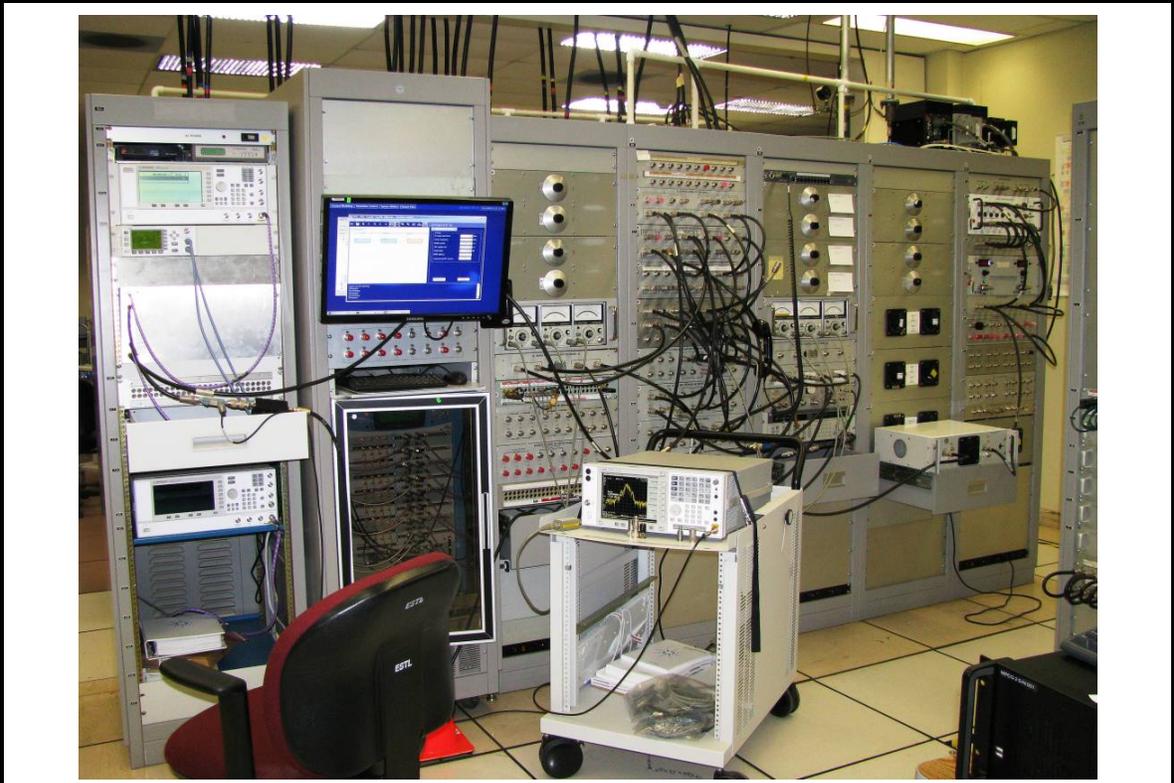
**CTDL -29**



**CTDL -30**



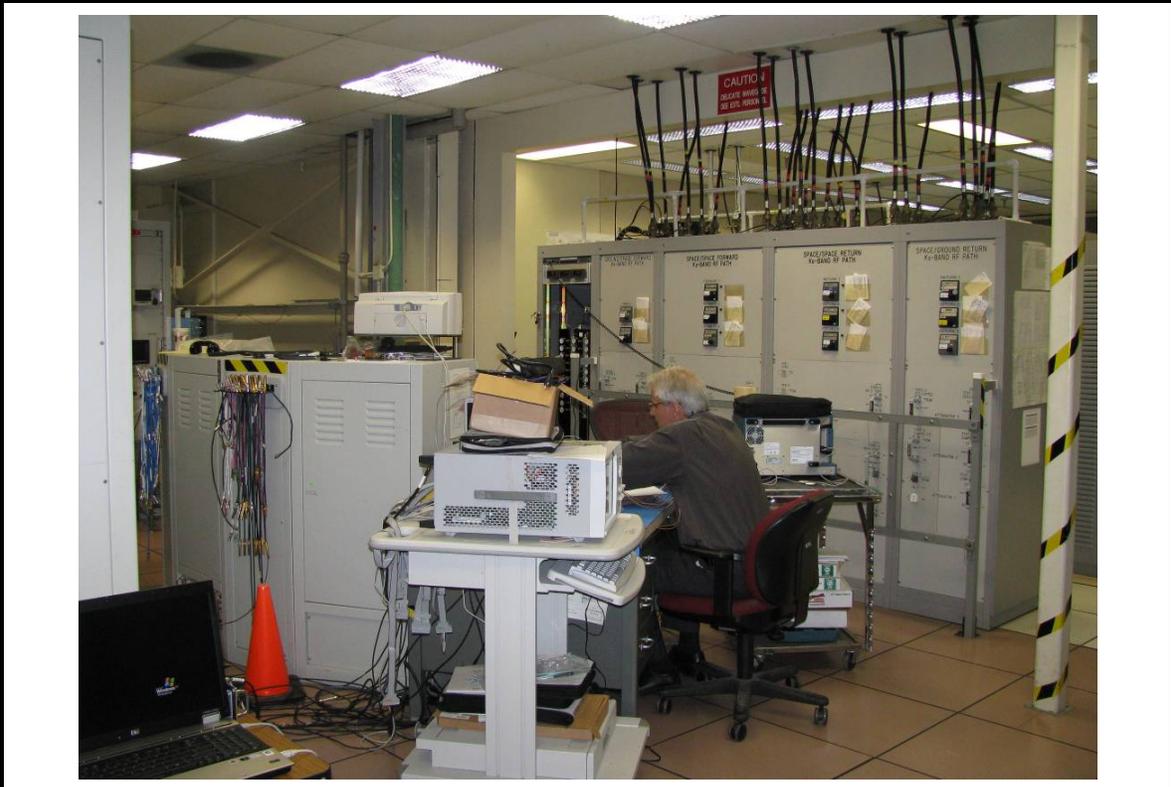
**CTDL -31**



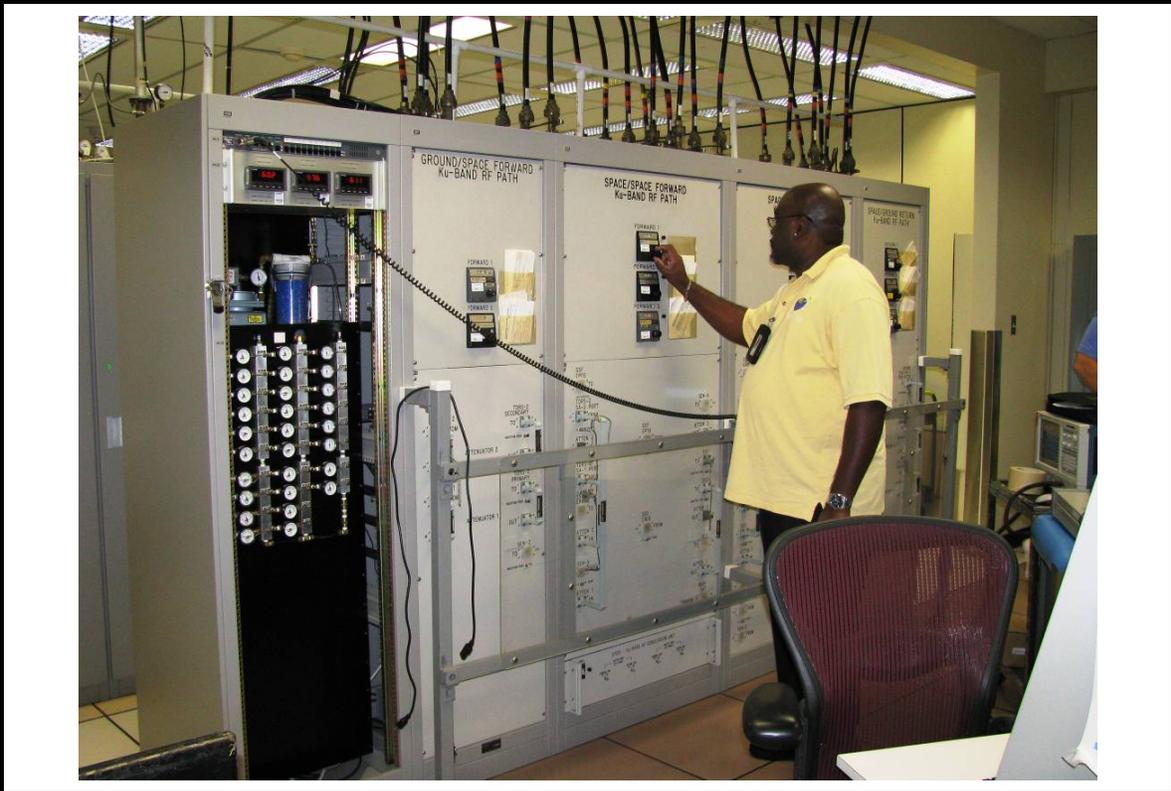
**CTDL -32**



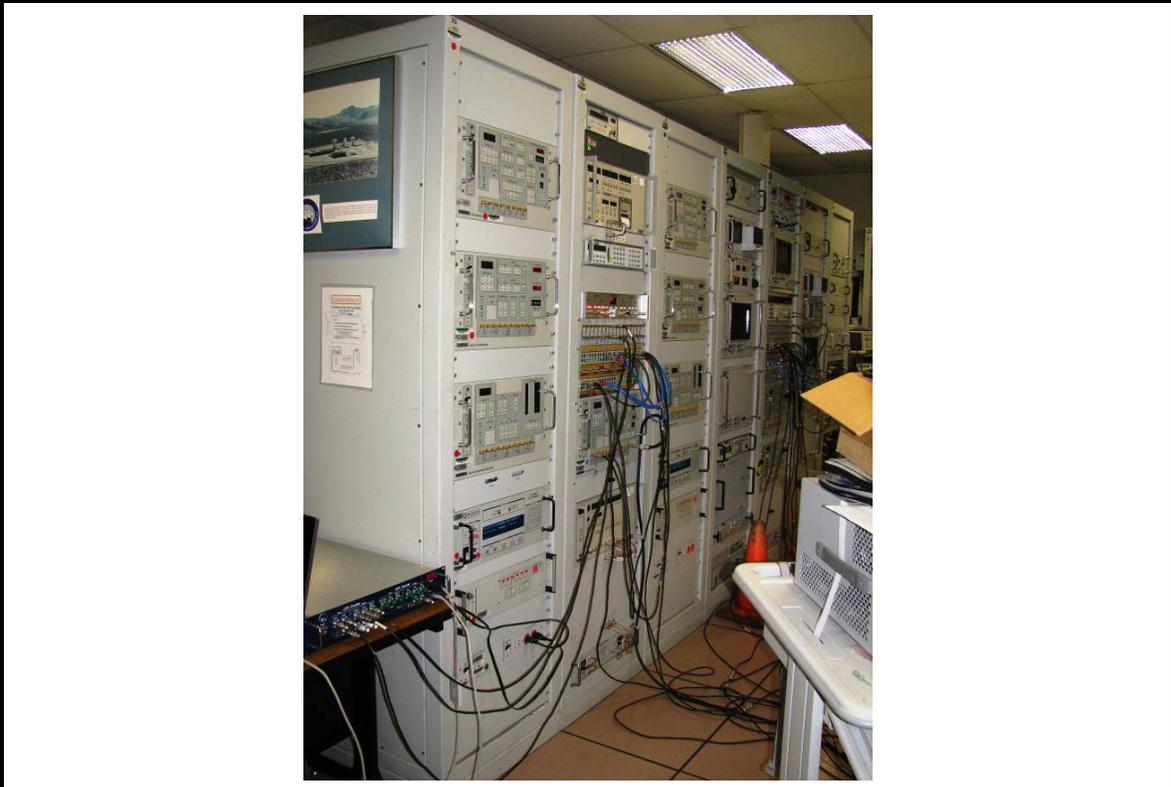
**CTDL -33**



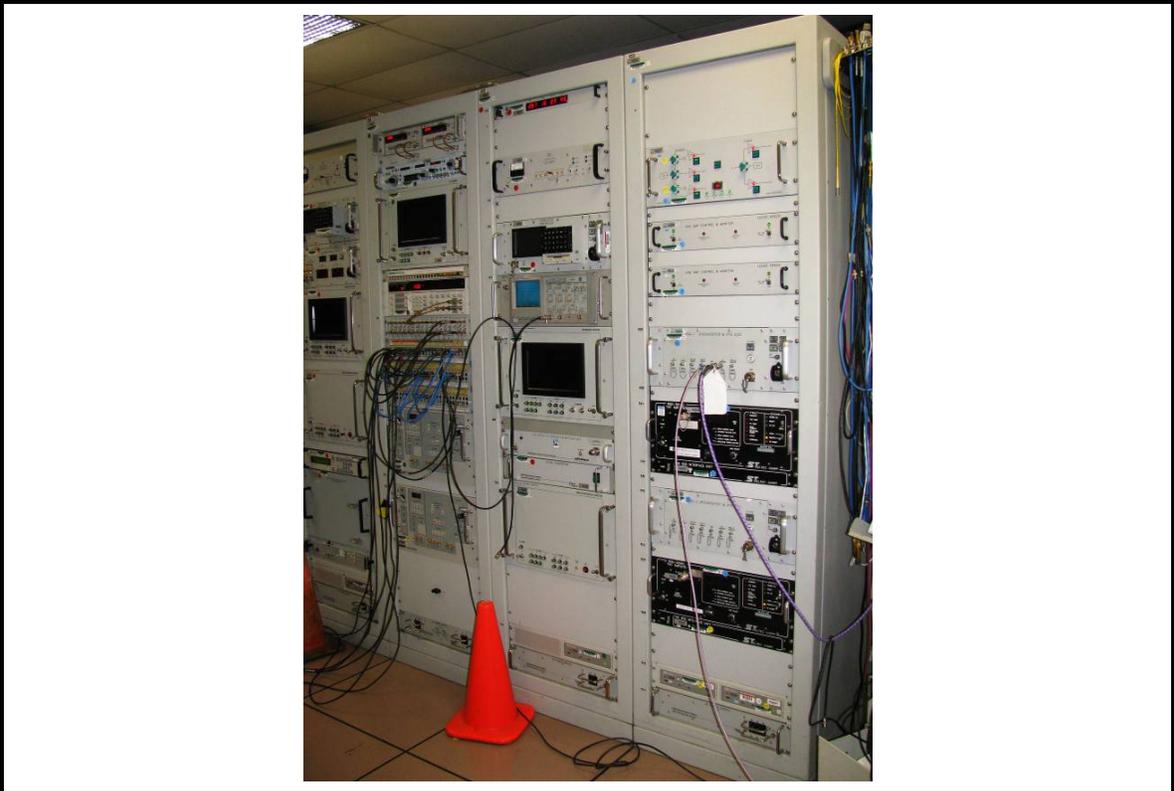
**CTDL -34**



**CTDL -35**



**CTDL -36**



**CTDL -37**



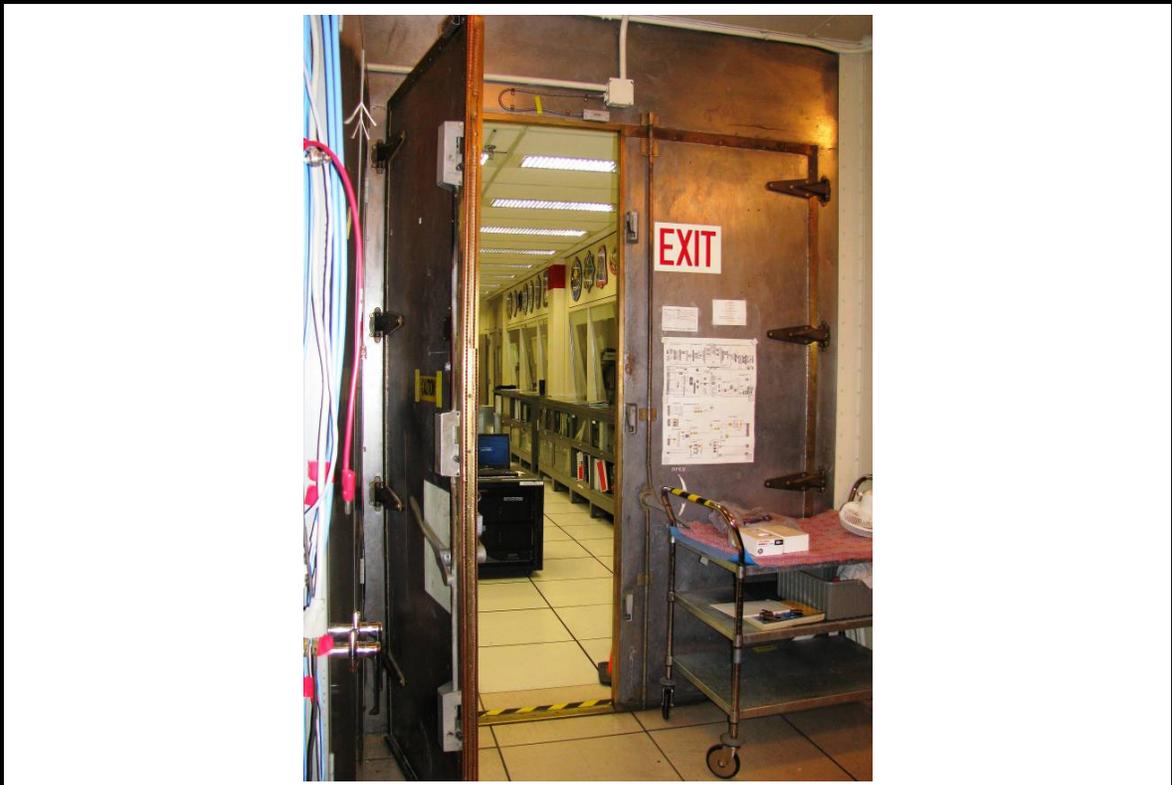
**CTDL -38**



**CTDL -39**



**CTDL -40**



**CTDL -41**



**CTDL -42**



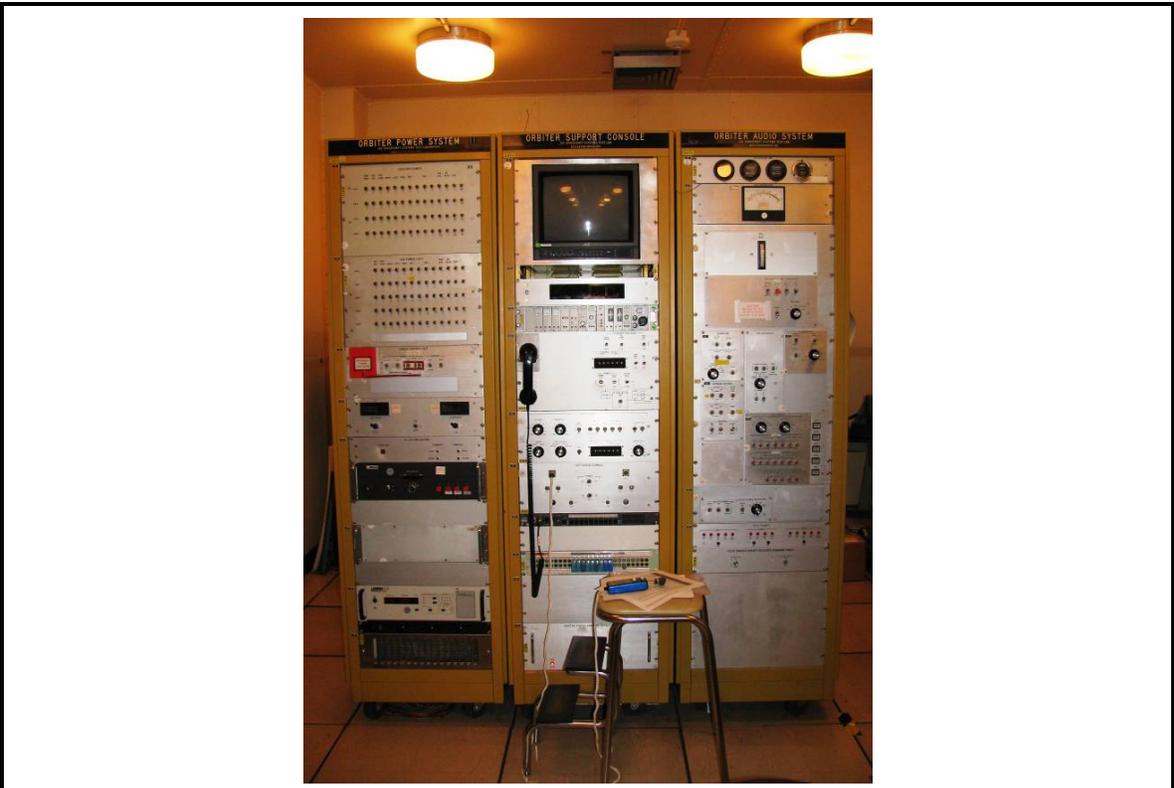
**CTDL -43**



**CTDL -44**



**CTDL -45**



**CTDL -46**



CTDL -47



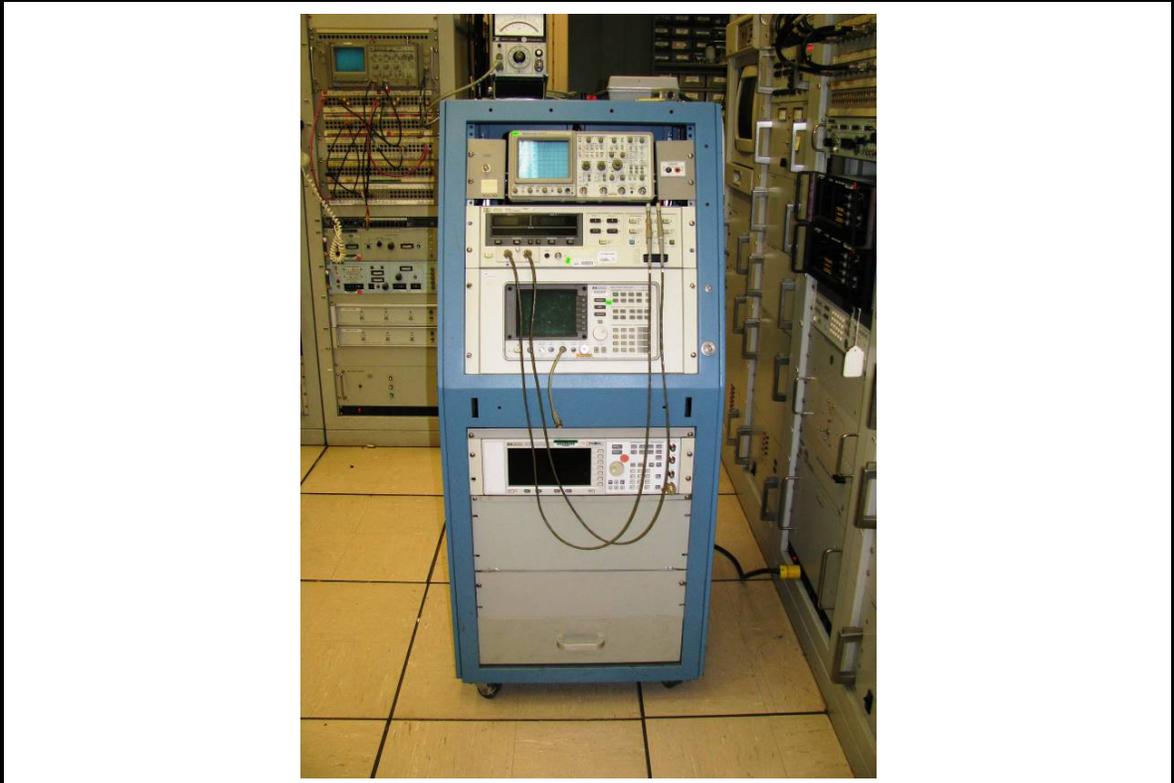
CTDL -48



**CTDL -49**



**CTDL -50**



**CTDL -51**



**CTDL -52**



**CTDL -53**



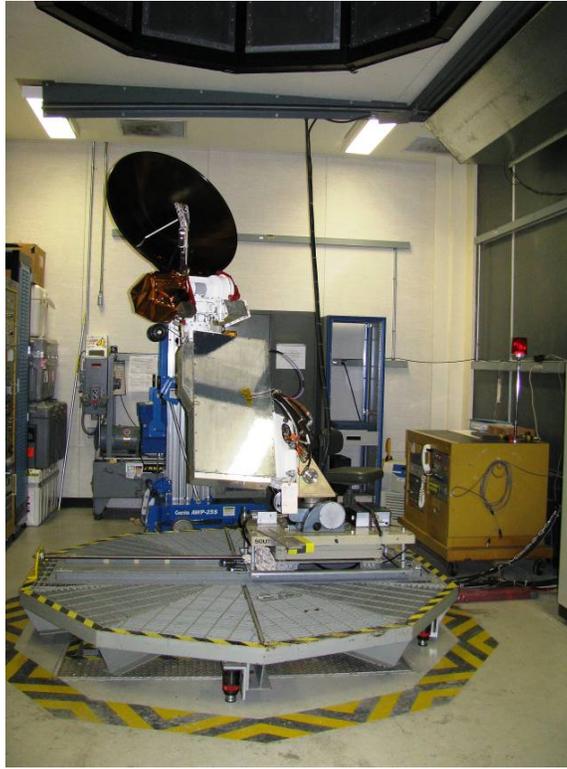
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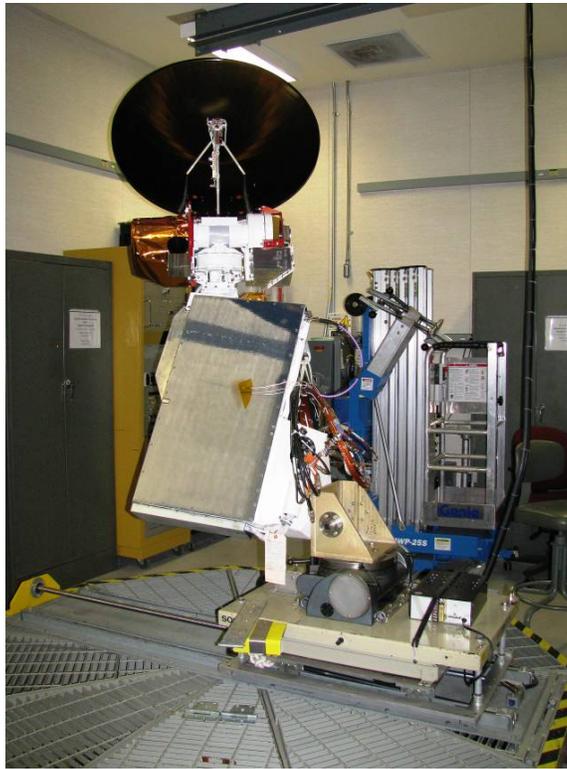
**CTDL -55**



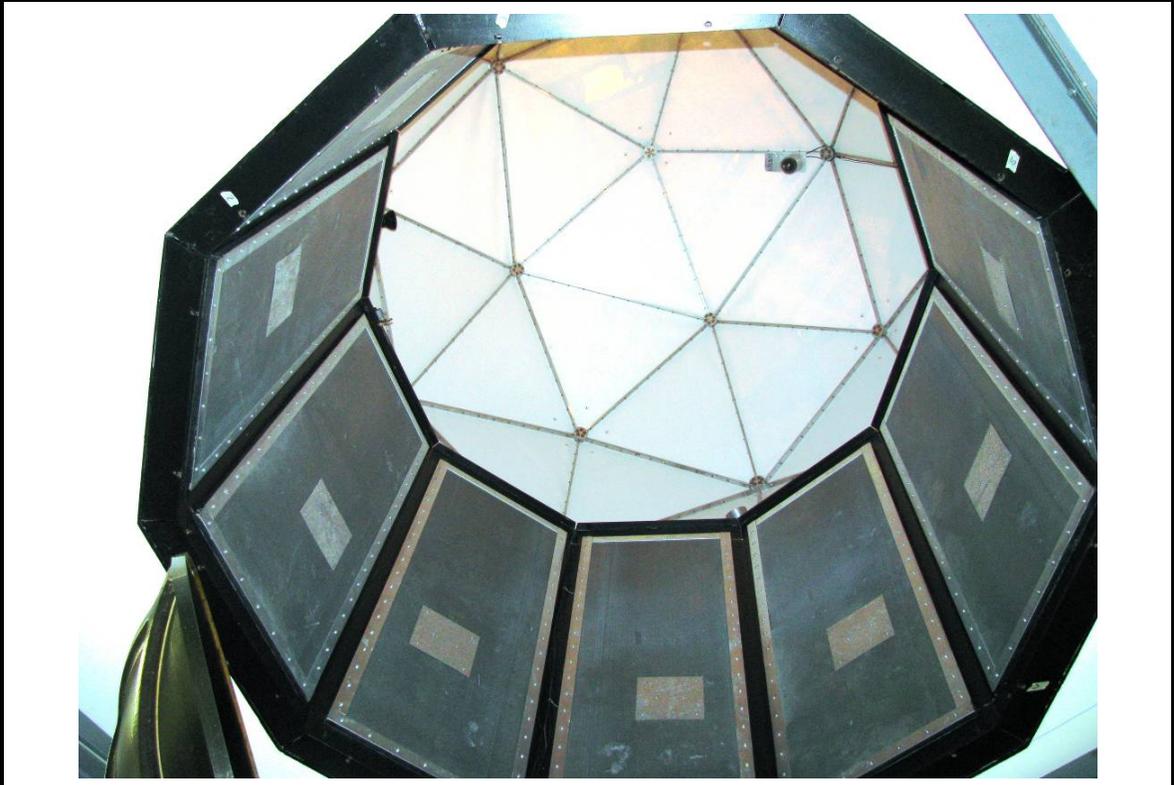
**CTDL -56**



**CTDL -57**



**CTDL -58**



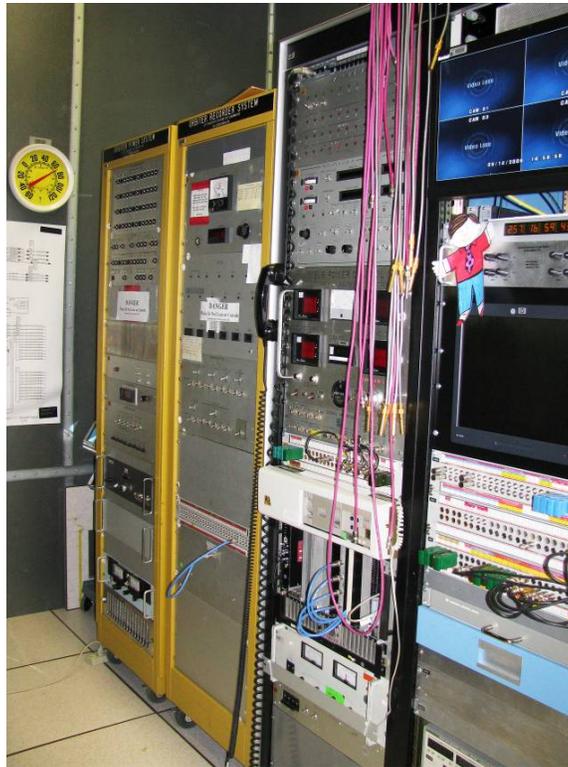
**CTDL -59**



**CTDL -60**



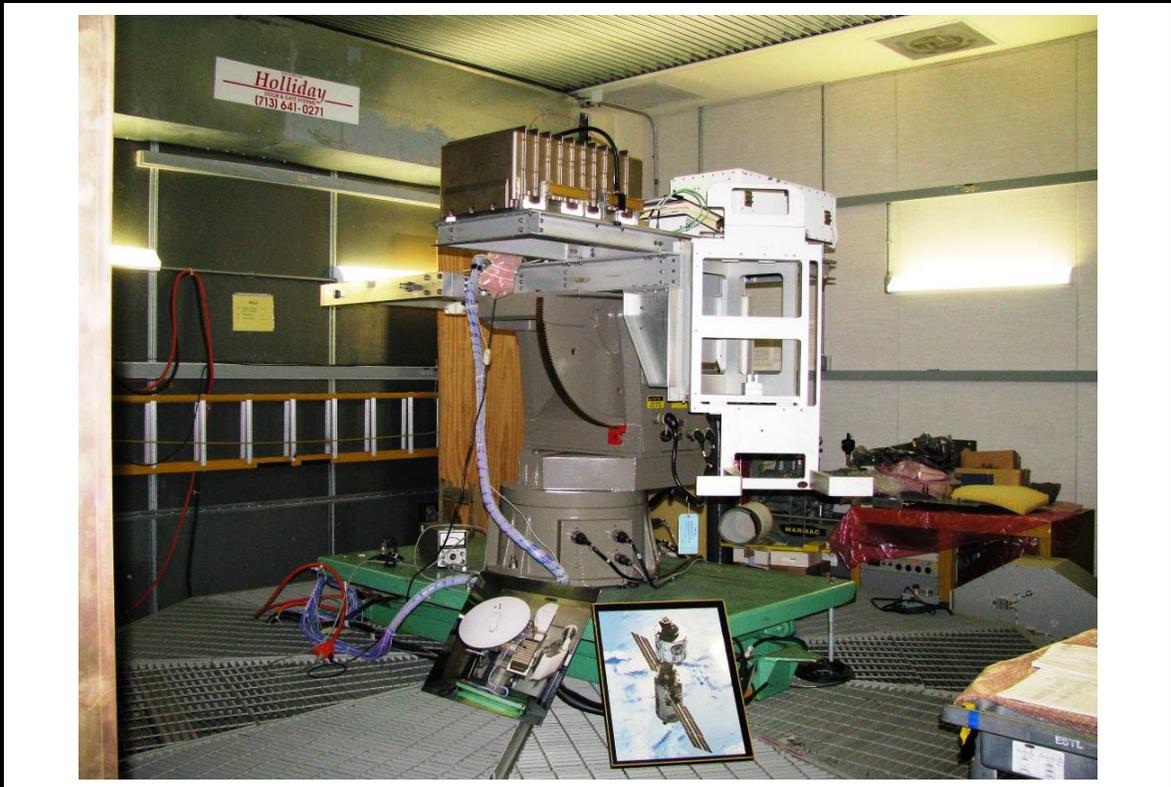
**CTDL -61**



**CTDL -62**



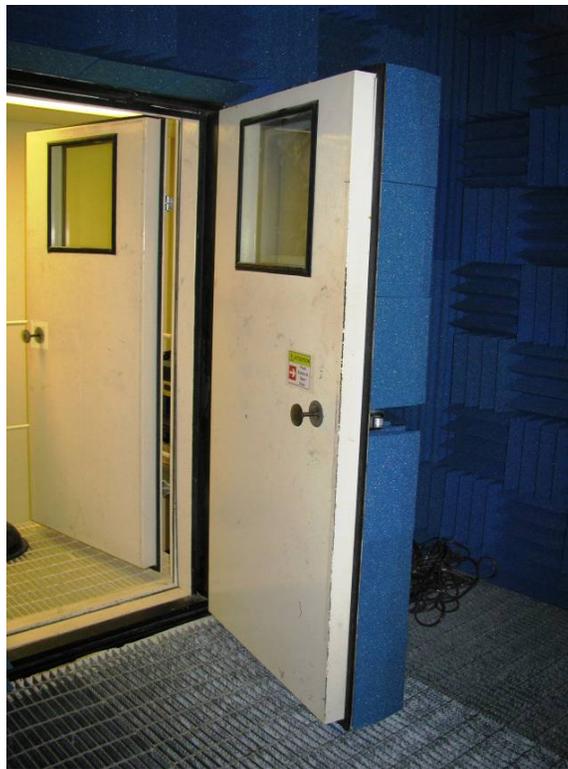
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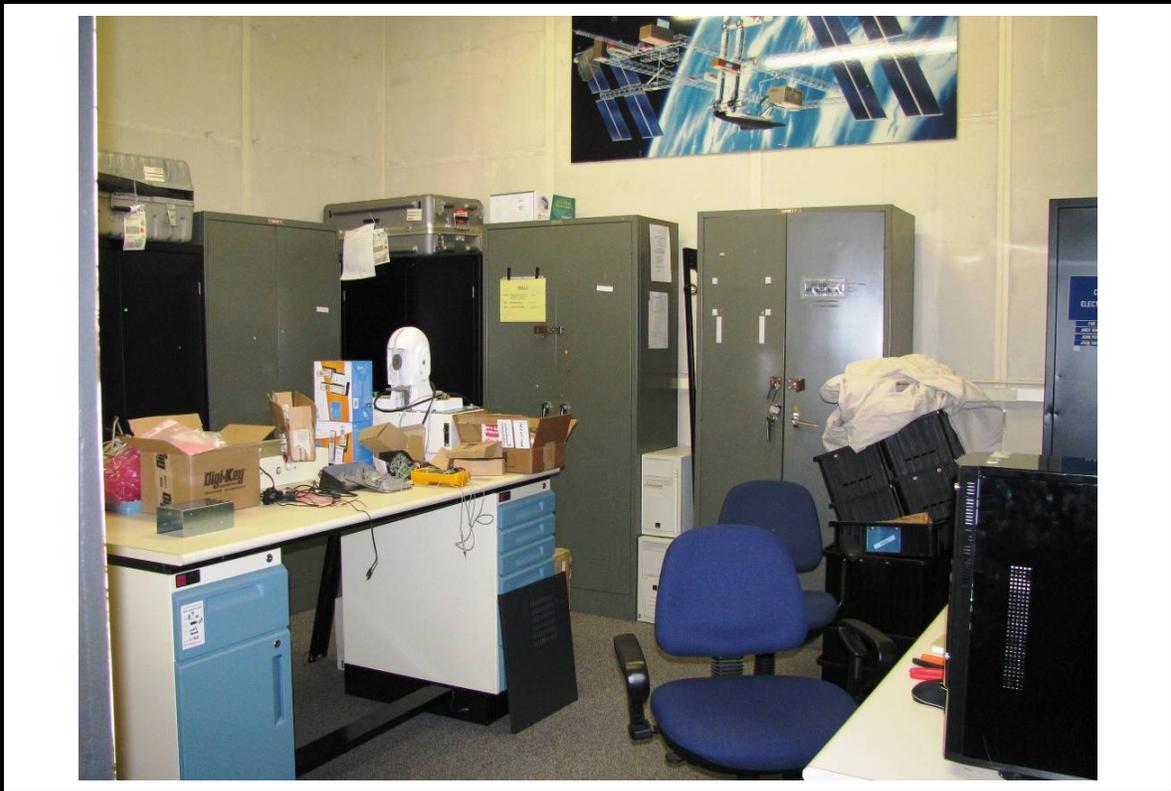
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**CTDL -65**



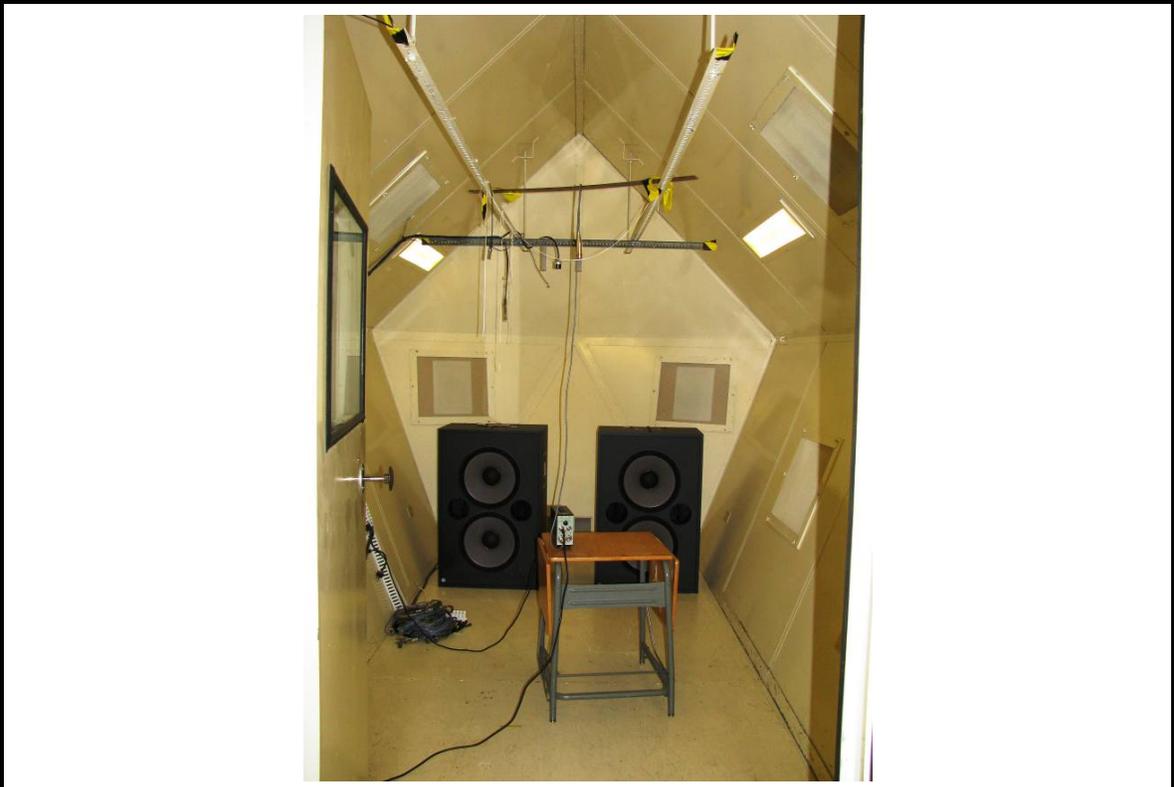
**CTDL -66**



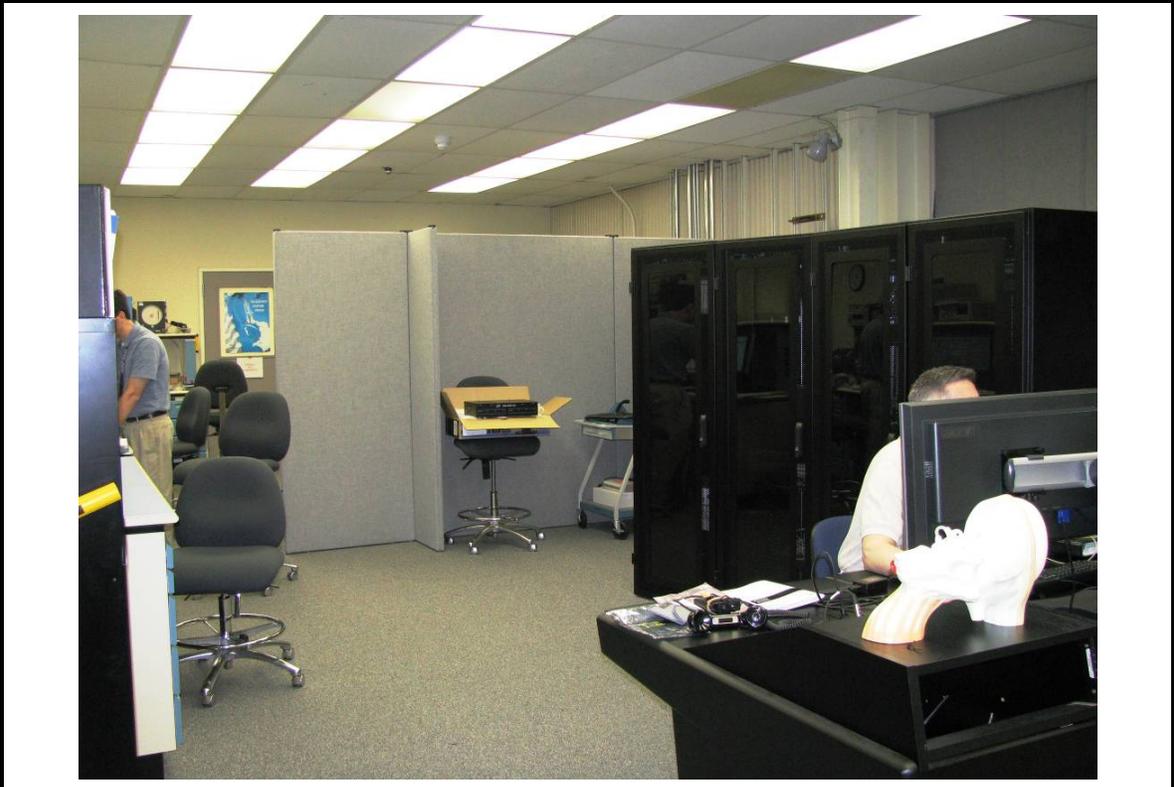
**CTDL -67**



**CTDL -68**



**CTDL -69**



**CTDL -70**



**CTDL -71**

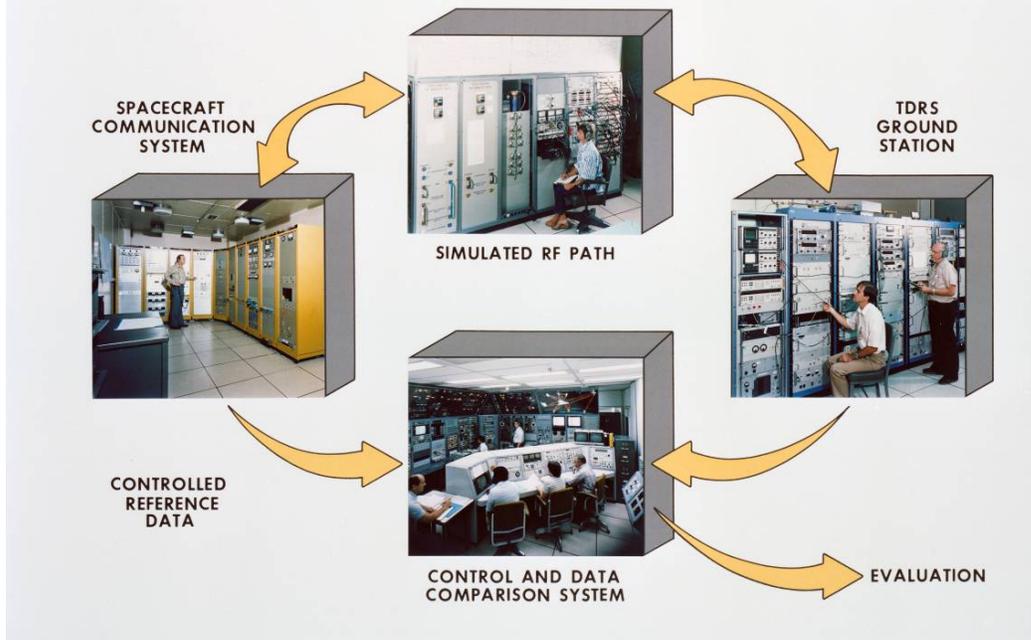


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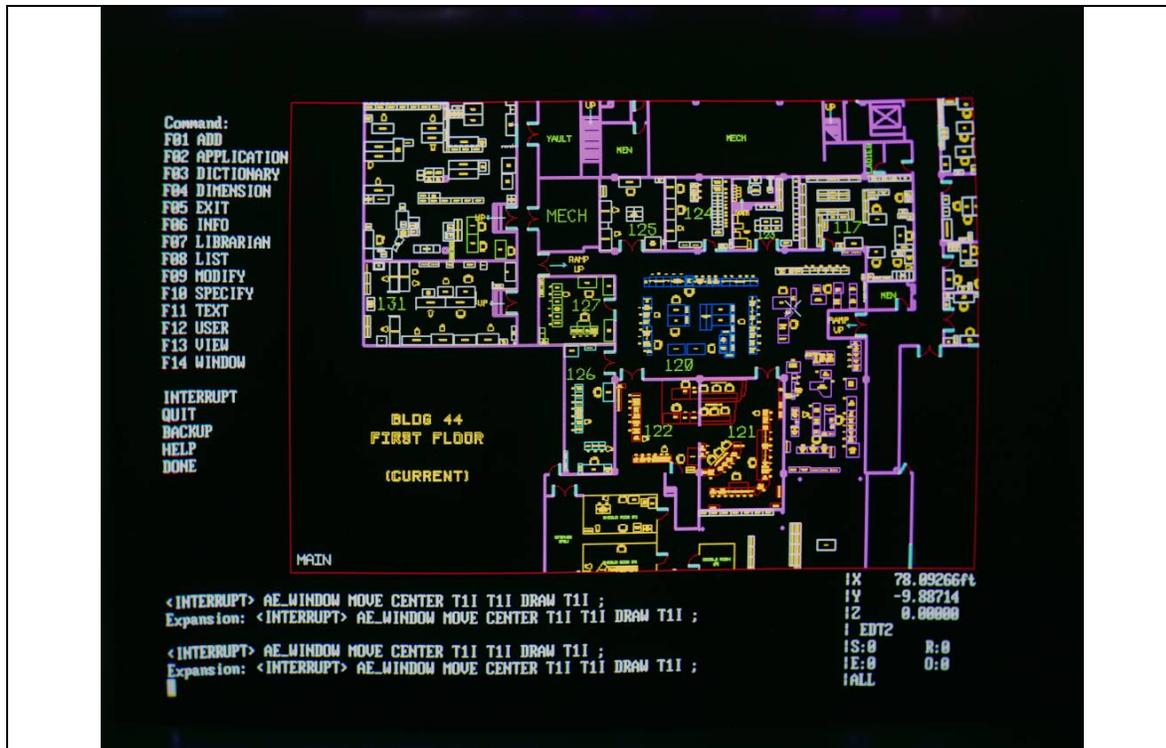


**CTDL -73**

### ELECTRONIC SYSTEMS TEST LABORATORY



**CTDL -74**



CTDL -75



CTDL -76



**CTDL -77**



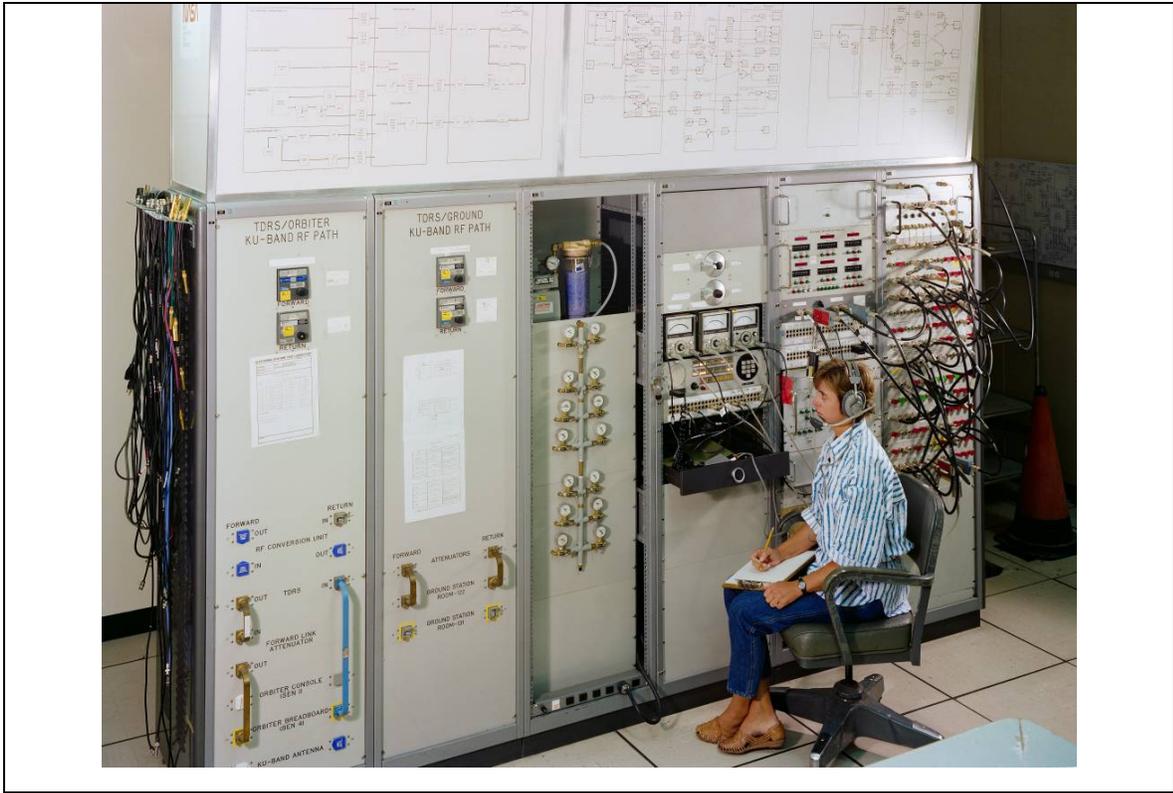
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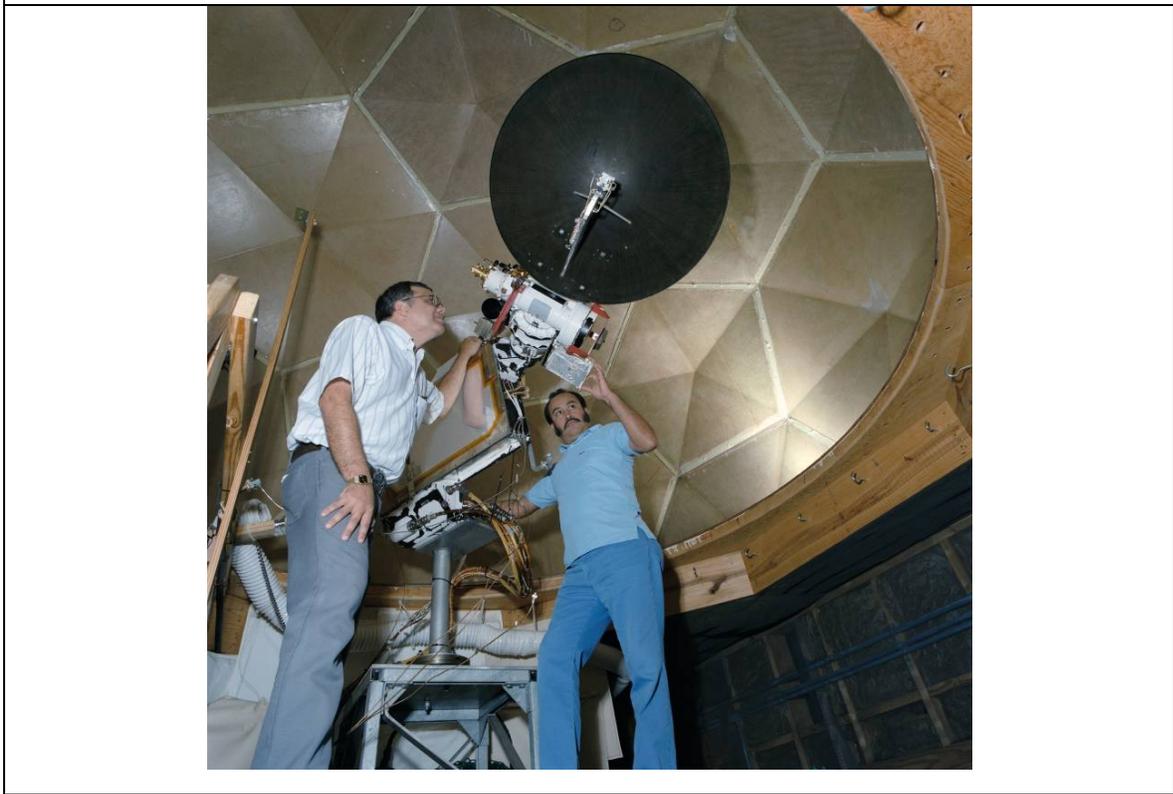
**CTDL -79**



**CTDL -80**



**CTDL -81**



**CTDL -82**



**CTDL -83**



**CTDL -84**



**CTDL -85**



**CTDL -86**



**CTDL -87**



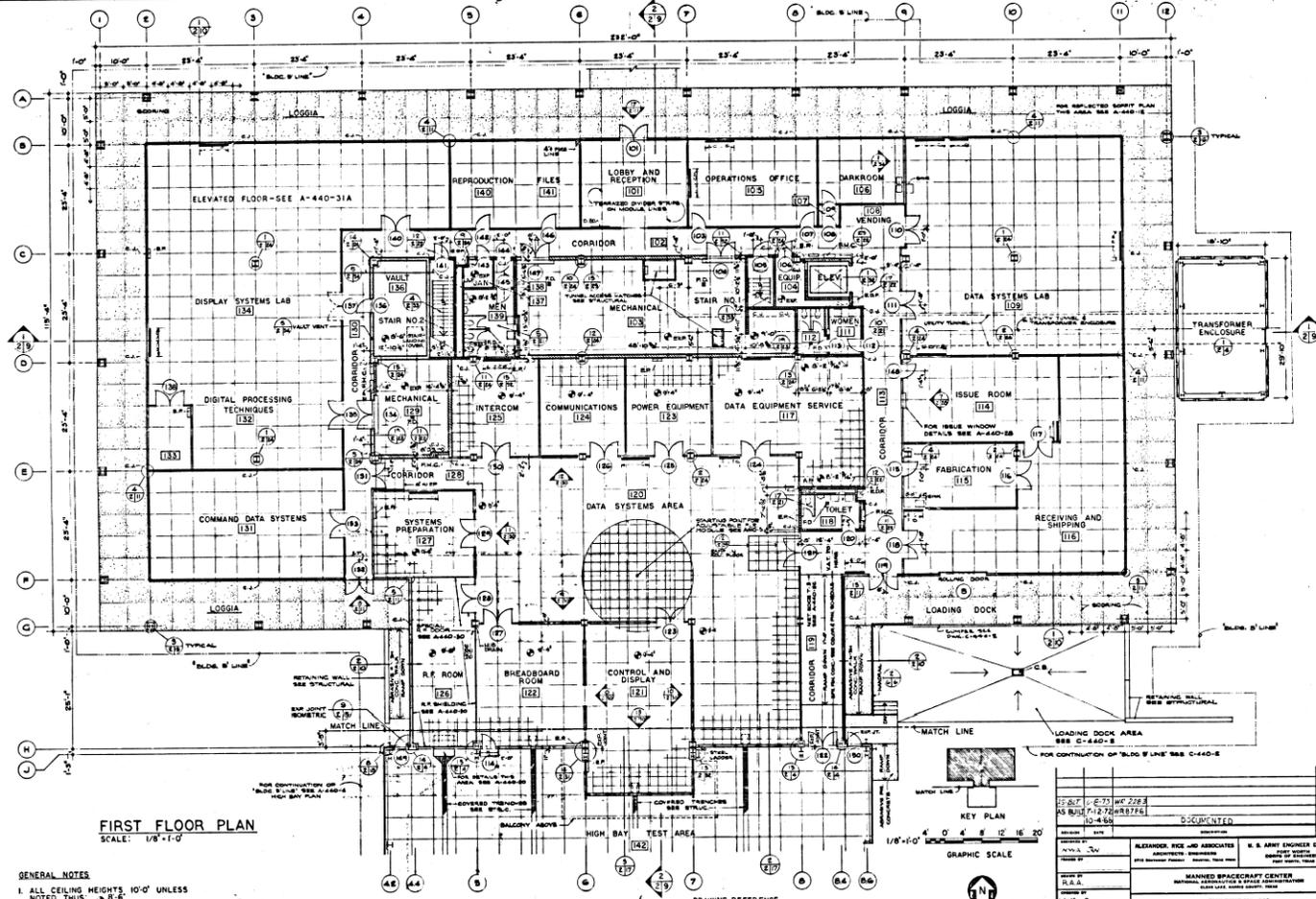
**CTDL -88**



**CTDL -89**



**CTDL -90**



FIRST FLOOR PLAN  
SCALE: 1/8" = 1'-0"

GENERAL NOTES

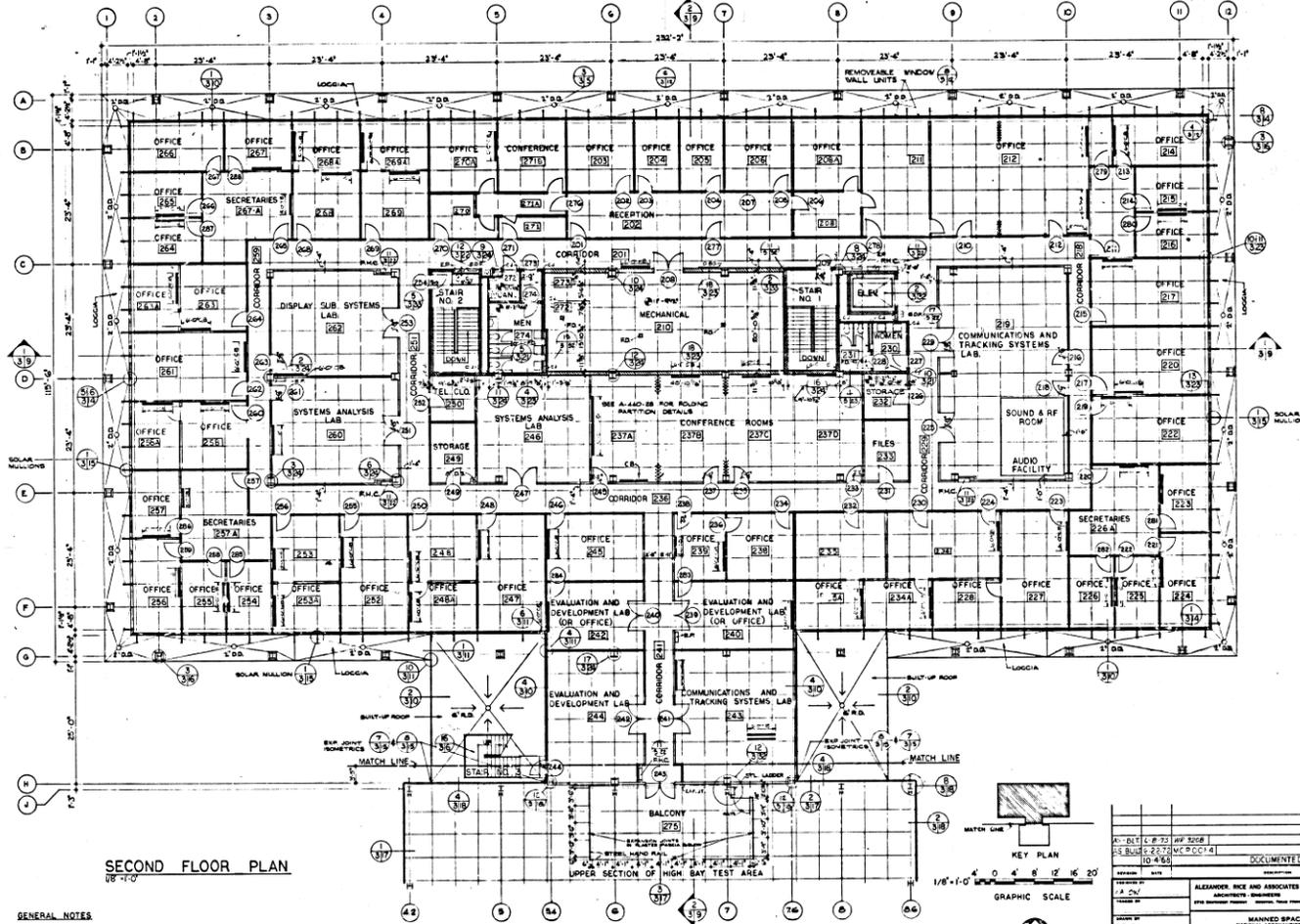
1. ALL CEILING HEIGHTS, 10'-0" UNLESS NOTED THUS: 8'-6"
2. EXP. INDICATES NO FINISHED CEILING STRUCTURE EXPOSED & FIREPROOFING
3. PARTITION CENTERLINES ARE ON 4'-8" MODULE LINES UNLESS OTHERWISE INDICATED
4. DOOR OPENINGS ARE CENTERED ON MODULE OS ON MODULE LINES UNLESS OTHERWISE INDICATED
5. ALL DIMENSIONS ARE TO FINISH WALL UNLESS OTHERWISE INDICATED
6. B.B. INDICATES LOCATION OF BULLETIN BOARD SEE DWG. A-440-22 FOR DETAILS
7. PROVIDE CONTROL JOINTS IN WALLS WHERE INDICATED ON PLAN BY "C.J."
8. SEE DWGS. A-440-19&20 FOR LOCATIONS WHERE W.T. V.B. ARE ADDITIVE NO.1

DRAWING REFERENCE

- EXTERIOR ELEVATIONS A-440-748
- CONTROL JOINTS IN MASONRY WALLS A-440-33
- CONTROL JOINTS IN G.W.B. PARTITIONS A-440-23
- CONTROL JOINTS IN EXT. ALUM. SIDING A-440-11
- TOILET PLANS & ELEVATIONS A-440-21
- COLOR & FINISH SCHEDULE A-440-19&20
- DOOR SCHEDULE A-440-26
- COLUMN DETAILS A-440-24
- INTERIOR PARTITIONS A-440-23
- ABBREVIATIONS & SYMBOLS A-440-1



PROJECT NO.	AS 83587-1-270	DATE	10-6-59
DESIGNED BY	W. A. J. W.	CHECKED BY	W. A. J. W.
DATE	10-6-59	BY	W. A. J. W.
PROJECT	ELECTRONIC SYSTEMS COMPATIBILITY FACILITY		
WORK	FIRST FLOOR PLAN NORTH WING		
DATE	FEB 60		



SECOND FLOOR PLAN  
1/8" = 1'-0"

GENERAL NOTES

1. ALL CEILING HEIGHTS, 8'-6" UNLESS NOTED THIS: @ 10'-0"
2. EXP INDICATES NO CEILING-STRUCTURE EXPOSED FIREPROOFING
3. PARTITION CENTER LINES ARE ON 4'-0" MODULE LINES UNLESS OTHERWISE INDICATED
4. DOOR OPENINGS ARE CENTERED ON MODULE OR CM MODULE LINES UNLESS OTHERWISE INDICATED
5. ALL DIMENSIONS ARE TO FINISH WALL UNLESS OTHERWISE INDICATED
6. DES INDICATES LOCATION OF DIRECTORY BOARD SEE DWG A-440-22 FOR DETAILS
7. PROVIDE CONTROL JOINTS IN WALLS WHERE INDICATED ON PLAN BY "CJ"
8. SEE DWGS A-440-19 & 20 FOR LOCATIONS WHERE VIT # 4 VS ARE ADDITIVE NO. 1

DRAWING REFERENCE

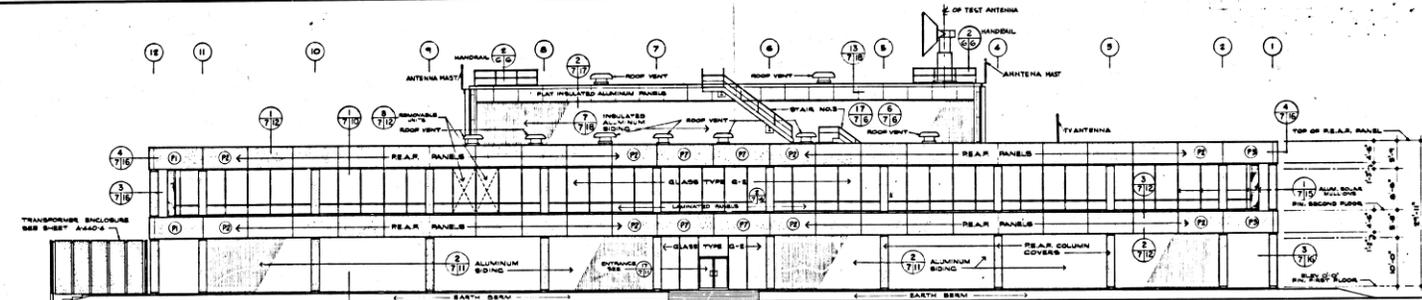
- EXTERIOR ELEVATIONS
- CONTROL JOINTS IN MASONRY WALLS
- CONTROL JOINTS IN GWB PARTITIONS
- ALUMINUM SOLAR MULLIONS
- TOILET PLANS & ELEVATIONS
- COLOR & FINISH SCHEDULE
- DOCN SCHEDULE
- COLUMN DETAILS
- INTERIOR PARTITIONS
- ABBREVIATIONS & SYMBOLS

- A-440-748
- A-440-33
- A-440-23
- A-440-15
- A-440-21
- A-440-19 & 20
- A-440-26
- A-440-24
- A-440-23
- A-440-1

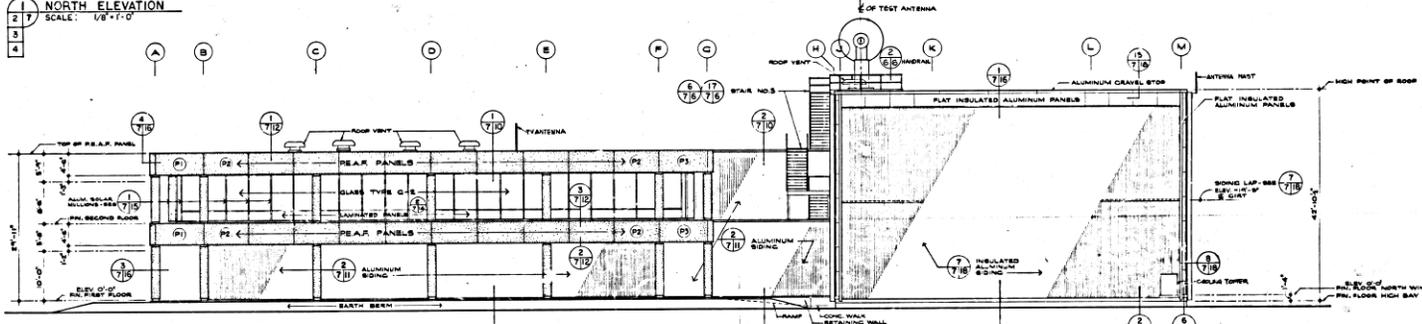


A-440-748 SS-BLDG-2272 W/P 3208 10-1-62		DOCUMENTED	STC
ALEXANDER, RICE AND ASSOCIATES ARCHITECTS 4714 BROADWAY, SUITE 1000, NEW YORK, N.Y.		U. S. ARMY ENGINEER DISTRICT HEADQUARTERS OFFICE OF FACILITIES FORT MONTESSANO, TEXAS	
MANAGED SPACECRAFT CENTER NATIONAL AERONAUTICS & SPACE ADMINISTRATION 3601 LANE, DALLAS COUNTY, TEXAS		BUILDING NO. 440	
DRAWN BY: [Signature]		CHECKED BY: [Signature]	
DESIGNED BY: [Signature]		DATE: FEB 65	

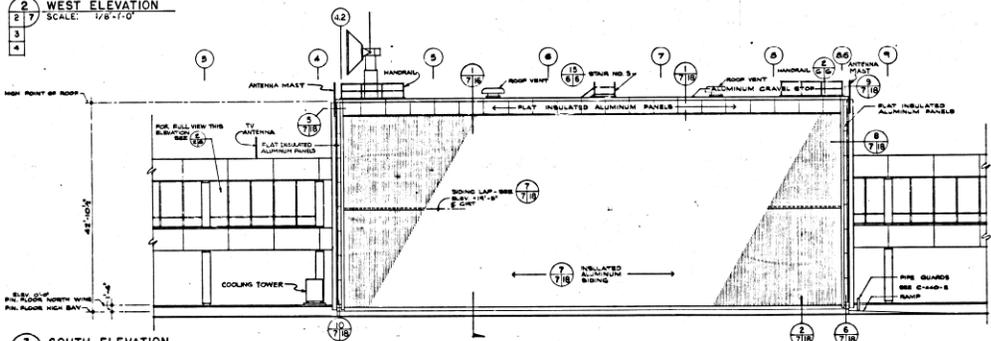




1 NORTH ELEVATION  
SCALE: 1/8"=1'-0"



2 WEST ELEVATION  
SCALE: 1/8"=1'-0"

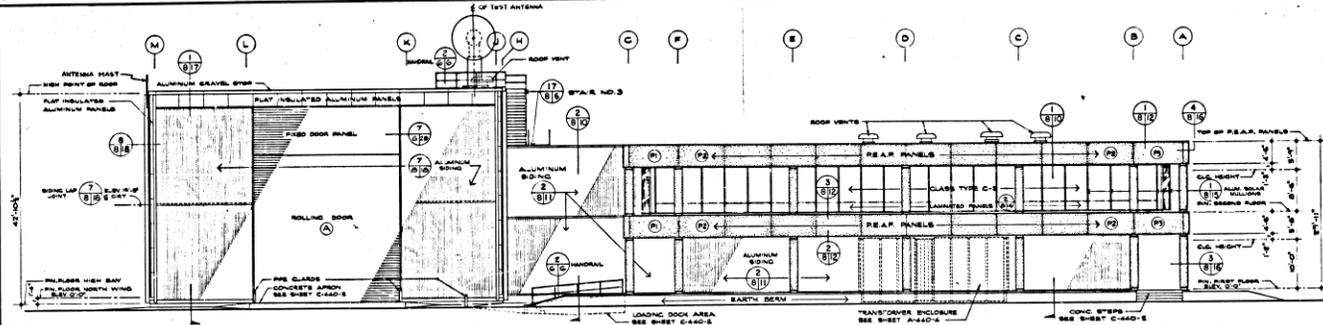


3 SOUTH ELEVATION  
SCALE: 1/8"=1'-0"

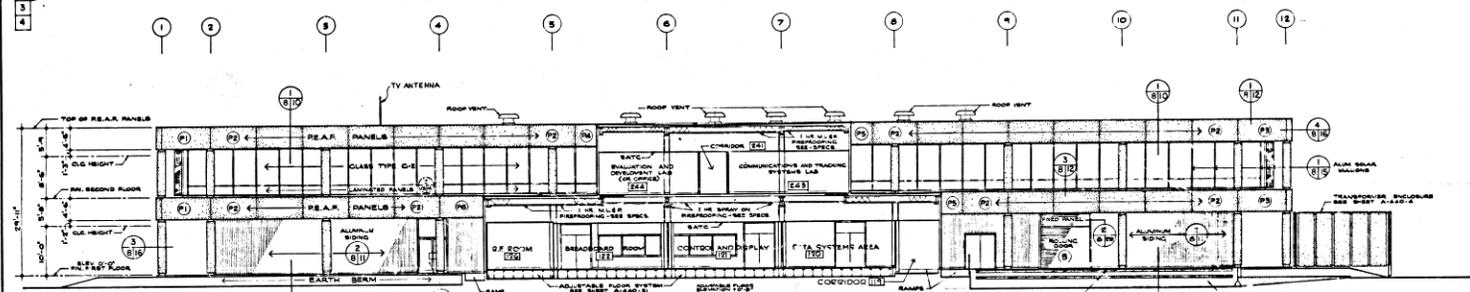
- EXTERIOR COLOR AND FINISH SCHEDULE**
- 1 REAR PANELS
  - 2 ALUMINUM RIBBED SIDING
  - 3 FLAT INSULATED PANELS
  - 4 ALUMINUM W/C S. PANELS, ETC.
  - 5 ALUMINUM FLASHING & TRIM
  - 6 ALUMINUM WINDOW WALL SOLAR MULLIONS AND ENTRANCES
  - 7 EXPOSED QUARTZ AGGREGATE AND WHITE PORTLAND CEMENT - SEE SPEC.
  - 8 TACOR CATERGERSKI DEKAT G-610-AS57 ON EXTERIOR - SEE SPEC.
  - 9 COLOR AND FINISH SCHEDULE FOR COLOR OF ALUMINUM BEAM HEADS EXPOSED ON INTERIOR - SEE IN SCHEDULE
  - 10 ALUMINUM TRIMS TO MATCH IN COLOR AND FINISH TO MATCH RIBBED SIDING UNLESS NOTED OTHERWISE ON DETAILS IN WHICH ANNOTATED - SEE SPEC.
- (CONTINUED ON DWG. A-440-B)

1/8"=1'-0" 0' 4' 8' 12' 16' 20'  
GRAPHIC SCALE

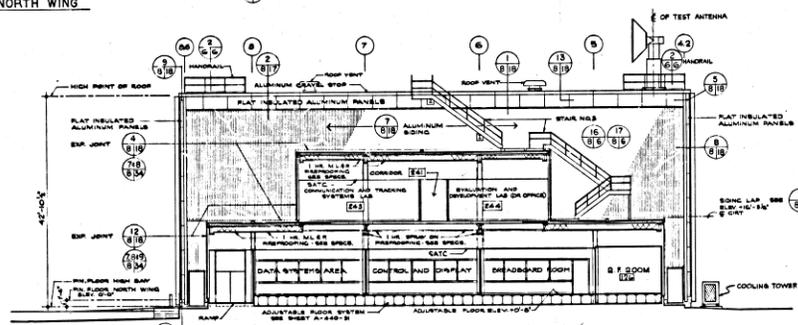
DATE	10-2-53	REVISION	RECORDED	STC
DESIGNED BY	ALEXANDER, ROSS AND ASSOCIATES			
CHECKED BY	ALEXANDER, ROSS AND ASSOCIATES			
DATE	FEB 1955			
PROJECT	ELECTRONIC SYSTEMS COMPATIBILITY FACILITY			
LOCATION	FEDERAL BUREAU OF INVESTIGATION			
SCALE	AS SHOWN			
PROJECT NO.	20			
DESIGNER	ALEXANDER, ROSS AND ASSOCIATES			
ENGINEER	ALEXANDER, ROSS AND ASSOCIATES			
ARCHITECT	ALEXANDER, ROSS AND ASSOCIATES			
DATE	FEB 1955			



1 EAST ELEVATION  
SCALE: 1/8" = 1'-0"

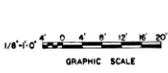


2 SOUTH ELEVATION NORTH WING  
SCALE: 1/8" = 1'-0"

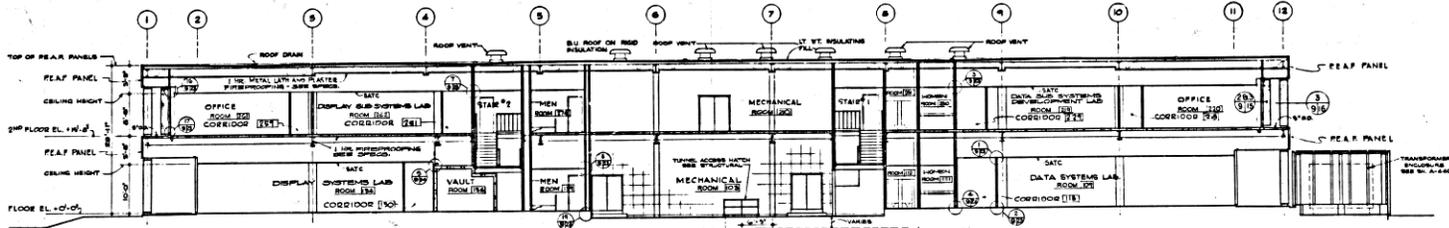


3 NORTH ELEVATION HIGH BAY  
SCALE: 1/8" = 1'-0"

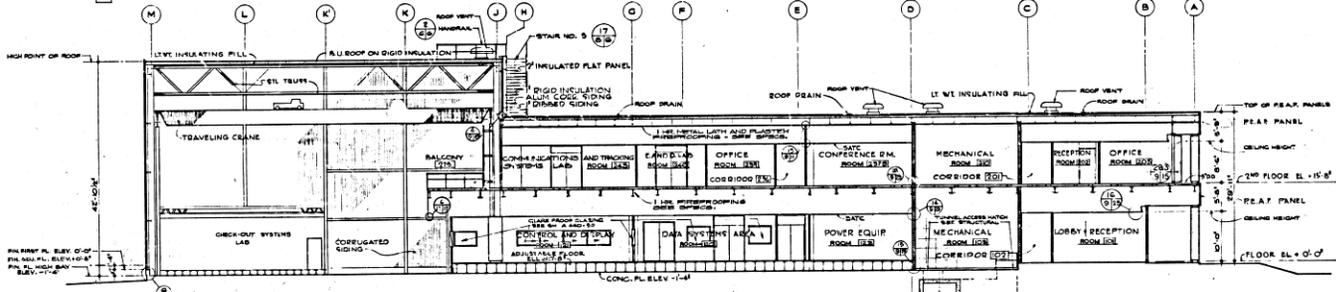
- EXTERIOR COLOR AND FINISH SCHEDULE (CONT FROM SHEET A-440.7)**
- 7. LAMINATED PANELS BLACK PORCELAIN-GLOSS STEEL FINISH - SEE SPECS.
  - 8. EXTERIOR METAL DOORS AND FRAMES (EXCEPT ALUMINUM) ROLLING DOORS AND PANELS METAL GATES AND PLUMBING AT TRANSFORMER ENCLOSURE. FED. STD. COLOR 45177, NASA BLUE
  - 9. ALL FERROUS VERTICAL VENTS, STACKS, CHIMNEYS, ETC. FED. STD. COLOR Z6440, GRAY
  - 10. STEEL SCOFFITS WHITE PORTLAND CEMENT - SEE SPECS.
  - 11. STAIR NO. 31 HANDRAILS ON HIGH BAY GALVANIZED - NATURAL
  - 12. ROOF AND NEAR LOADING DOCK



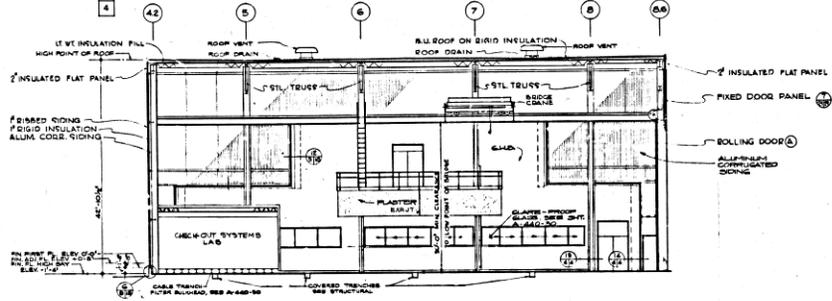
PROJECT NO.	30-468	DOCUMENTED	572
DESIGNED BY	ALEXANDER RICE AND ASSOCIATES	U. S. ARMY ENGINEER DISTRICT	DAAG 10-7000
CHECKED BY	DAVID W. HARRIS	DAAG 10-7000	DAAG 10-7000
DATE	FEB 75	21	
<b>MANNEDE SPACECRAFT CENTER</b> AIR FORCE DISTRICT OFFICE 1000 W. 10TH AVENUE DENVER, COLORADO 80202			
PROJECT TITLE	ELECTRONIC SYSTEMS COMPATIBILITY FACILITY		
EXTERIOR ELEVATIONS	BUILDING NO. 440		
DATE	FEB 75	440-8	9 36



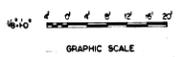
1 LONGITUDINAL SECTION



2 TRANSVERSE SECTION



3 LONGITUDINAL SECTION AT HIGH BAY

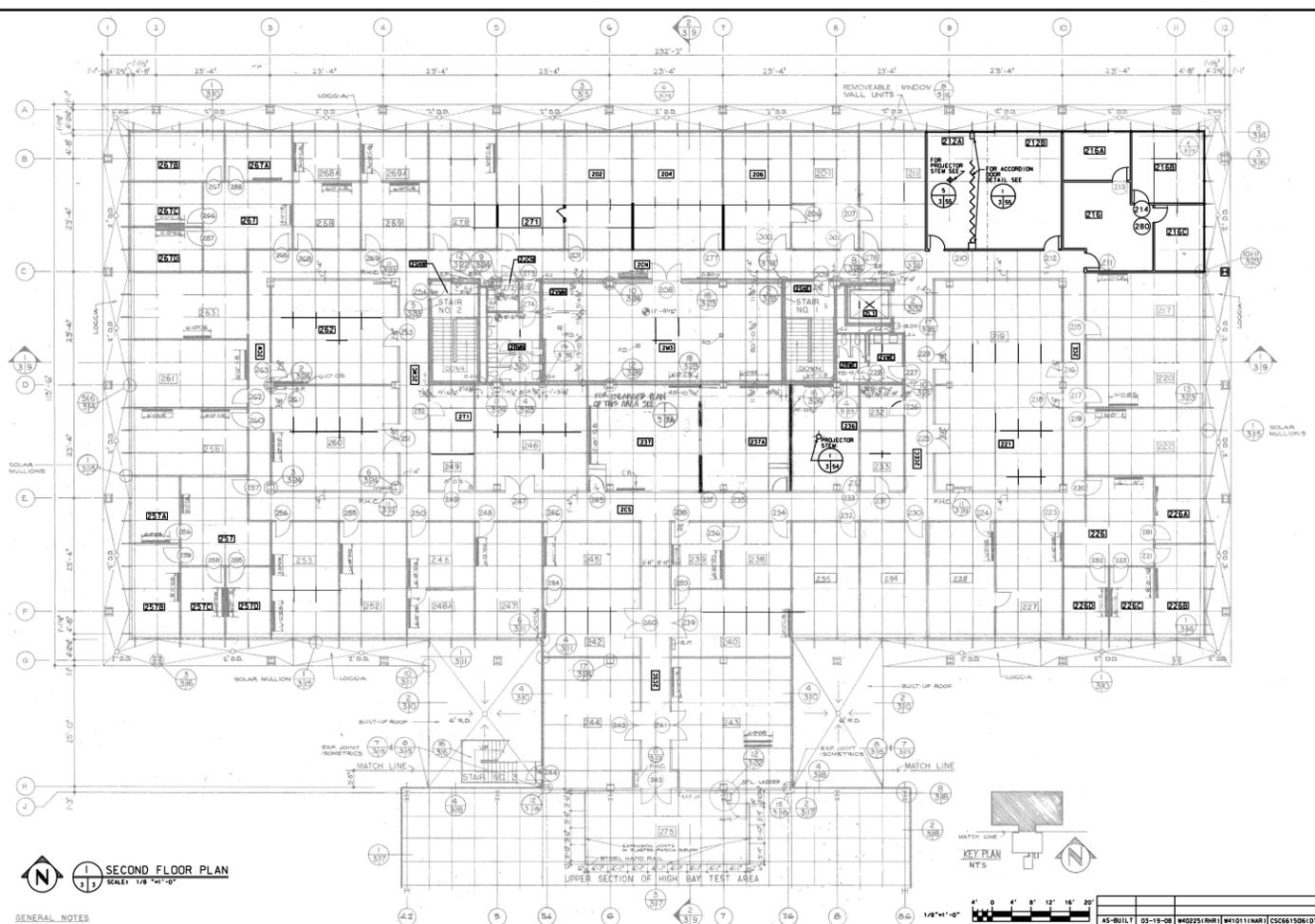


10-468	DOCUMENTED	SIC
WVA Div	ALEXANDER, RICE AND ASSOCIATES ARCHITECTS ENGINEERS	U. S. ARMY ENGINEER DISTRICT
D. B. D. R.	MAINTENANCE CENTER	22
WVA Div	BUILDING NO. 440	
	ELECTRONIC SYSTEMS COMPATIBILITY FACILITY	
	SECTIONS THRU BLDG.	
DATE	FEB '55	
SCALE	1/4" = 1'-0"	
PROJECT	10-440-9	
DESIGNED BY	WVA	
CHECKED BY	WVA	
APPROVED BY	WVA	









**1 SECOND FLOOR PLAN**  
SCALE: 1/8" = 1'-0"

**GENERAL NOTES**

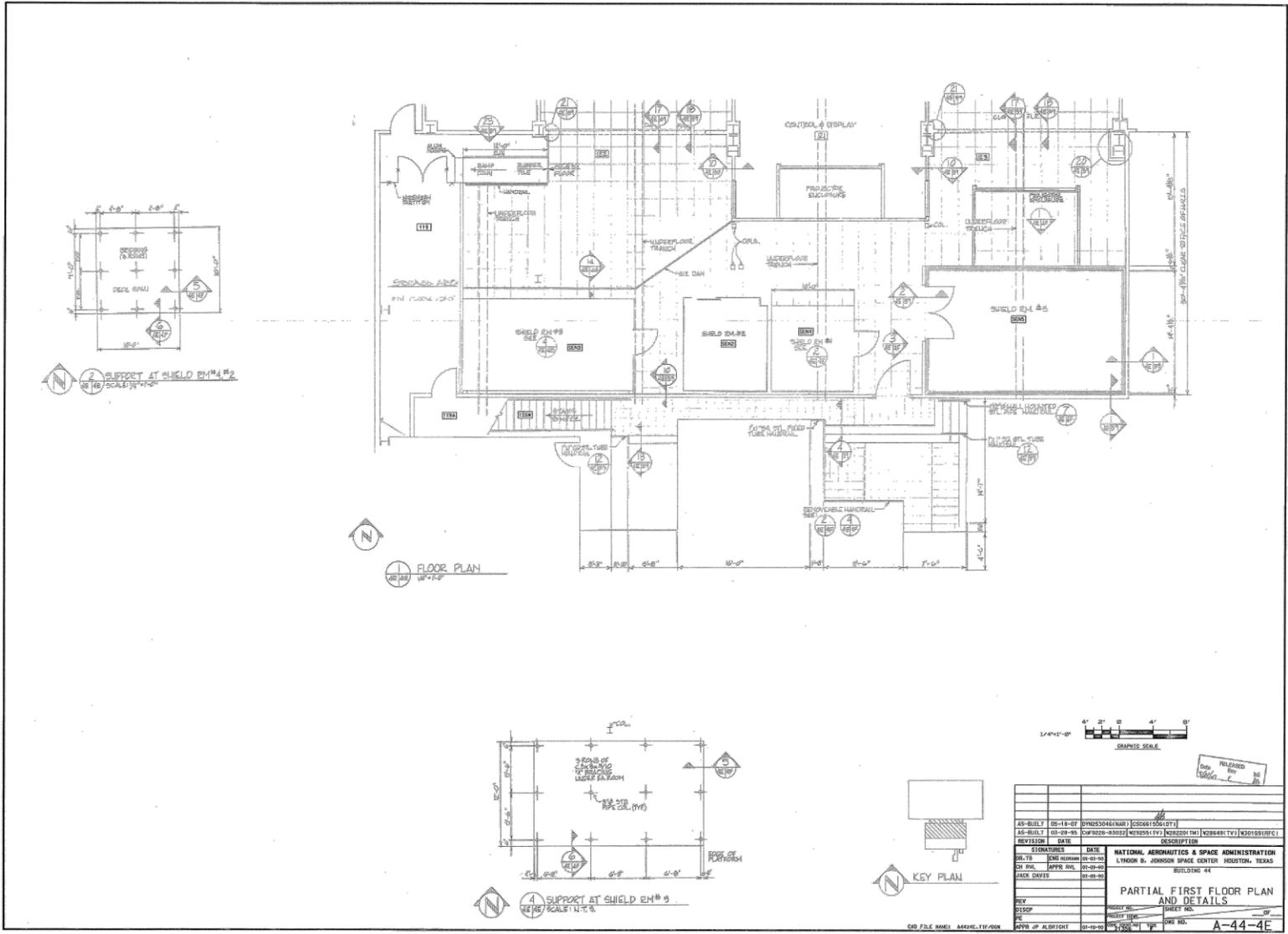
1. ALL CEILING HEIGHTS 8'-0" UNLESS NOTED THUS: @ 10'0"
2. @RSP INDICATES NO CEILING-STRUCTURE EXPOSED FIREPROOFING
3. PARTITION CENTER LINES ARE ON 4'-0" MODULE LINES UNLESS OTHERWISE INDICATED
4. DOOR OPENINGS ARE CENTERED ON MODULE OR 1/2 MODULE LINES UNLESS OTHERWISE INDICATED
5. ALL DIMENSIONS ARE TO FINISH WALL UNLESS OTHERWISE INDICATED
6. 0 B.D. INDICATES LOCATION OF DIRECTORY BOARD SEE DWG A-44 -22 FOR DETAILS
7. PROVIDE CONTROL JOINTS IN WALLS WHERE INDICATED ON PLAN BY "CJ"
8. SEE DWGS. A-44 -19&20 FOR LOCATIONS WHERE VAT #VB ARE ADDITIVE NO.1

- DRAWING REFERENCE**
- EXTERIOR ELEVATIONS A-44 - 71 B
  - CONTROL JOINTS IN MASONRY WALLS A-44 - 33
  - CONTROL JOINTS IN GIBB PARTITIONS A-44 - 23
  - ALUMINUM SOLAR MULLIONS A-44 - 15
  - TOILET PLANS & ELEVATIONS A-44 - 21
  - COLOR & FINISH SCHEDULE A-44 - 19 & 20
  - DOOR SCHEDULE A-44 - 26
  - COLUMN DETAILS A-44 - 23
  - INTERIOR PARTITIONS A-44 - 1
  - ABBREVIATIONS & SYMBOLS A-44 - 1

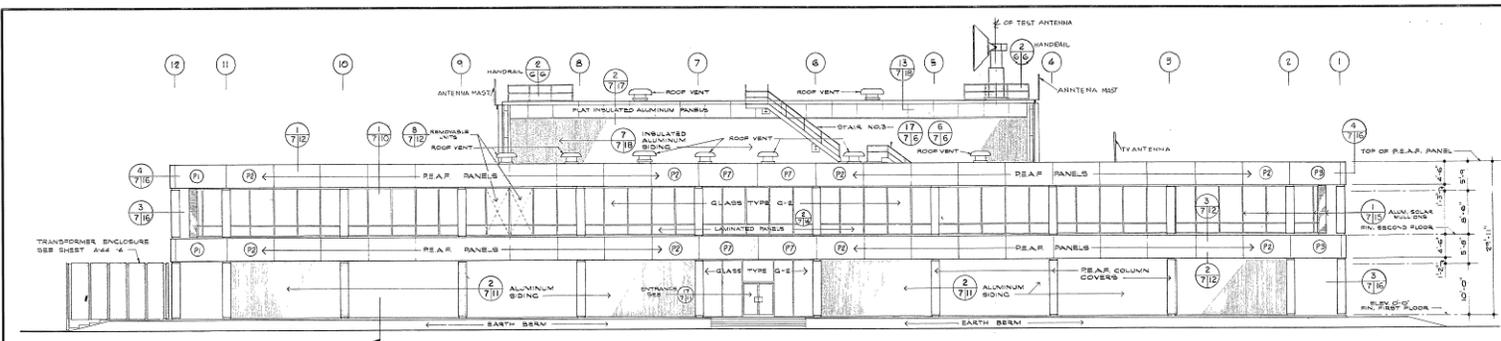


AS-BUILD	03-19-08	M0225(RH)	M1011(NAR)	CC661506(DT)	M3680(DT)
AS-BUILD	02-13-02	M3015(D,S)	M22321(TW)	IP04138P38(DT)	M40215(DT)
AS-BUILD	06-11-92	M2129(DT)	M2129(DT)	M2129(DT)	M2129(DT)
AS-BUILD	04-05-90	M2008(M)	M2008(M)	M2008(M)	M2008(M)
REVISION	DATE	BY	DATE	DESCRIPTION	
DR. DR. RA	END. W. DR.	DR. RA		NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
CH. W. RA	APPR.			LYNNON B. JOHNSON SPACE CENTER HOUSTON, TEXAS	
BUILDING 44					
SECOND FLOOR PLAN					
NORTH WING					
REV	DATE	BY	DATE	DESCRIPTION	
DISCP					
APPV	LED ZIBANE				

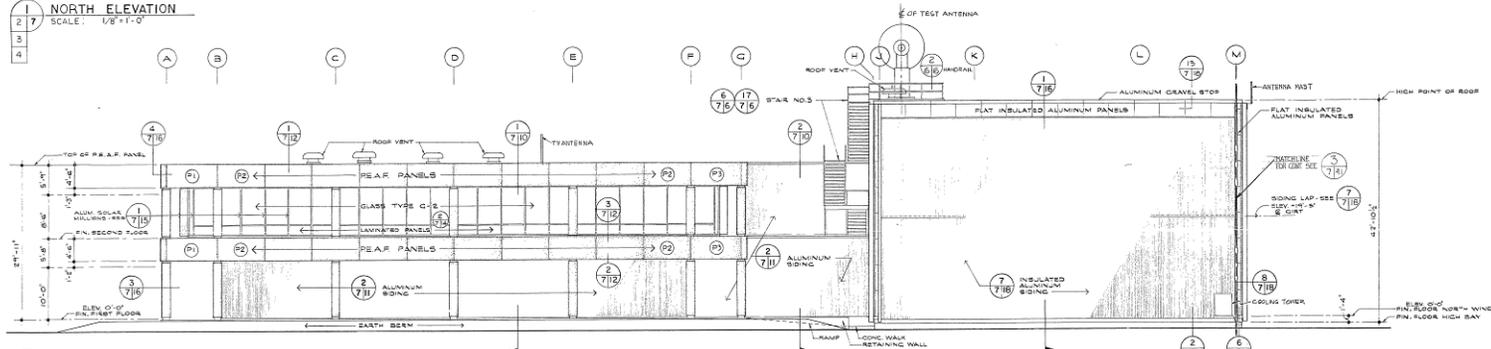
**CTDL-99**



**CTDL-100**

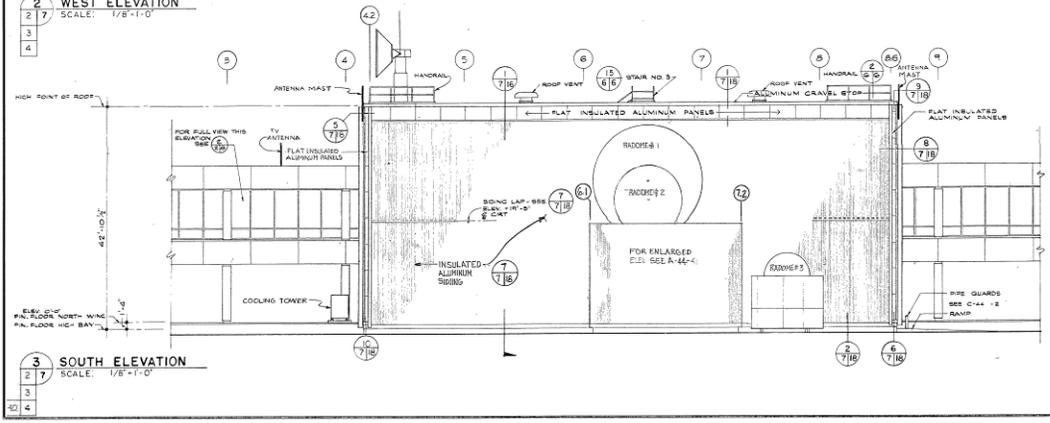


1 NORTH ELEVATION  
SCALE: 1/8"=1'-0"

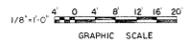


2 WEST ELEVATION  
SCALE: 1/8"=1'-0"

- EXTERIOR COLOR AND FINISH SCHEDULE**
- 1. PEAR PANELS EXPOSED QUARTZ AGGREGATE AND WHITE PORTLAND CEMENT - SEE SPEC.
  - 2. ALUMINUM RIBBED SIDING "ALCOA CARTRIDGE GRAY E. XYS-A55" ON EXTERIOR. SEE INTERIOR COLOR AND FINISH SCHEDULE FOR COLOR OF ALUMINUM SIDING EXPOSED ON INTERIOR.
  - 3. FLAT INSULATED PANELS ANODIZED ALUMINUM SIMILAR TO BLDG. 36 - SEE SPEC'S.
  - 4. ALUMINUM MULLIONS, FRAMA, ETC. ANODIZED TO MATCH WINDOW SCHEDULE SPEC'S.
  - 5. ALUMINUM FLASHING & TRIM COLOR AND FINISH TO MATCH RIBBED SIDING.
  - 6. ALUMINUM WINDOW WALL SOLAR MULLIONS AND ENTRANCES. COLES NOTED ANODIZED ON DETAILS IN WHICH CASE MATCH WINDOW WALL - SEE SPEC'S.
- (CONTINUED ON DWG. A-44-B)

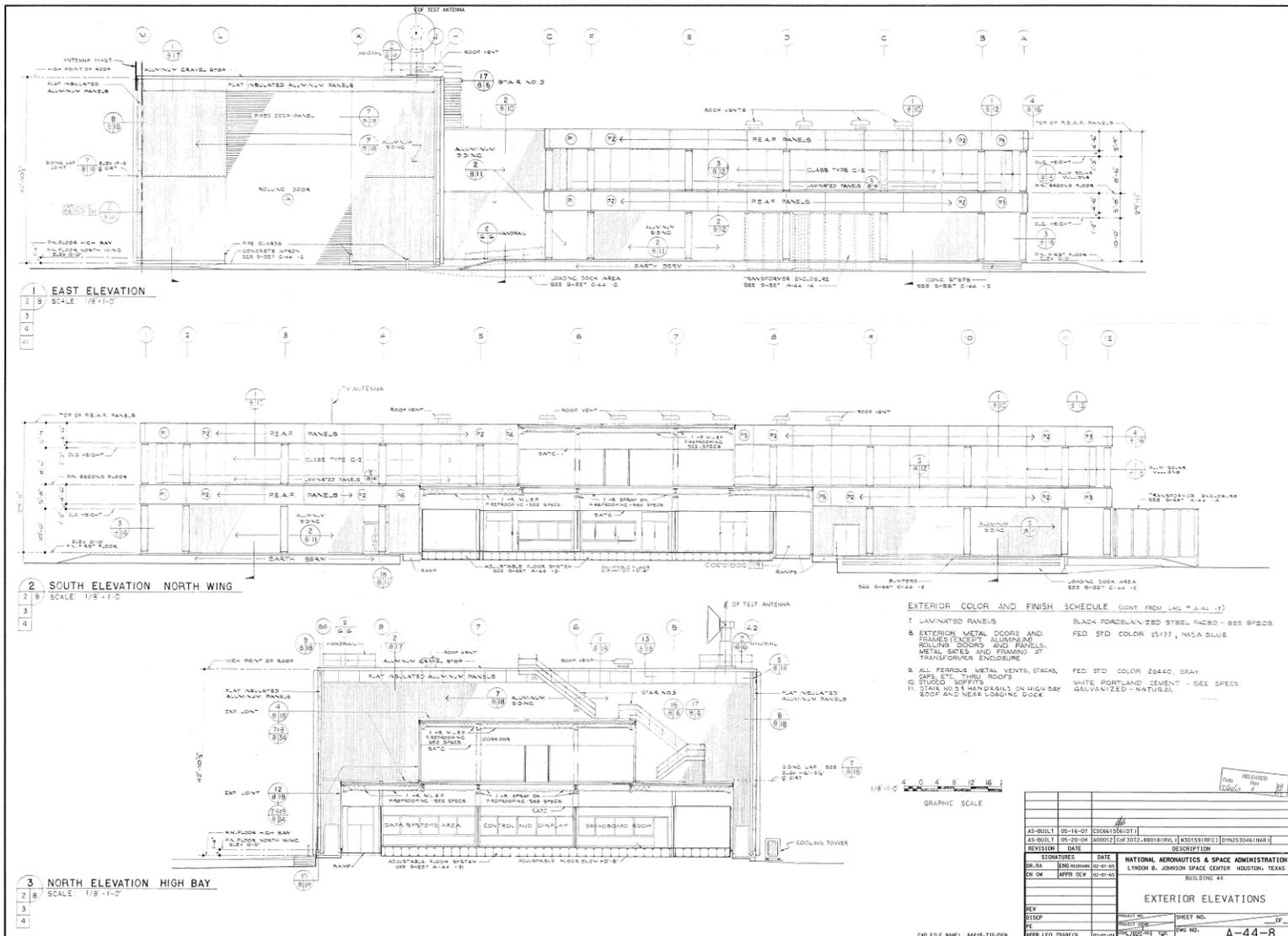


3 SOUTH ELEVATION  
SCALE: 1/8"=1'-0"

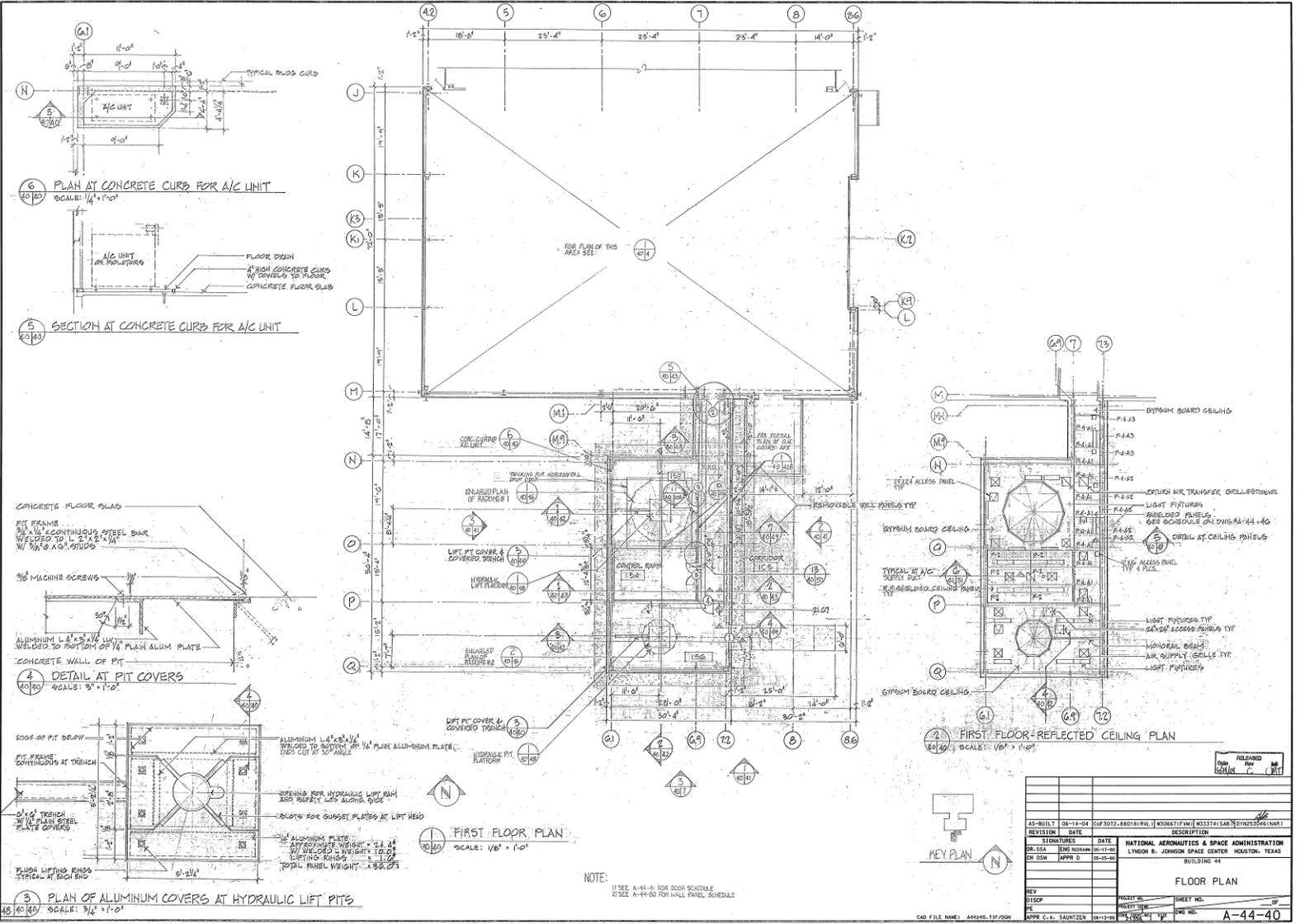


AS-BUILT		05-20-04	A00012	COF 2072-880181818	DYNS38161818
REVISION	DATE	DESCRIPTION			
DR. RA	END REVISION	02-01-03	NATIONAL AERONAUTICS & SPACE ADMINISTRATION		
DR. OR	APPROX. O.K.	02-01-03	LYNNON B. JOHNSON SPACE CENTER HOUSTON, TEXAS		
			BUILDING 44		
EXTERIOR ELEVATIONS					
REV	DATE	PROJ. NO.	SHEET NO.		
DISC					
APP					
APP	LEO ZRNECK	02-01-03	17	DWG. NO.	A-44-7

CAD FILE NAME: A4421.TIF.DWG



CTDL-102



**CTDL-103**

