Glenn Research Center

Altitude Wind Tunnel

Section 106 Check Sheets

Recordation of the Glenn Research Center – Section 106 Process

Project, activity or undertaking:	FY2006 Demolition of Altitude Wind Tunnel (Bldg. 7)
Project Description and reasons for undertaking:	The project will demolish the Altitude Wind Tunnel exterior portion of the Building 7 complex but retain the Test Section in Building 7. The demolition of a major structure will require the abatement of Lead Based Paint and Asbestos Containing Materials. The demolition will entail the removal of all of the structure of the AWT (approximately 3,000 Tons of Steel that will be recycled) and concrete foundations to two feet below grade. The AWT has not been used as a wind tunnel since 1960. The exterior of the tunnel is rusted and deteriorated past the point of repair. It is an eyesore and is becoming a safety hazard. Cost estimates have been prepared to perform lead based paint abatement, repainting of the exterior shell and structure, and some minor structural repairs. That work was estimated to cost $4,000,000. This would only be a cosmetic remedy. The structure would serve no useful research or institutional purpose after that investment.
Ohio Historic Inventory form number	CUY-4587-15
Project manager or Point of Contact:	Robert Houk
Date:	July xx, 2006.
Date of GRC Evaluation Checklist/REC:	October 11, 2004
GRC Facility Preservation Officer:	Leslie Main

Step 1. Initiate Section 106 Process	
Are federal funds involved? If no, then proceed with undertaking since not subject to further Section 106 review.	Yes. The demolition of the Altitude Wind Tunnel will be funded from the NASA Construction of Facilities (CoF) Program.
Is undertaking the type of activity that could affect historic properties? If no, then proceed with undertaking since not subject to further Section 106 review.	Yes.
Identify potential consulting parties.	The Ohio Historic Preservation Office, the Western Reserve Historical Society, the Cleveland Landmarks Commission, NASA Retirees, the NASA History Office, the Cleveland Restoration Society, and the cities of Cleveland, Fairview Park, North Olmsted, and Brook Park. There are no known Tribal Historic Preservation Offices (THPO) with interest in Lewis Field.
Develop a plan to provide the public with an opportunity to learn and discuss undertaking.	A Community Awareness meeting was held on April 27, 2006 on the GRC Campus. Meeting announcements were sent to local public libraries (Fairview Park, North Olmsted, Brookpark, Cleveland Public), the Sun Post/Sun Herald, and the Cleveland Plain Dealer. Announcements were sent to NASA retirees and an announcement was published in GRC's Aerospace Frontiers. The meeting discussed the history of the AWT, the demolition process, the environmental impact, and the historical mitigation process. The meeting ended with a Question and Answer session.
Submit to SHPO and request consultation.	May 4, 2004

Step 2. Identify Historic Properties	
Identify if Significant:	
A. Significant due to association with events	Yes. The AWT was significant in early development of jet engine aircraft. The AWT contributed to aeronautic research, aerospace propulsion and space flight systems. NASA Glenn Research Center has been at the forefront of jet and rocket engine studies in general, particularly under altitude conditions. The AWT was a primary component in the center's early research. The ability to test full-size engines instead of just a single cylinder, as was previously done, resulted in a more rapid transition from design to flight testing. The Altitude Wind Tunnel, which first began operation in 1944, was the first wind tunnel in the country capable of testing full-scale engines under simulated altitude conditions. The facility was converted from a wind tunnel to a vacuum chamber in 1962 and was renamed the Space Power Chamber. The new Space Power Chamber was utilized through the early 1970s for Centaur system testing and separation tests. The AWT was the nation's first wind tunnel capable of testing full-scale engines in simulated altitudes. Engine power, speed, drag, vibration, and cooling could all be analyzed in altitude conditions. The massive exhauster system and refrigeration system could simulate altitudes up 50,000 feet and produce speeds of 500mph. The tunnel's support buildings and systems were also used to operate the Icing Research Tunnel.

	Wartime Research Almost all of the NACA's research during the war concentrated on improving existing military aircraft. A notable exception was the Altitude Wind Tunnel's very first test, the Bell YP-59A Airacomet. The Airacomet was powered by the GE I-16, which was the first turbojet engine manufactured in the United States. The I-16 was based on a Whittle jet engine, which was secretly brought from Britain to the United States in 1941. Despite the enhancements made in the Altitude Wind Tunnel, the Airacomet remained too problematic and inefficient to be used for World War II combat. Much of the center's efforts during the war were concentrated on solving cooling problems for the new Boeing B-29 bomber's Wright R-3350 engines. The aircraft had been rushed through production for the war, but the R-3350s often burned up or failed at higher altitudes. The engines underwent a series of investigations over the course of six months in 1944. NACA researchers were able to resolve the cooling problem and increase fuel efficiency by 18%. These improvements were not integrated into the engine design until after the war. US Strategic Bombing Commander, Curtis LeMay, opted to forsake the high-altitude precision bombing for low-altitude incendiary bombing which caused more casualties but would not strain the B-29's engines. **Early turbojets** Following the war, the NACA was finally able delve into new research, particularly with turbojet and ramjet engines. Turbojet studies actually began in late 1944 with studies on the Westinghouse 19B and 19XB engines, the GE TG-180 engine and afterburner, and the Lockheed YP-80A Shooting Star, which was the first jet aircraft

	entirely manufactured in the United States. Air distribution, windmilling, and basic operating problems with the Shooting Star's GE I-40 engine were improved. The YP-80A evolved into the F-80 and was used extensively in the Korean War. The Altitude Wind Tunnel underwent several upgrades in the late 1940s and early 1950s to increase the tunnel's speed and altitude capabilities. This included reducing the size of the test section. Originally entire fuselages could be inserted, but even with the smaller size test section, entire engines and nacelles could be used. Testing continued on ramjets, turbojets, and the jet-powered turboprops. **Mercury Program** By the late 1950s, though, other more advanced facilities, including the new Propulsion Systems Laboratory, were relied on for more and more engine testing. As the space program emerged and the center became part of NASA, the facility began to be utilized for its cavernous space rather than its wind tunnel capabilities. Escape rocket tests for the Mercury capsule were performed inside the wide section of the tunnel. In 1959, the original astronaut corps traveled to Cleveland to be test their ability to bring a tumbling Mercury capsule under control in the Multi-Axis Spin-Test Inertia Facility Trainer apparatus which was also installed inside the Altitude Wind Tunnel. **Space Power Chamber** Between 1958 and 1960, the lab refocused its efforts almost completely towards the space program. Although the AWT had already played a prominent role with the Mercury Program, its

	continued use was in question. Unwilling to let this historically significant facility fall into obsolescence, NASA Lewis administrators decided to convert the tunnel into vacuum chamber. During this conversion process, two massive bulkheads were installed inside the tunnel, creating two vacuum chambers. It also included rewelding the tunnel's joints, installing a new vacuum pump house, and creating a dome that could be removed to insert test equipment. On September 12, 1962 the Altitude Wind Tunnel was officially renamed the Space Power Chamber or SPC. **Centaur** In 1961, Center Director Abe Silverstein convinced NASA to transfer the Centaur Program from Marshall Space Flight Center to NASA Lewis. A mock-up Centaur rocket was installed in the Space Power Chamber to study entire systems tests in a space environment. The other end of the tunnel was used for shroud separation tests. These tests contributed to the Surveyor, Orbiting Astronomical Observatory, and many other Centaur missions. **Rehab** By the mid-1970s fewer tests were conducted in the Space Power Chamber and it fell into obsolescence. There was a proposal in the early 1980s to overhaul the facility and convert it back into a wind tunnel for icing research tests. After several years of preliminary studies, the $150 million renovation was cancelled and the facility has remained unused.
B. Significant due to association with persons	No. Minor association with John Glenn and the Mercury Program Astronaut Corps, but not enough to qualify for this criteria.
C. Significant because it embodies distinctive	No. The AWT was the first wind tunnel to be able to simulate

characteristics	atmospheric conditions, such as temperature and air pressure, for conditions above sea level. Also, the related Refrigeration Building 9 is significant due to the engineering feat to achieve this large scale refrigeration system. (Bldg. 9 is in use, directly supporting another research facility, the Icing Research Tunnel {IRT}. The IRT is the currently the most utilized wind tunnel at GRC.) However, the AWT wind tunnel, chambers, and supporting facilities are typical of similar research facilities, and are not unique.
D. May yield information important in prehistory or history.	No. The site was significantly disturbed during the construction of the AWT and its supporting facilities and utilities. Because of this, the site would not reveal any information or artifacts.
Identify if it has Integrity:	
Property is able to be preserved; has physical integrity to still communicate what made it significant. Contains 1 of the 7 aspects of integrity: location, design, setting, material, workmanship, feeling, or association.	The property retains much of its original integrity, but the structure is deteriorating due to corrosion. The facility could not be used again as a wind tunnel without significant investment. And if would only duplicate facilities that are currently operational. All of the vacuum systems have been removed from the Space Power Chamber and larger vacuum facilities exist at GRC that can be used for testing space craft. The annual maintenance costs for AWT are $93,000. And as stated above, a major project to stabilize the facility would cost $4,000,000 (see Appendix B for the cost estimate) and would not provide a productive research facility.
Determination of Undertaking's Area of Potential Effects (APE)	
Alternative locations?	Not applicable. The former capabilities of the AWT are duplicated or exceeded at other research facilities either at Glenn Research

	Center or two other NASA centers, Langley Research Center or Ames Research Center. The cost to relocate the AWT or build a duplicate facility would be cost prohibitive.
Disturbance of the ground?	Disturbance expected during demolition. The massive concrete support structures and foundations will be removed to two feet below grade. The area will be repaved for stormwater control. The paving will be adequate as a temporary parking area.
Locations from which visible?	The AWT is visible from GRC campus and the top part of the tunnel is visible from Cleveland Hopkins Airport. See the attached photographs.
Change in land use, traffic, public access, etc.?	Initially, the site will likely be used for parking. There are discussions about building a new Refrigeration Building on the site to enhance the capabilities of the IRT or building a new research facility at that site.
Gather information on the APE	
See Appendix A, OHI forms, which include a site plan and building plan, and Appendix C, Photographs of the Facility.	
Identify historic properties within the APE	
The property is located within an area that the Gray & Pape 2002 Survey identified as eligible for listing as a Historic District. The property is in the vicinity of the Zero Gravity NHL. The property is very close to the Icing Research Tunnel, a facility that may be eligible for NRHP listing.	
Evaluate Historic Significance of Property; NASA Determination of Eligible or Ineligible	
Eligible. Continue to Step 3 of Section 106 process	The Altitude Wind Tunnel complex is eligible for listing on the National Registry of Historic Places (NRHP) because of its legacy of contributions to Aeronautics and the early space program, especially the Mercury and the Centaur programs as described in

	Step 2a. The most significant part of the AWT is the test section. The large structure of the AWT and its supporting technology were only there to create test conditions of full sized and scaled test articles. As part of this demolition project, NASA will be saving the test section of the AWT and will make it into a Historical interpretation center. Even though the AWT control room has been gutted, it will also be included as part of the interpretation center.
Step 3. Assessing Adverse Effects	
Finding of Adverse Effect	
Because the AWT is eligible for listing on the NRHP, NASA finds that the demolition of this property meets the criteria of Adverse Effect. The Adverse Effect is the removal of the tunnel structure and foundations, but the Test Section of the AWT will be retained as described above. Continue to Step 4 of the Section 106 process.	
Step 4. Resolving Adverse Effects	
Avoiding Adverse Effects	
A. Moving the undertaking to an alternate site	This alternative would be cost prohibitive. There are facilities at GRC and within other NASA Centers that duplicate the capabilities of the AWT and the Space Power Chamber.
B. Using an alternative design	There was a proposal in the early 1980s to rehabilitate the facility and convert it back into a wind tunnel for icing research tests. After several years of preliminary studies, the $150 million renovation was scrapped and the facility has remained unused.

C. Pursuing an alternative to the undertaking	1. After the AWT was no longer needed as a wind tunnel, the structure was adapted three times. The first adaptation was to test the escape rocket for the Mercury capsule. Scale models of the Mercury capsules were tested inside the wide section of the tunnel. The second adaptation was in 1959, when the original astronaut corps traveled to Cleveland to be test their ability to bring a tumbling Mercury capsule under control in the Multi-Axis Spin-Test Inertia Facility Trainer apparatus, which was also installed inside the Altitude Wind Tunnel. The third adaptation was changing the structure into the Space Chamber (see Step 2a Subtitle **Space Power Chamber**). Since then, NASA has built newer facilities, at GRC and other NASA Centers, that perform the same functions but have expanded the capability beyond what could be accomplished even if the AWT was rehabilitated. 2. Rehabilitation of the exterior structure only as an alternative was considered. The work would involve removing rust, replacing corroded steel panels, preparing the metals, mitigating contaminants (i.e., abating lead based paint and asbestos containing materials) and painting the structure. A construction cost estimate was prepared by Crawford Consulting in August 25, 2003. Estimate for the painting was $4,000,000 (approximately 20% less than the cost of the undertaking). If this alternative was pursued, NASA would have the recurring costs of repainting the structure every 8 to 10 years. That would be a significant cost for a facility that is no longer serviceable or of use to the Government. 3. Rehabilitation of the structure for a new use is an alternative that was considered (see Step 4b).
D. No undertaking at all.	NASA has chosen the approach of not doing anything over the past

	20+ years. As a good steward of government assets, with the increasing awareness of Safety and Environmental concerns of the deteriorating structure, NASA believes that something must be done within the next few years.
Mitigation Measures	
• Alternative design & limiting the magnitude of the project.	NASA considered the demolition of the whole AWT. NASA has decided to retain the AWT Test Section, improve the area of the Test Section and renovate the former AWT Control Room as an historic interpretation area. Displays of photographs of testing within the AWT, as well as other interpretive materials, will be set up. The AWT Test Section will be a tour stop for guided tours of Lewis Field.
• Alternative location	There are no alternative locations.
• Rehabilitating some historic properties	Adjacent to the AWT is the Icing Research Tunnel (IRT). The two facilities were built during the Second World War. Both facilities were provided services by the Refrigeration Building, which will remain in service after the demolition of AWT is complete. The IRT is already considered a national landmark by the American Society of Mechanical Engineers (ASME) and may be eligible for listing on the NRHP.
• Planning for preservation and maintenance	Please reference Step 4.c2.
• Moving historic properties or marketing the property for donation, sale, or lease	Due to the size and obsolescence of the structure, this alternative would not be feasible.
• Documenting property before destroying it •	This is significant because the technology tested and developed by NACA and NASA in the AWT and the Space Power Chamber are more important than the structure. Properly compiling historical

	scientific and engineering documents is important to NASA. Because of this, NASA is planning the following Historic Mitigation and Documentation for the AWT; 1) Retaining the Test Section and Control Room and setting it up as interpretive site and tour stop. NASA will produce museum quality display boards the show the history of the AWT and the technology that was developed from the testing performed there. 2) A Community Awareness meeting was held on April 27, 2006 on the GRC Campus. Meeting announcements were sent to local public libraries (Fairview Park, North Olmsted, Brookpark, Cleveland Public), the Sun Post/Sun Herald, and the Cleveland Plain Dealer. Announcements were sent to NASA retirees and an announcement was published in GRC's Aerospace Frontiers. The meeting discussed the history of the AWT, the demolition process, the environmental impact, and the historical mitigation process. The meeting ended with a Question and Answer session. A monograph will be published recording the history of the AWT. The monograph will include full-sized photographs. 3) A web site with public access will be developed for the AWT. Historic photographs of the construction and testing within the Test Section, the tunnel, and in the Space Power Chamber will be available for viewing. Photographs of the current state of the AWT and photographs documenting the demolition of the AWT will also be available for viewing. The text from the monograph will also be available for viewing.

	4) HAEB/HAERS documents of the AWT complex will be prepared and archived. These documents will summarize the construction, historical context, technological significance, and a physical description of the AWT. Included in this documentation will be selected photographs and architectural drawings from NASA's files. 5) NASA will collect, appraise, and maintain a collection of historically significant documents that will become a permanent record of the AWT. These documents may include correspondence, architectural drawings, maps, scientific or engineering publications, and related materials. 6) NASA will update the photographic images by digitizing unscanned negatives and photographs and uploading them to the GRC Imagenet database. NASA will perform several 360 degree images of the AWT before demolition begins. NASA will compile film and video of tests performed in the AWT and have the film/video digitized. From the above digitized files, NASA will produce a CD-ROM or DVD that will include photographs, panoramic photographs, video clips, and scanned documents. This disc could supplement the monograph or be distributed separately. 7) Oral interviews will be conducted with NASA retirees, facility and program managers, and others. These interviews will be recorded and transcribed. Selected interviews will be videotaped. 8) NASA will produce a documentary video that would describe the facility, its history, and research programs.

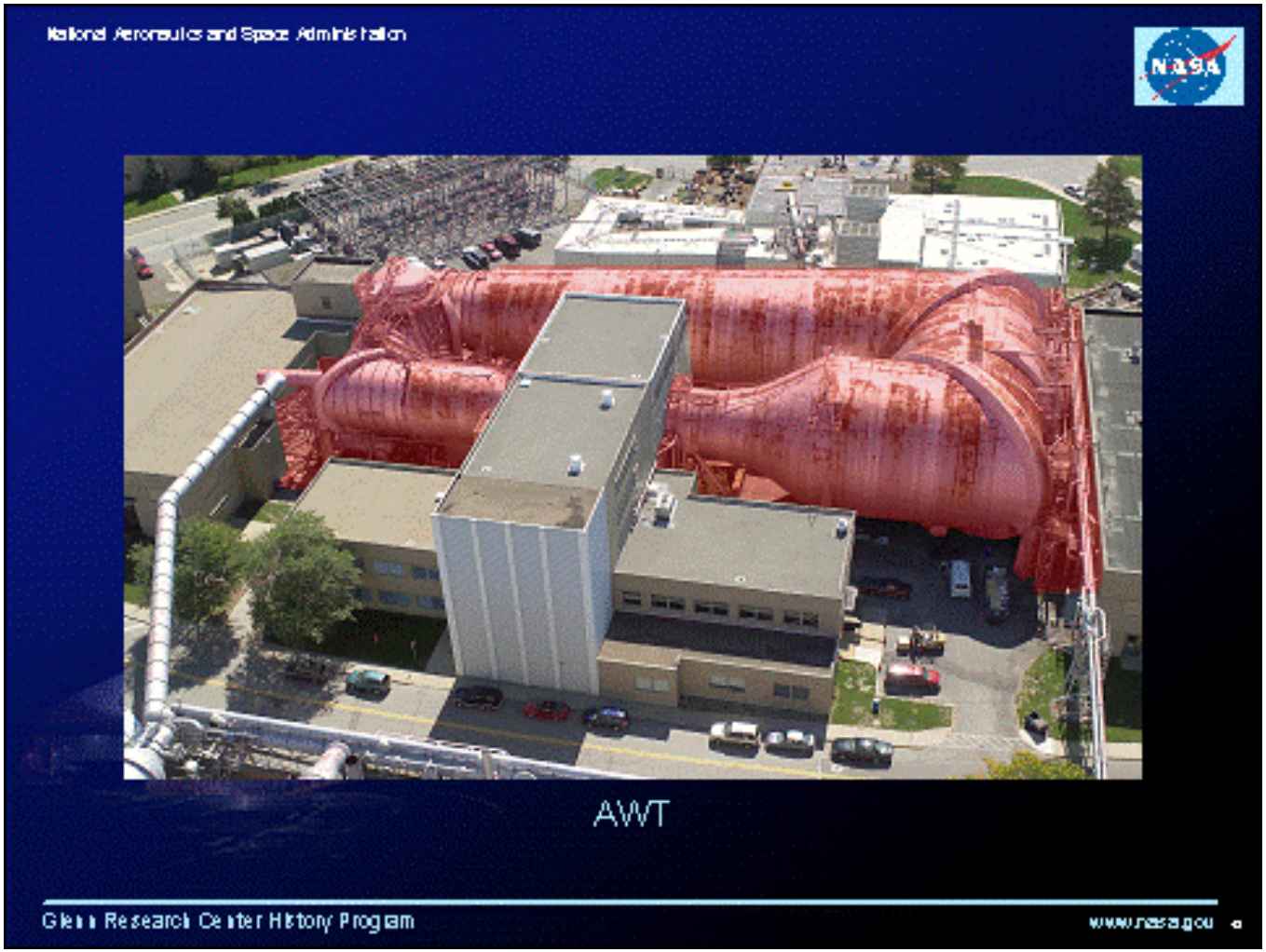
Recovering data from archeological site	See Step 2d.

Accepting loss of historic property	NASA is willing to accept the loss of this property. NASA Headquarters has concurred with and advocates the proposed demolition of AWT. With the Aeronautics Research budget being 1/17th of NASA's overall budget, funding for improving Aeronautics research facilities at GRC would be better invested in other wind tunnels (IRT, the 10x10 SWT, the 8x6 SWT) or the PSL #3 & #4. The facility, as configured, has been out of service for more than 30 years. During the 1960's, the tunnel underwent major modifications to create the Space Power Chamber to support specific test goals for the Centaur Program. Since then, no significant research work has been done in the tunnel circuit since Centaur. Because the AWT is a large structure, the maintenance costs for the facility are very high and the facility is in poor condition. During the 30 years that the AWT has been out of service, significant hardware has been removed from the Wind Tunnel complex such as the fan, drive shaft, turning vanes, and compressors. All of the vacuum pumps for the Space Power Chamber have been removed. The Government completed a preliminary engineering study in the mid-1980's to substantially modify the AWT circuit for use as a new Icing Research Tunnel Facility. The project was cancelled due to the excessive costs involved to rehabilitate the AWT.

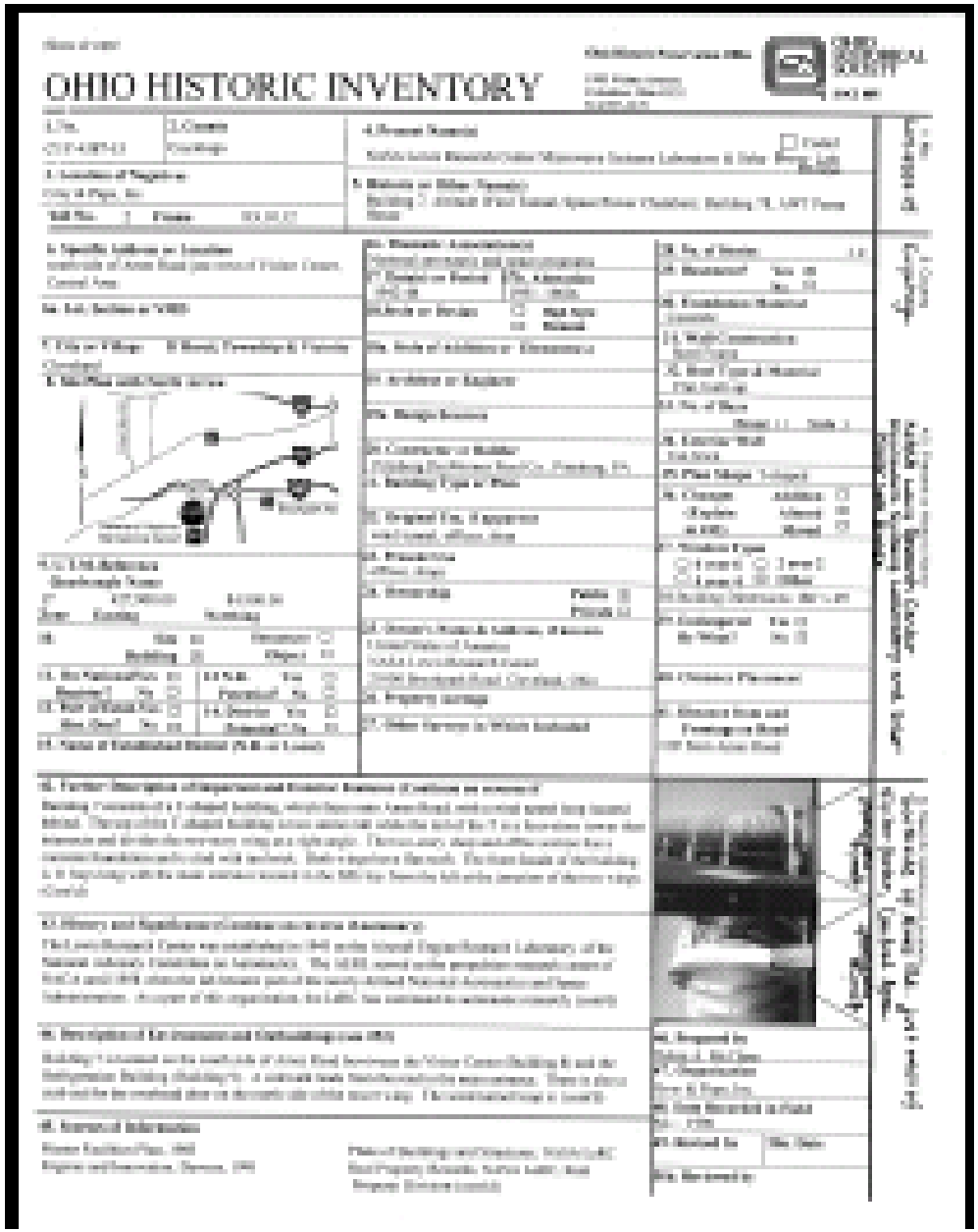
	There are no current NASA mission requirements for either near-term or long-term use of the tunnel circuit other than as a potential Visitor's Center Tour stop. A recently completed cost estimate to do minor exterior repairs and repaint the tunnel circuit and utilities was in excess of $4.0M. See appendix B. Currently, NASA GRC is a land locked site. The area that will be cleared by the demolition of the AWT will allow NASA to locate new research capability in that area. The current NASA GRC proposal is to remove the entire AWT circuit except for the Test Section within the High Bay Building as part of the Bldg. 7 complex. The only major costs involved with retaining the Test Section would be for closures on both sides of the High Bay and residing the High Bay after existing asbestos panels are removed.
Notify council – participate in consultation? Consulting parties involved in discussion Public comment & involvement during resolution of adverse effects	Yes. NASA will invite the ACHP to consult in this process.
MOA	

Appendix A

OHI Forms for the Altitude Wind Tunnel



Extent of Demolition for the Altitude Wind Tunnel
(Highlighted in Red)



OHIO HISTORIC INVENTORY

51. Condition of Property

☐ Excellent ☐ Ruin
☒ Good/Fair ☐ Destroyed/Burned
☐ Deteriorated
Date

52. Historic Outbuildings and Dependencies
Barn Type(s)

Corn Crib or Shed ☐ Smoke House ☐ Privy ☐
Summer Kitchen ☐ Spring House ☐ Garage ☐
Silo ☐ Ice House ☐
Designed landscape ☐

53. Affiliated OAI Site and multiple

Archaeological Features:	Observed	Expected on Basis of Archival Research
Well		
Privy		
Cistern		
Foundation		
Structural Rubble		
Formal Trash Dump		
Other		

54. Farmstead Plan

42. (Cont'd)

In 1995, a one-story, three by one bay, 3,800 square foot addition was constructed on the north facade of the west "wing" of Building 7. This addition matches the original building in construction and materials.

The bays of the two-story wing are delineated by paired and single plate glass pivoting windows with continuous concrete sills and spans of alternating projecting courses of brick between each set. These windows replace the original grouped sets of horizontally-divided, multi-paned stall sash windows. The main entry into Building 7 is from Avery Road (north) through a set of double glass doors with a glass transom and box (cont'd)

43. (Cont'd)

while also advancing technologies in aerospace propulsion, and space flight systems.

The Altitude Wind Tunnel (AWT) has been cited as historically the most important facility at the LeRC. The AWT was designed as a closed circuit tunnel with a 31' diameter fan capable of producing air velocity as high as 425 mph at simulated altitudes of 30,000 feet and as low as 250 mph at 1,000 feet. The U.S. Army pressed for the design and construction of the AWT in 1942 because of its need for a full-scale testing unit to analyze and solve problems of adequate engine cooling. Private industry could not afford such a large and expensive facility, so it was left to NACA to delve into solving such engine problems and, in doing so, became involved in development.

Steel shortages slowed construction of the nickel-steel shell of the tunnel. Design was slowed also by the requirement for an extensive refrigeration system to serve both the AWT and the Icing Research Tunnel, also in construction. The Carrier Corporation was brought in to design this system, which broke ground in terms of large scale engineering feats and contributed, through testing performed with its help, to (cont'd)

44. (Cont'd)

located to the rear of the shop and office building. Parking is allowed in the paved area underneath the tunnel when tests are not being run.

Continuation Page One

3. Photographs provided by NASA: C-1992, AERL 4804, AERL 5064-A, C-5681, C-5308, C-8983, C-19794

28. Sam W. Emerson Co., Cleveland, Ohio: The Carrier Company

38. Building Dimensions: one wing measures 74' x 23'.

42. metal canopy above. A similar entry existed in the seventh bay (on the west "wing" of the office section), but the construction of the one-story addition filled in this space. A secondary entry is located on the west facade of the two-story wing and consists of paired glass and metal doors, a glass transom and a box metal canopy. A narrow overhead door is also located on this facade.

The tall section of the T-shaped building contains a shop area in its northern end and a hatch into the tunnel on its southern end. The northern end of this tower intersects with the office/shop wing. Its north facade faces onto Aiken Road. This facade contains a large, overhead door, which leads into an open shop area. The exterior of this four-story tower is clad with tan brick on its northern end and is partially clad with horizontal metal siding on its southern end. The northern section formerly held horizontal ribbon windows on the three upper floors. These windows have been filled in with brick, but the concrete sills are still visible. To the rear of the tower, some of the original horizontally divided multi-paned windows have been covered over with metal siding.

The wind tunnel intersects the tower on its southern end where one of the test sections is located. The tunnel creates a rectangular loop that is larger on its western end than on its eastern end. The tunnel structure is supported by large concrete piers and steel supports. The interior of the tunnel, designed as a closed circuit system, has been modified several times over the years. In 1962, the facility was modified as the Space Power Laboratory to allow for environment testing of the Atlas/Centaur vehicle. The latest modifications, designed to allow research tests on tilting, propeller-powered and V/STOL vehicles, were not successful. In 1991, the name of the facility was changed to the Microwave Systems Laboratory.

Building 78
Building 78, constructed between 1951 and 1952, is positioned crosswise underneath the eastern end of the wind tunnel loop. It is a one-story, flat-roofed structure with a basement and measures 47 by 28'. The building has a concrete foundation and is clad with tan brick. The main access into Building 78 is through a metal door on the east side. A metal, box canopy is located above this entry. Access doors are also located on the south and west facades. The west entry consists of a metal door with metal side panels flanked by horizontally-divided, multi-paned windows. A vented transom is located above. The south entry consists simply of a pair of metal doors. The north facade has a large opening filled-in with glass block. An stairway on this facade is open to the basement level with a metal pipe railing surrounding the opening. The cooler pit of the wind tunnel is located directly under the east leg of the loop and is adjacent to the north end of Building 78. It is a concrete structure with metal cladding. Originally, this building served as the Water Pump House for the Altitude Wind Tunnel. It was equipped with four Fairbanks-Morse 250 horsepower pumps. Around 1964, two of these pumps were removed for use at the Plum Brook Station. Also in the 1960s, the facility was modified as the Solar Mirror Cleaning/Solar Power Laboratory Pump House, which involved the installation of four cleaning tanks and new ventilation and plumbing systems.

43. shortening the war. Carrier built and tested many original components in its design for the refrigeration system. The refrigeration plant contained 14 Carrier centrifugal compressors and a unique heat exchanger capable of producing a minimum temperature of -48 F. The new compressor developed in this endeavor became one of the company's standard products after the war.

The first unofficial test in the AWT was performed in February 1944. Although the tunnel had been constructed with piston engine tests in mind, the first engine to be tested was the I-16 turbojet, which had been secretly designed by the General Electric Company. For the test, an entire fuselage of a Bell Aircraft P-59A with its wings sawed off was squeezed into the 20' diameter test section. The first official tests in the AWT, run in May, were conducted on the Wright R-3350 piston engine, which was used in the B-29 Superfortress used in strategic bombing of Japan from the China mainland.

After the war, the AWT was adapted to test early turbojet and turboprop engines at simulated altitude conditions. With the NASA change in mission, the AWT was converted to a vacuum facility to test rockets in 1958. In the early 1960s, the "Space Power Chamber" was used to test the Centaur rocket, the important upper stage rocket fueled by liquid hydrogen.

45. Overall Cultural Resource Reconnaissance Survey of NASA Lewis Research Center, Cleveland, Ohio, Gray & Pape, Inc., 1996

facing northwest

facing west

Continuation Page One

3. Photographs provided by NASA: C-1992, AERL 4804, AERL 5064-A, C-5681, C-5508, C-8983, C-19794

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The tail section of the T-shaped building contains a shop area in its northern end and a hatch into the tunnel on its southern end. The northern end of this tower intersects with the office/shop wing. Its north facade faces onto Ames Road. This facade contains a large, overhead door, which leads into an open shop area. The exterior of this four-story tower is clad with tan brick on its northern end and is partially clad with horizontal metal siding on its southern end. The northern section formerly held horizontal ribbon windows on the three upper floors. These windows have been filled in with brick, but the concrete sills are still visible. To the rear of the tower, some of the original horizontally divided multi-paned windows have been covered over with metal siding.

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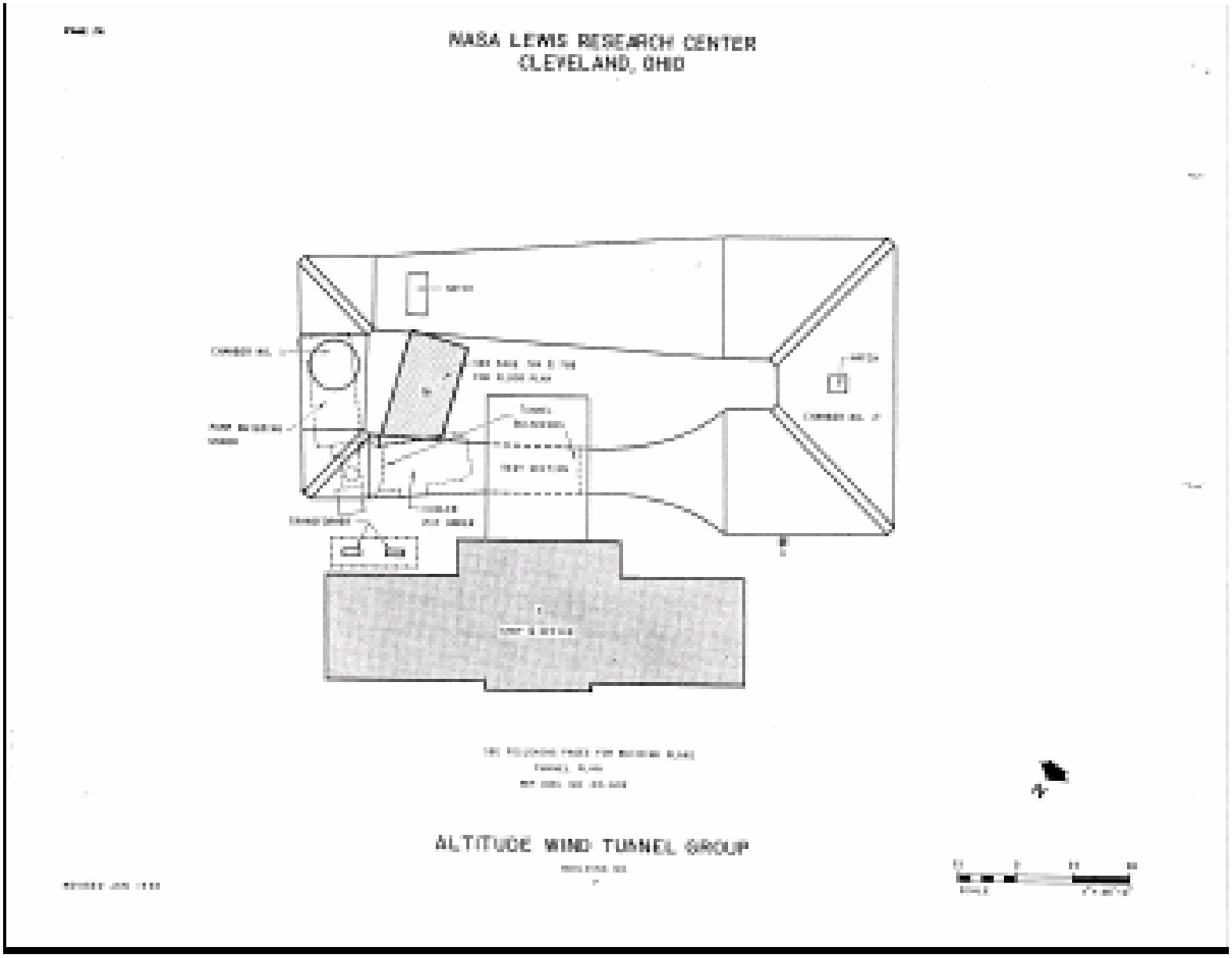
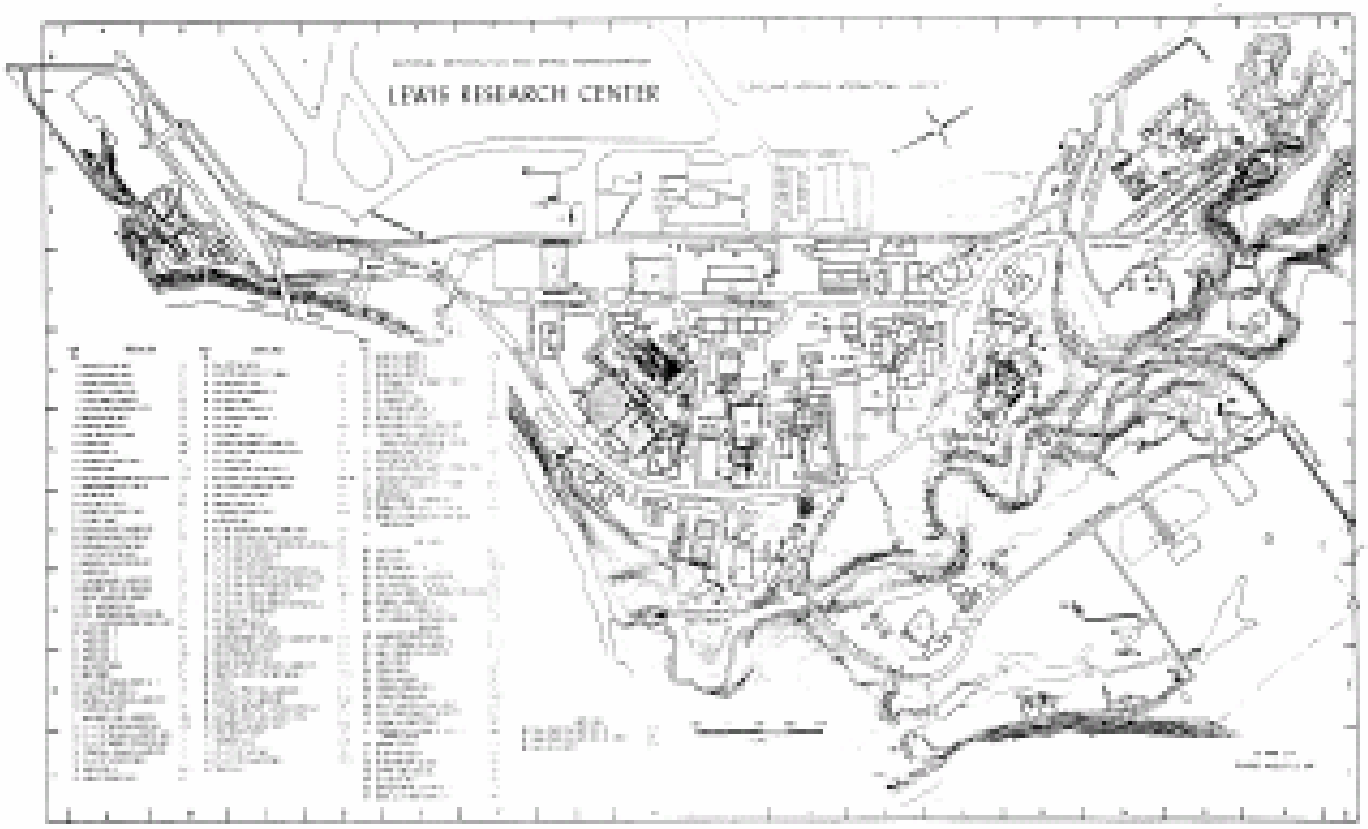
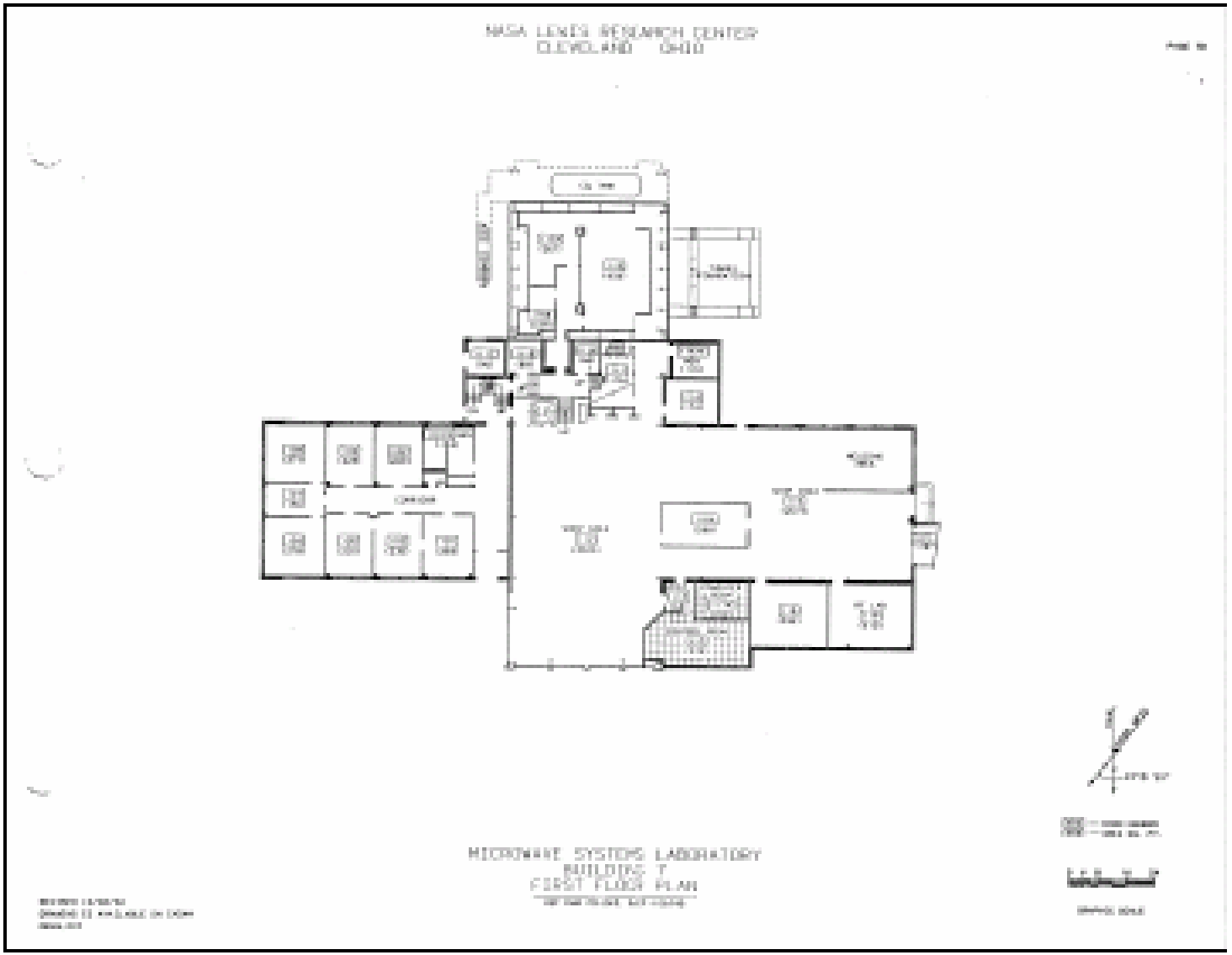
45. Overall Cultural Resource Reconnaissance Survey of NASA Lewis Research Center, Cleveland, Ohio, Gray & Pape, Inc., 1906

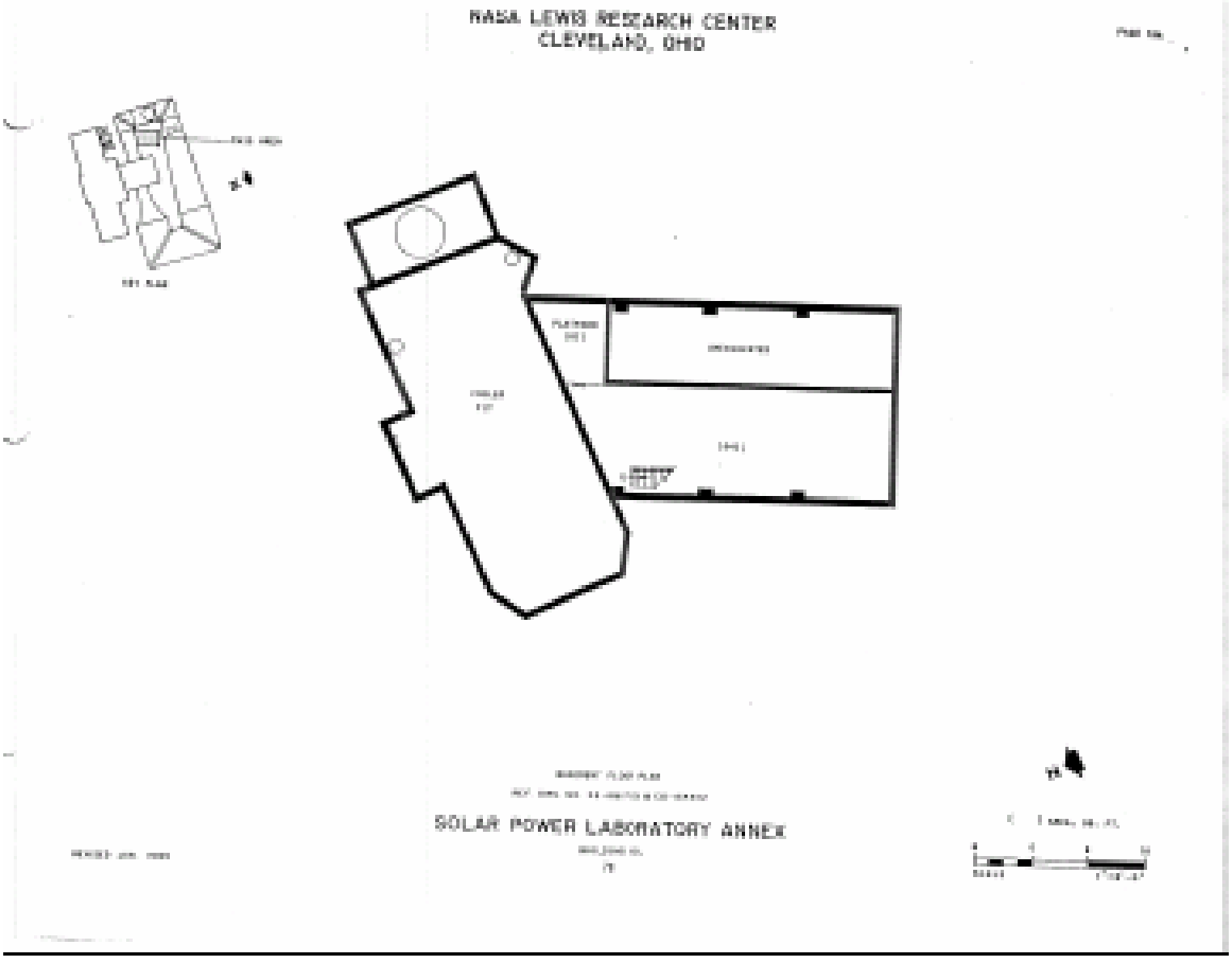
facing northwest

facing west


NASA LEWIS RESEARCH CENTER
CLEVELAND, OHIO
ALTITUDE WIND TUNNEL GROUP


LEWIS RESEARCH CENTER


NASA LEWIS RESEARCH CENTER
CLEVELAND OHIO
MICROWAVE SYSTEMS LABORATORY
BUILDING 7
FIRST FLOOR PLAN


NASA LEWIS RESEARCH CENTER
CLEVELAND, OHIO
SOLAR POWER LABORATORY ANNEX

NASA Lewis Research Center Microwave Systems Laboratory
(formerly the Altitude Wind Tunnel)
Building 7
Laser Prints Courtesy of NASA Lewis Research Center Imaging Technology Center

1. C-3992, February 29, 1944
   Interior view of the throat section of the wind tunnel.

2. AERL-4804, May 4, 1944
   View of Altitude Wind Tunnel and Refrigeration Building from across Ames Road. View to south.

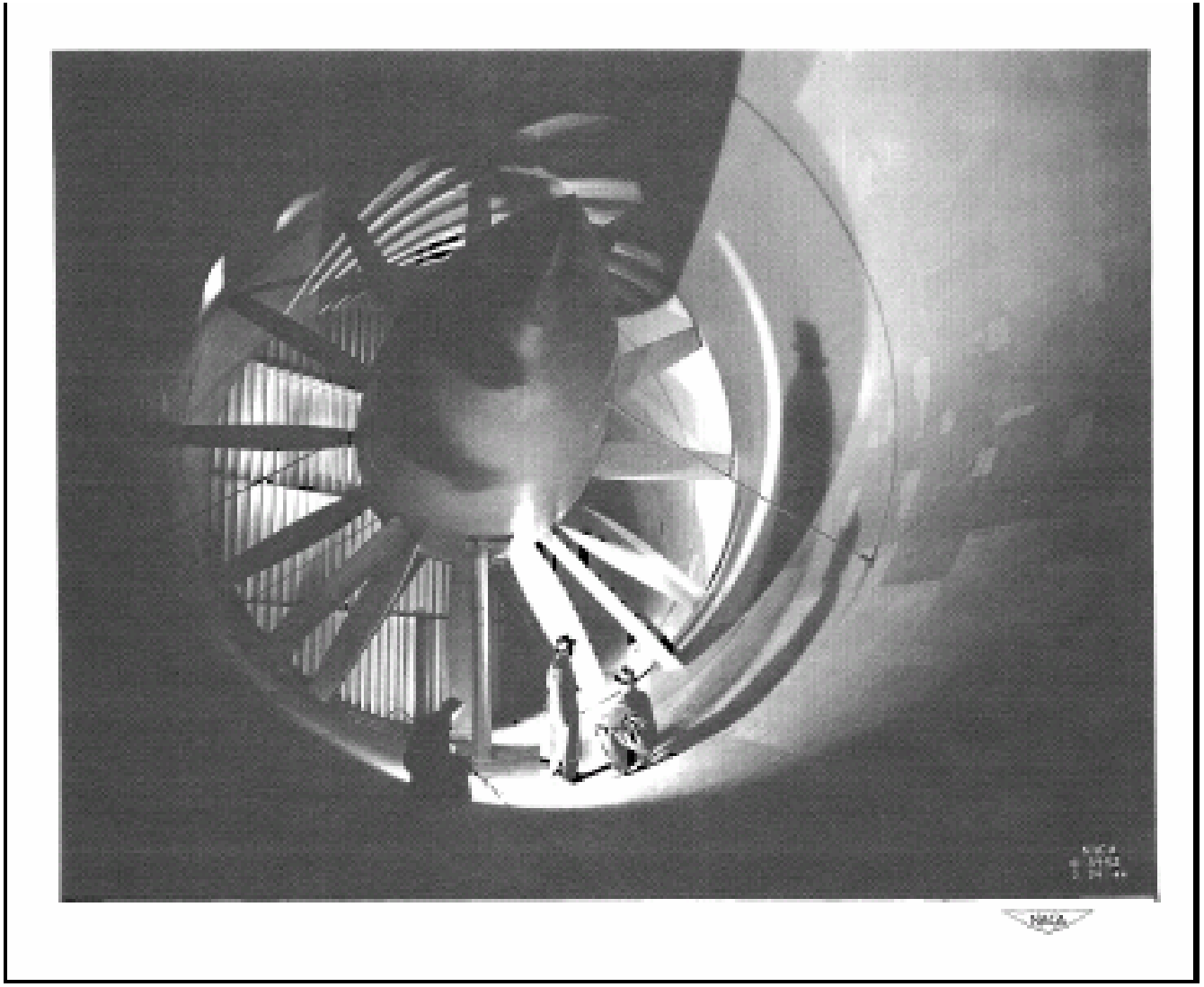
3. AERL-5864-A, May 27, 1944
   Aerial view of Altitude Wind Tunnel, flanked by Building 8 (Visitor Center, then Exhauster Building for the AWT) and Building 9 (Refrigeration Building). View to south.

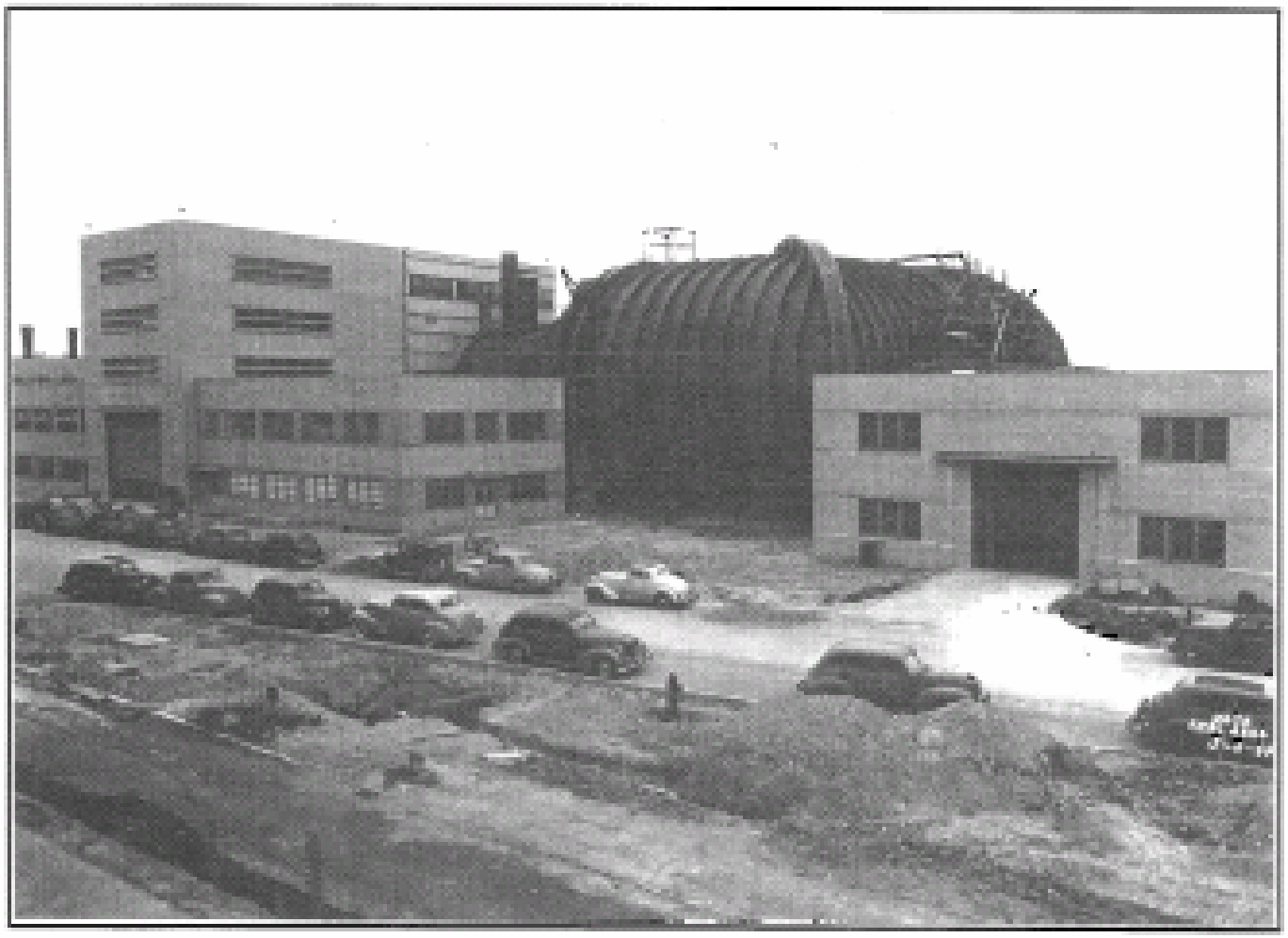
4. C-5681, July 14, 1944
   Original Fact Sheet on the Altitude Wind Tunnel listing facility description, purpose, and research projects to be undertaken.

5. C-5208, June, 16, 1944
   Schematic drawing showing Altitude Wind Tunnel and associated buildings. "Probably most unique among the research facilities of the National Advisory Committee for Aeronautics at its Aircraft Engine Research Laboratory in Cleveland, Ohio, is the altitude wind tunnel where research is conducted on problems relating to the combining of the aircraft power plant with the remainder of the airplane structure."

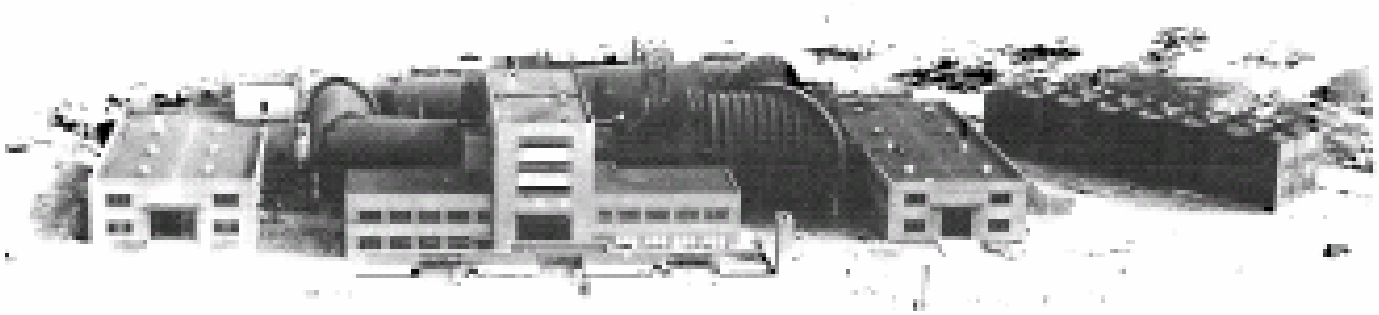
6. C-8983, March 16, 1945
   "In the Altitude Wind Tunnel at the Aircraft Engine Research Laboratory of the National Advisory Committee for Aeronautics, Cleveland, Ohio, aircraft engine installations can be subjected to trial under simulated altitude conditions. Here is shown a -80 airplane, with wings removed, mounted in the test section of the tunnel for determination of its jet engine performance."

7. C-19784, October 21, 1947
   View of full sized turbojet engines inside the Altitude Wind Tunnel, showing a heavily instrumented axial-flow engine installed in the tunnel test section.

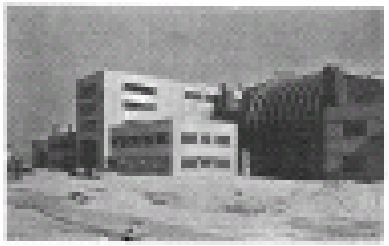


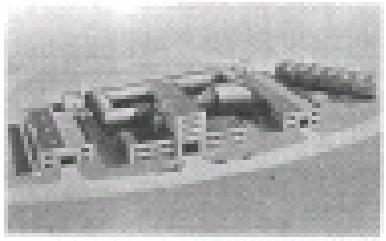


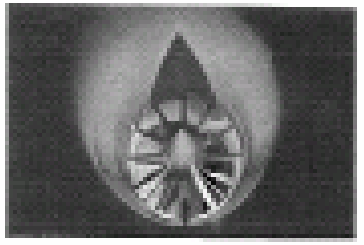
A 1944 photograph of the Altitude Wind Tunnel.



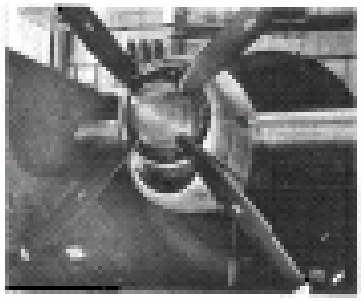
Altitude Wind Tunnel



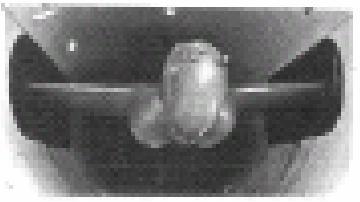




Tunnel Drive Propeller



B-29 engine nacelle in tunnel

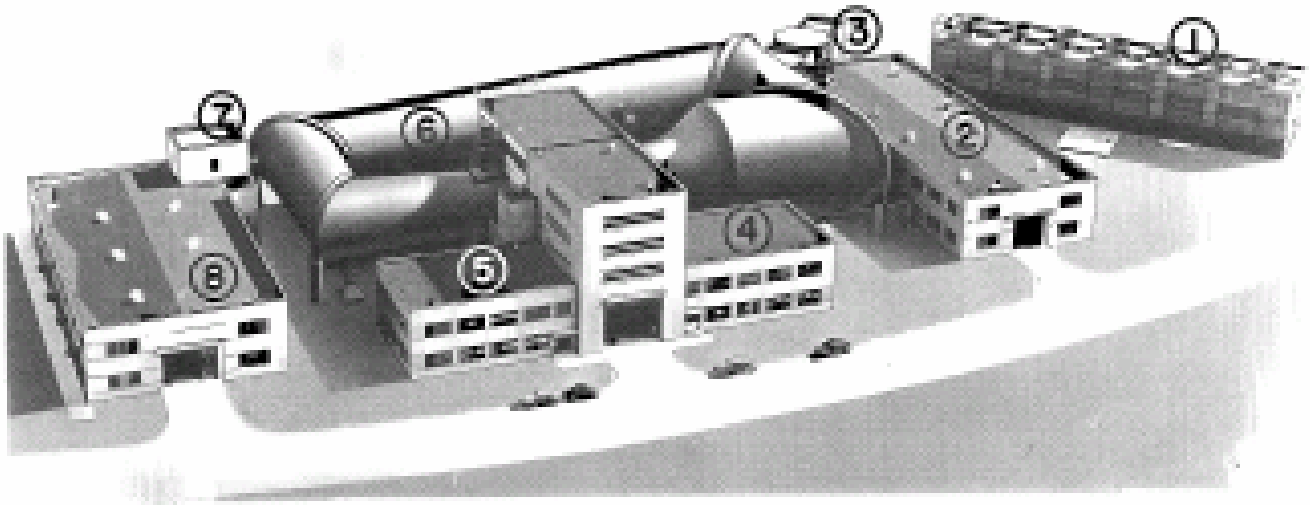


Model of a jet-propelled airplane

Description:
- Test section 20 foot diameter, closed throat
- Power 80,000 hp
- Speed 500 mph (at 30,000 feet altitude)
- Pressure and temperature - Variable from ground level conditions to those existing at 30,000 feet altitude
- Refrigeration capacity - Sufficient to test a 4000 hp engine at 48 degrees below zero

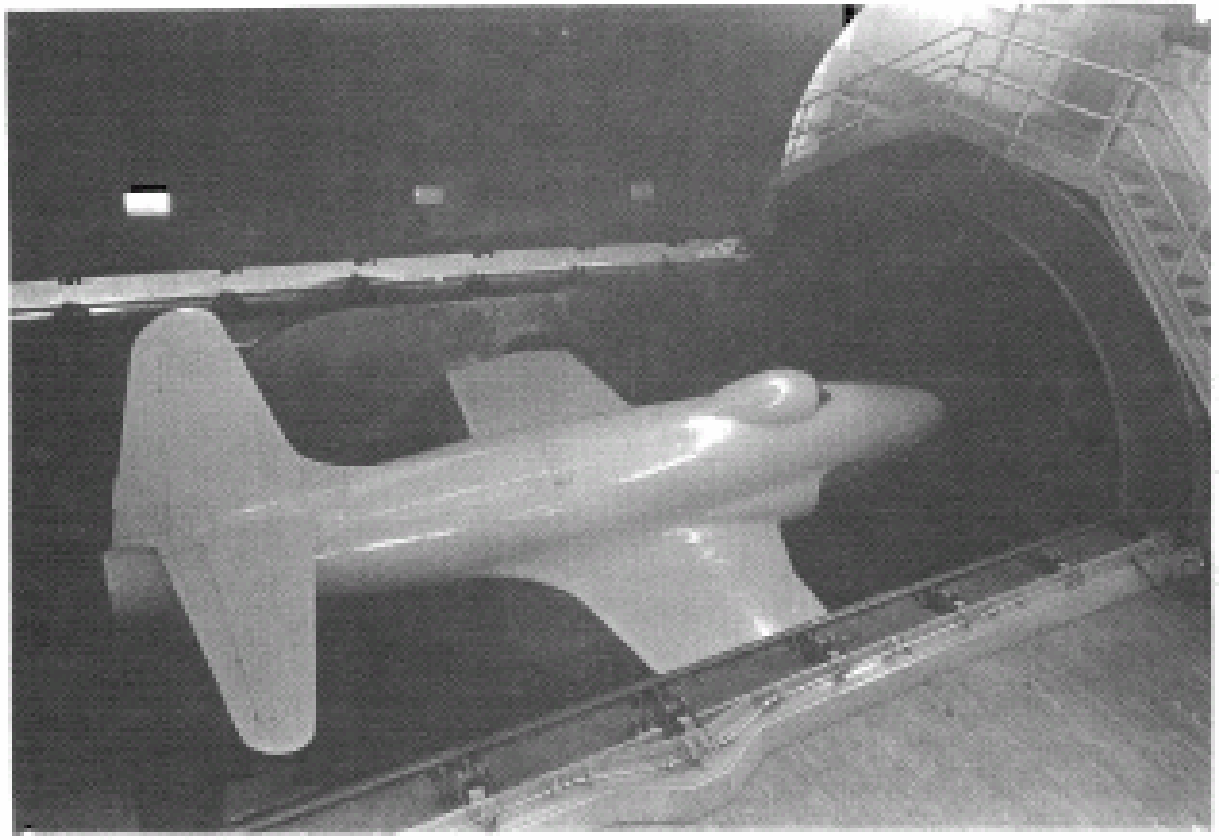
Purpose:
To conduct research on all problems relating to the combining of the aircraft power plant with the remainder of the airplane structure

Research projects:
(a) Jet-propulsion research
(b) Cooling and cooling of aircraft engines
(c) Variation of engine power with altitude
(d) Propeller performance at high-speed, high altitude conditions

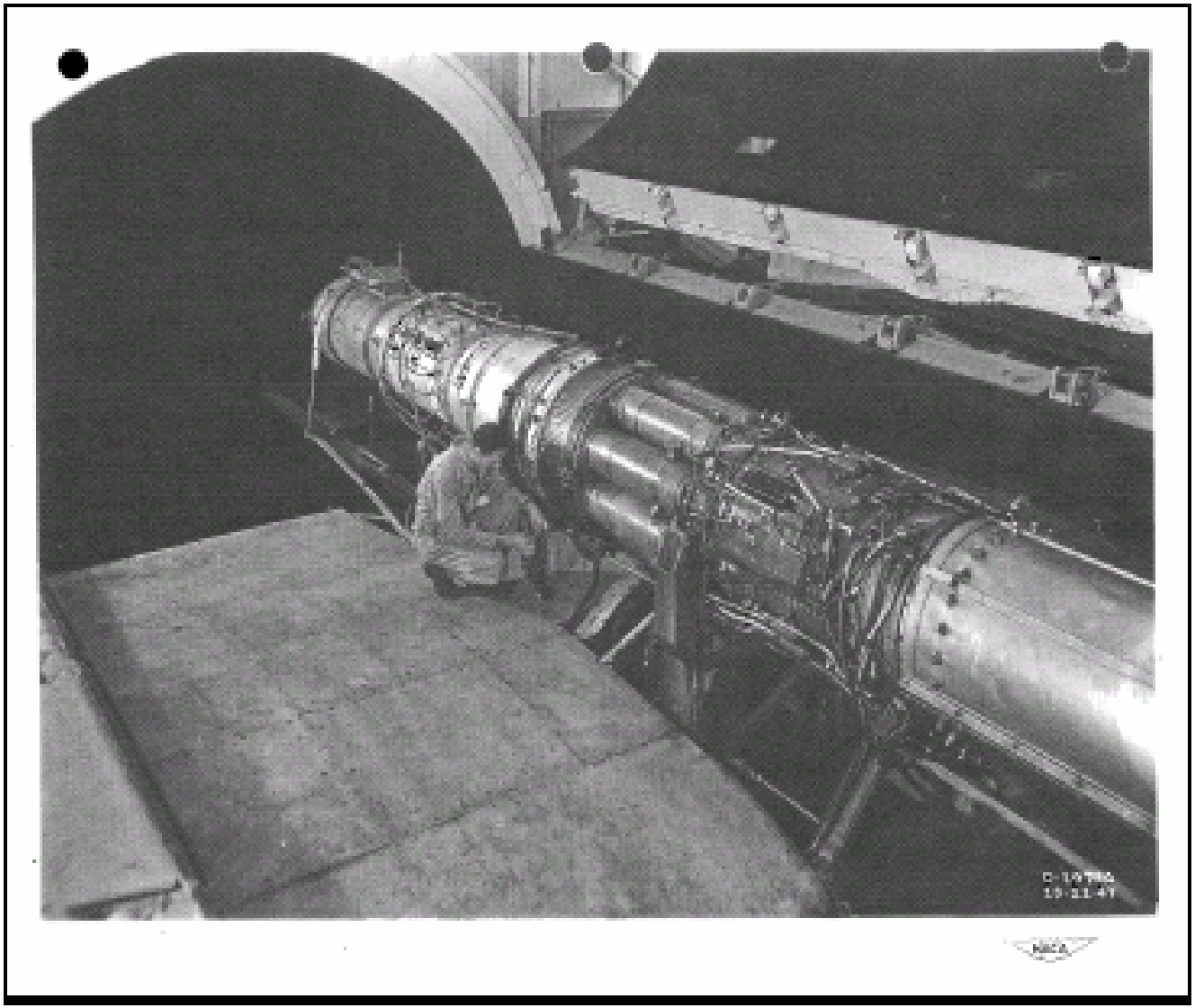


Probably most unique among the research facilities of the National Advisory Committee for Aeronautics at its Aircraft Engine Research Laboratory in Cleveland, Ohio, is the altitude wind tunnel where research is conducted on problems relating to the combining of the aircraft power plant with the remainder of the airplane structure.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AIRCRAFT ENGINE RESEARCH LABORATORY
CLEVELAND, OHIO



C-8983 In the Altitude Wind Tunnel at the Aircraft Engine Research Laboratory of the
3-16-45 National Advisory Committee for Aeronautics, Cleveland, Ohio, aircraft engine installations can be subjected to trial under simulated altitude conditions. Here is shown a P-80 airplane, with wings removed, mounted in the test section of the tunnel for determination of its jet engine performance.


C-14786
10-21-47

Appendix B

Cost Estimate for Repairs and Painting of Altitude Wind Tunnel Structure

NOTES / CLARIFICATIONS / QUALIFICATIONS

Project: NASA Glenn Research Ctr. - Building 7 Painting Only
Location: Cleveland, Ohio
Job Number: 2003-24

Note Number	Description
1	This estimate was prepared to help the National Aeronautics and Space Administration (NASA) allocate funds for projects.
2	This report is intended to help / assist a knowledgeable systems analyst to decide which repairs or demolition projects can be accomplished with present allocations or to request the proper amount of allocations for future years.
3	Caution is advised when choosing "selected" or "single" items because certain tasks cannot be done without cost ramifications. Certain scopes of work must be combined to achieve the correct cost for the desired task. For example, the base bid is the basic portion of this project, and the other options must be associated with the base bid per each scope of work.
4	This estimate may also be used as a guide for determining future allocations or future repairs. If the construction / demolition is performed in smaller quantities / amounts, a premium must be added to the task. This estimate is calculated in 2003 dollars for the present year. To meet your future year allocations, a 3% escalation fee per year should be added. On a majority of the projects, we have added two years of escalation.
5	Particular attention should be used in all items listed as being self performed by NASA. This would include removing all loose furniture and equipment before demolition occurs.
6	If singular scopes of work are chosen, the general conditions may not be a true reflection of actual costs. A percentage can not be applied and be accurate.
7	Our firm used the resources of Precision Environmental Co. and Fuller Environmental Co. for work associated with the hazardous material report. This includes asbestos abatement and containment and mercury clean-up..
8	Our firm has assumed that all crushed concrete materials stay on site and be used as backfill material at a later date or as needed. This can be incorporated in the process of bringing the demolished building back to existing elevations/grade or by hauling to the abandoned water retention basins at the edge of the site.
9	We have not allowed for any premium time to complete the work. Our assumption is that it is up to the contractor to determine their own work schedule to best suit their needs. If a compressed schedule is required overtime premiums should be applied.
10	Each building was priced as a stand alone building; therefore, giving the owner (N.A.S.A.) the ability to choose which year the demolition will occur.
11	We have assumed that the painting process would be performed one section at a time; therefore, the contractor would not be performing any work during the winter months.

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Location	CSI	Item Description	Takeoff Quantity	Takeoff Unit	Total Unit Price	Grand Total
		01 General Conditions				
01 General		**01 General**				
	01	General Requirements				
	01300	**Administrative Requirements**				
01 General	01310700	Field personnel clerk	52.0	week	400.00	20,800
01 General	01310700	Field personnel, field engineer	52.0	week	1,005.00	52,260
01 General	01310700	Field personnel, general purpose laborer	52.0	week	925.00	48,100
01 General	01310700	Field personnel, project manager	52.0	week	1,605.00	83,460
01 General	01310700	Field personnel, superintendent	52.0	week	1,510.00	78,520
01 General	01310700	Field personnel, timekeeper	52.0	week	780.00	40,560
	Due to the complexity of certain projects it it difficult for engineers, managers, or superintendents to track man hours on jobs with large labor force making it necessary for a general contractor to use a timekeeper.					
01 General	01310700	Field personnel, safety person	52.0	week	1,510.00	78,520
01 General	01321500	Photographs, cameraman & film, including processing, color	52.0	days	1,225.00	63,700
	Due to the fact that this is such a difficult project we feel any responsible contractor would document progress and procedures via photography in order to protect themselves from future litigation.					
		Administrative Requirements Total				**465,920**
	01400	**Quality Requirements**				
01 General	01450500	Testing	1.0	proj	25,000.00	25,000
		Quality Requirements Total				**25,000**
	01500	**Temporary Facilities & Controls**				
01 General	01520500	Office trailer	12.0	mnth	650.00	7,800
01 General	01520550	Field office expense, office equipment	12.0	mnth	250.00	3,000
01 General	01520550	Field office expense, office supplies	12.0	mnth	150.00	1,800
01 General	01520550	Field office expense, telephone bill	12.0	mnth	400.00	4,800
01 General	01520550	Field office expense, field office lights & HVAC	12.0	mnth	150.00	1,800
01 General	01530700	Safety	12.0	mnth	2,500.00	30,000
01 General	01530700	Temporary Enclosure	12.0	mnth	25,000.00	300,000
	Rent a Vented Temporary Enclosure Similar to Bridge Painting to Encapsulate Hazardous Materials & Overspray.					
01 General	01540750	Scaffolding	200.0	Csf	125.00	25,000
	For easy access to areas out of the safe reach of laborers.					

1

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Location	CSI	Item Description	Takeoff Quantity	Takeoff Unit	Total Unit Price	Grand Total
01 General	01560100	Barricades	1,500.0	lnft	45.00	67,500
		Jersey barriers, chain link fence, or orange plastic protective fencing.				
01 General	01580700	Signage	50.0	each	100.00	5,000
		Temporary Facilities & Controls Total				**446,700**
		General Requirements Total				937,620
01 General		**01 General Total**				**937,620**
		01 General Conditions Total				**937,620**
		02 Demolition				
01 General		**01 General**				
	02	Site Construction				
	02100	**Site Remediation**				
01 General	02110300	Hazardous Materials	1.0	lsum	500,000.00	500,000
		Site Remediation Total				**500,000**
	02200	**Site Preparation**				
01 General	02220100	Surface Preparation of Exterior Metal Skin of Wind Tunnel	75,317.0	sqft	12.50	941,463
		This is to prep the metal surface to receive paint.				
		Our visual inspection of the exterior surface of the wind tunnel revealed a large amount of rusted areas, this would have to be corrected before the paint could be applied.				
		This could range from sandbalsting to replacement of some of the exterior metal skin.				
		Site Preparation Total				**941,463**
		Site Construction Total				1,441,463
01 General		**01 General Total**				**1,441,463**
		02 Demolition Total				**1,441,463**
		03 Painting				

2

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Location	CSI	Item Description	Takeoff Quantity	Takeoff Unit	Total Unit Price	Grand Total
01 General		01 General				
	09	Finishes				
	09900	Paints & Coatings				
01 General	09910620	Painting of Wind Tunnel	75,317.0	sqft	10.00	753,170
		Includes minor sand blasting, scraping, cleaning, and painting				
01 General	09910620	Miscellaneous Painting	1.0	lsum	200,000.00	200,000
		Includes ductwork,catwalk and other micellaneous steel, and concrete foundation.				
		Paints & Coatings Total				953,170
		Finishes Total				953,170
01 General		01 General Total				953,170
		03 Painting Total				953,170

3

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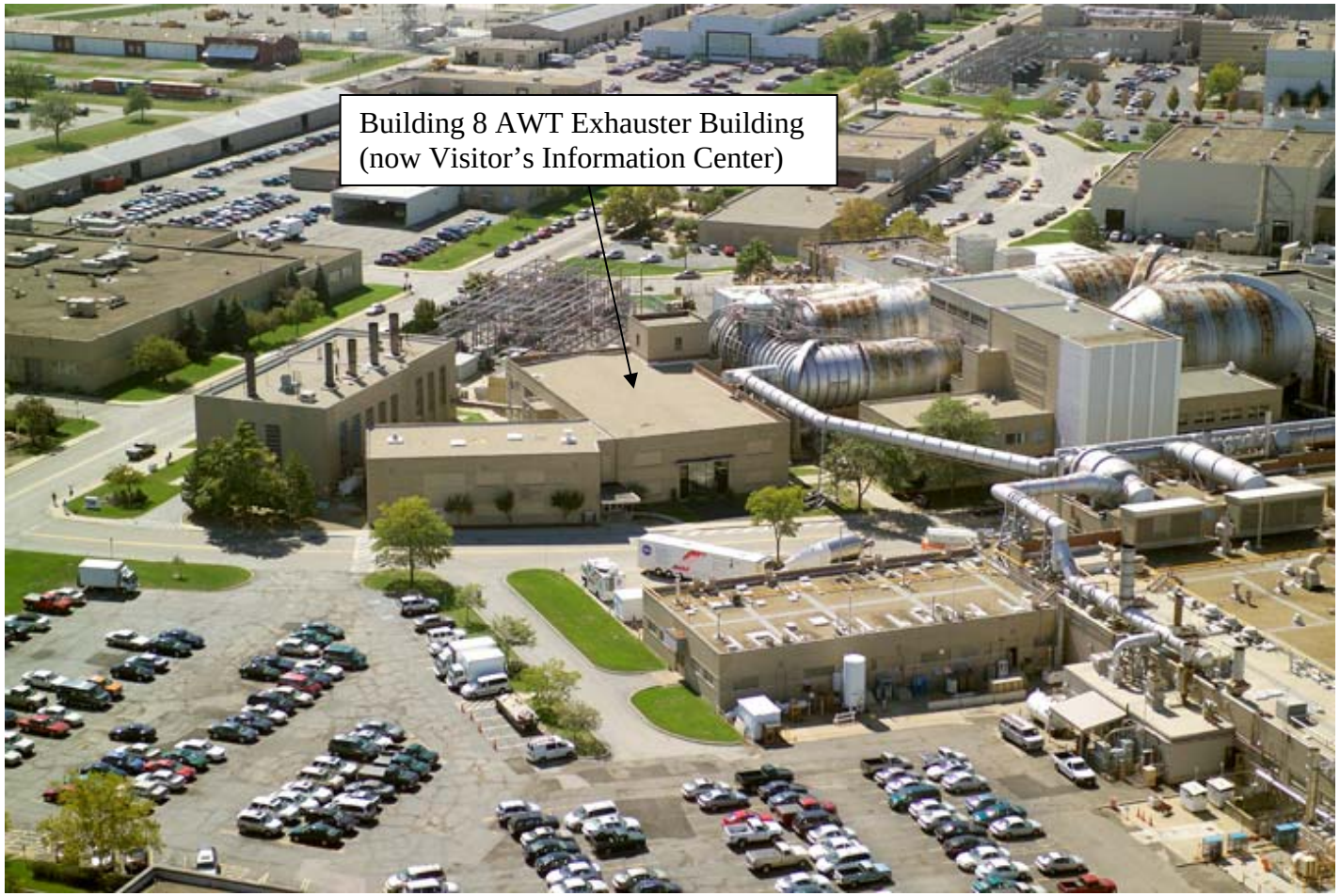
	Division	Labor	Mat	Subs	Equip	Other	User	Total
01	General Requirements	677,050	235,570	25,000				937,620
02	Site Construction	456,695		500,000	484,767			1,441,463
09	Finishes	789,181	163,989					953,170

Overhead	316,564
Subtotal	3,648,816
Contractor's Profit	182,441
Subtotal	3,831,257
Contractor's Bonds & Insurance	95,781
Subtotal	3,927,039
Contingency	392,704
Subtotal	4,319,743
Escalation - 3% per year to 2004	129,592
Subtotal	4,449,335
Escalation 3% per year to 2005	133,480
Total Estimate	4,582,815

Appendix C

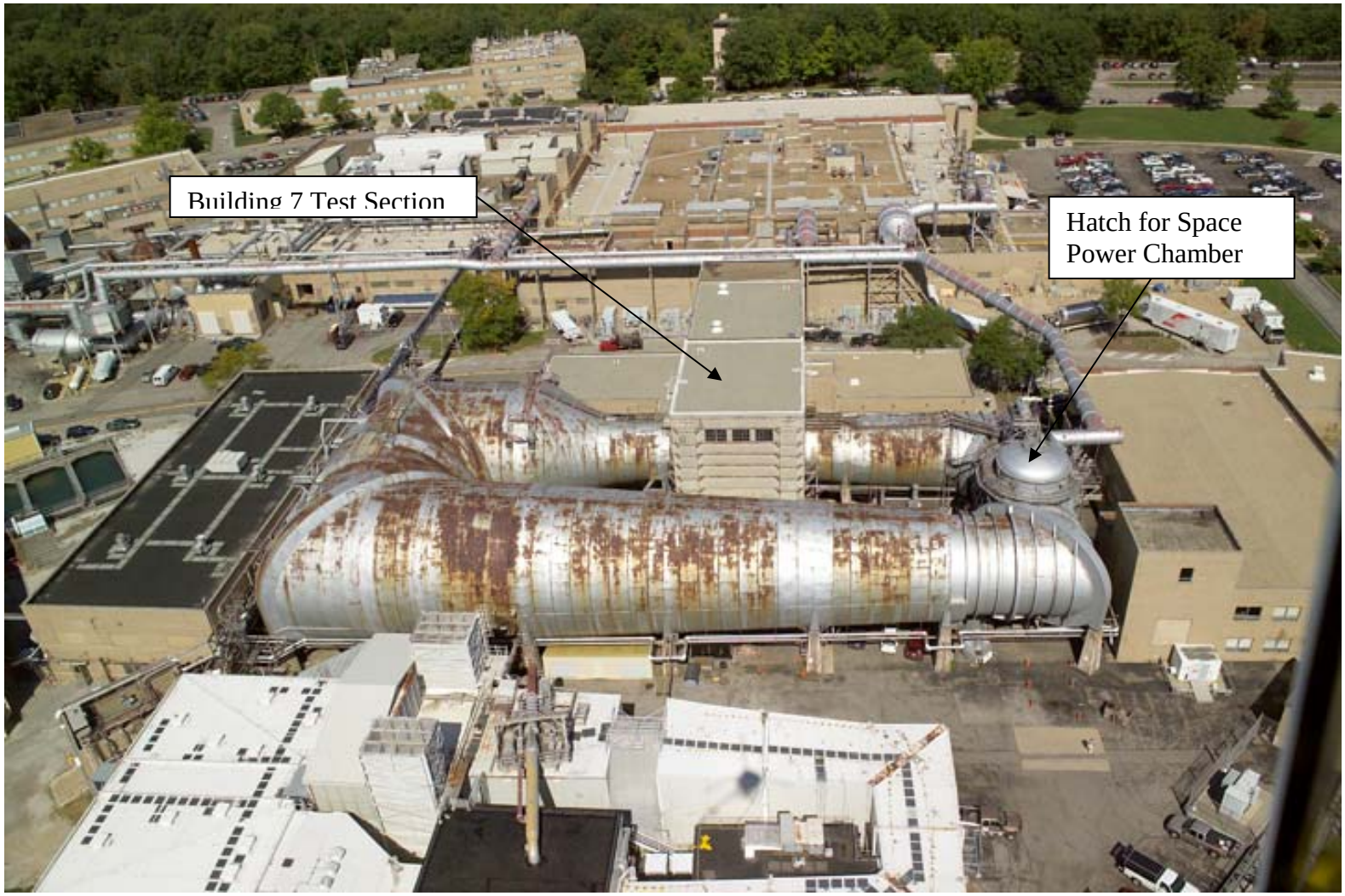
Ariel Photographs
Of the
Altitude Wind Tunnel

Photograph No. 1 - Altitude Wind Tunnel Viewed from the South with the Icing Research Tunnel and Substation “B” in the Foreground



Photograph No. 2 – Altitude Wind Tunnel Viewed from the Northeast with the Drive Motors and Compressor Building to the Left.

Photograph No. 3 – Altitude Wind Tunnel Viewed from the Northwest with the Refrigeration Building to the Right.



Photograph No. 4 – Altitude Wind Tunnel from the South, Test Section in the Building in the Center of the Picture.