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Project name:
Engineering and Missions Operations Facility N278 Project

Project reference:
60636084

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September 16, 2020

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Memo

Subject: Section 106 Consultation on the Engineering and Missions Operations Facility N278 Project, NASA Ames Research Center, Moffett Field, Santa Clara County, California

1. Introduction

The National Aeronautics and Space Administration (NASA) Ames Research Center (ARC) proposes to construct the Engineering and Missions Operations (EMO) Facility N278 (Building N278) Project (project or undertaking) at the NASA ARC, Moffett Field, Santa Clara County, California. As the lead federal agency, NASA is responsible for compliance with Section 106 of the National Historic Preservation Act of 1966 (54 United States Code §306108), as amended, which requires federal agencies to take into account the effects of their activities and programs on historic properties, and its implementing regulations in 36 Code of Federal Regulations (CFR) Part 800. The purpose of this memorandum is to provide necessary information for compliance with Section 106, including a description of the undertaking and the Area of Potential Effects (APE), the methodology used to identify and evaluate historic properties within the APE, a description of the affected historic properties, and an assessment of potential effects resulting from the undertaking.

1.1 Project Location

The project site is located on the NASA Ames Campus at NASA ARC, Moffett Field, Santa Clara County, California (see Figures 1 and 2 in Appendix A). The building site is southwest of the intersection of Mark Avenue and Warner Road, which is located within the boundary of the NASA Ames Wind Tunnel Historic District, which is listed in the National Register of Historic Places (NRHP).

1.2 Project Personnel

This study was conducted by cultural resources professionals who meet the Secretary of the Interior's Professional Qualifications Standards (48 Federal Register 44738). Trina Meiser, M.A., Senior Architectural Historian, served as the Principal Investigator; Jay Rehor, M.A., RPA, addressed archaeological resources; Lauren Downs, M.A., RPA, provided map figures; and Kirsten Johnson, M.A., served as the lead verifier of this document.

2. Description of the Undertaking

The project involves construction of Building N278, which is considered an undertaking per 36 CFR § 800.3(a). The project will create a new facility that meets mission requirements to reduce the footprint and operations and maintenance costs while providing a healthy, safe, efficient, modern, flexible, and sustainable work environment.

The EMO Facility will help consolidate and modernize facilities in alignment with NASA's mission. The facility will optimize NASA ARC EMO operations in a state-of-the-art facility that will reinforce the mission of NASA ARC. Building N278 will co-locate several key program functions and include offices, meeting space, technical labs, and workshops. Following the U.S. General Services Administration (GSA) Public Buildings Service (PBS) criteria for design, construction, and operation of federal civilian buildings, the project uses the P100 Facilities Standard and NASA's Design Guidelines and Program of Requirements as a guide in determining the requirements for the design of the facility. The project will also use the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) v4 Building Design and Construction certification program with LEED Silver as NASA's minimum certification requirement; GSA is targeting LEED Gold Certifications, to be determined as the design progresses.

The project will require the demolition of approximately 83,000 square-feet of existing facilities, including Building N216 (existing pre-engineered metal building and concrete building), Building N251 and its underground grease trap, two empty underground gas tanks, the Motor Pool fuel station, the paved parking lot, and existing wind tunnel footings found at the project site. The project will also require relocation of an existing 36-in.-diameter storm drain. Several underground conduit lines are present within the proposed building footprint. These can be removed, rerouted, or left in place (pending the foundation design of the new building). Based on similar projects, the site will likely require some level of contamination remediation, thus likely qualifying the project as a brownfield. The staging area for this project will be limited to existing paved parking lots in the vicinity of the project site.

The project will then construct Building N278, a new, proposed two-story, 55,323-gross-square-foot laboratory and office building (see Select Project Drawings provided in Appendix B). Design options for the exterior walls include a painted stucco system on 12-inch concrete masonry units with an interior finished with 5/8-inch gypsum wall board on 3-5/8-inch metal furring on air-vapor barrier and R-30 exterior insulation; impact resistant gypsum wall board may be required on the laboratory and shop areas. Tilt-up concrete panels and/or insulated metal panels could also be utilized for the exterior walls. Curtain walls will consist of aluminum window wall systems, insulated glass, and aluminum thermally-broken framing systems at conditioned spaces. Windows will consist of pre-finished aluminum windows, curtain walls, and translucent panels with insulated glass units for all storefront, doors, and curtain walls. The eastern elevation will serve as the main public entry. This is where the existing parking lot is to remain and where the main focal point of the building is to be established as the site is approached from the southeast along Mark Avenue. This corner would feature a prominent cantilevered covered entry. Entrance configurations will consist of anodized aluminum entrance systems at main entrances and exits. Utility doors will consist of painted steel doors (insulated) and frames, and mechanically operated overhead (roll-up) doors. The interior laboratory area is intended to be flexible and efficient, and as open as possible with clear sight lines and logical circulation. Transparency and visual connections will facilitate both safety and collaboration. Partitions, where required are intended to be demountable and typically glass when occurring in the open lab zone. The permanent partition that separates the building circulation spine will be full height glass.

The project will provide a green belt open space feature along the west side of the new building. The greenbelt will be physically accessible to project occupants and will include pedestrian-oriented paving with physical site elements that accommodate outdoor social activities.

Select project drawings are provided in Appendix B.

3. Area of Potential Effects

The APE is defined to address both direct and indirect impacts on potential historic properties and encompasses areas that may be affected by both temporary and permanent construction activities (see Figure 3 in Appendix A). For archaeological resources, the APE includes the limits of the project area, including areas of temporary staging and construction ground disturbance. Below-grade activities are limited to the project site; therefore, only the immediate project footprint was assessed for archaeological resources. The APE for construction of the new building extends to a vertical depth of 20 feet below surface (the proposed depth of improved soil columns for the new foundation system; see discussion below), though deeper excavations up to 30 feet below surface may be necessary for removal of existing infrastructure (underground gas tanks and the existing wind tunnel footings). Above-ground activities include temporary staging, which is unlikely to have indirect impacts on historic properties, and construction of Building N278 and its landscaping. Construction of Building N278 may create visible, auditory, or atmospheric changes in the settings of adjacent historic properties; therefore, the APE includes the first tier of buildings adjacent to the project's footprint. Because the project site is located in the NASA Ames Wind Tunnel Historic District, the entire district is included in the APE.

4. Identification of Historic Properties

Historic properties are defined as any district, site, building, structure, or object that is included in or is eligible for listing in the NRHP. The APE has been previously surveyed for archaeological and architectural resources, and architectural resources have been previously evaluated for NRHP eligibility. The following sections address the methodology and efforts to identify historic properties in the APE.

4.1 Archaeological Resources

The land that comprises ARC has changed dramatically since the early 20th century from predominantly agricultural use to an extensive military airfield installation beginning in 1931 and aeronautical research and development beginning in 1939. Extensive surface disturbance occurred throughout ARC with grading and fill to create the airfield and the campuses with hundreds of buildings and structures to support operations.

A comprehensive investigation of previous archaeological studies at ARC was completed in 2017 (AECOM 2017). The *NASA Ames Research Center Archaeological Resources Study* involved a desktop survey of archival resources and a geoarchaeological assessment of the entire ARC site and included an assessment of archaeological sensitivity and the potential for buried archaeological resources. The study concluded that there is low potential for more deeply buried prehistoric archaeological resources across ARC. No archaeological resources have been previously identified in or near the APE. A review of the 2017 investigation indicates that the proposed work is located in an area of low prehistoric or historic archaeological sensitivity (see Figure 4 in Appendix A).

The project site is the former location of the 7-ft. x 10-ft. Wind Tunnel No. 2 (formerly Building N216, demolished). The depth of previous disturbance associated with the former Building N216 wind tunnel includes 2-foot to 3-foot-thick pile caps supported on approximately 30-foot-long driven concrete displacement piles. Additionally, two underground gas tanks and several utility lines are known to exist in the project site. The area is highly disturbed and entirely paved. No new survey was performed.

The expected depth of ground disturbance necessary to construct Building N278 is up to 20 feet below existing grade. The foundation for the new building is anticipated to consist of 3-feet 0-inch-thick concrete spread footings located 1 foot below grade. Most of the spread footings will be four 18-inch-diameter by 16-foot-long grouted soil columns. The soil columns would be constructed by mixing cement grout with the in-situ soil.

The project would be limited to previously disturbed areas with low potential for deeply buried prehistoric sites. Therefore, it is not anticipated that archaeological resources will be encountered as a result of this undertaking. The APE is entirely paved, and further archaeological survey or testing related to the undertaking is not necessary, and no potential effects on potentially significant archaeological resources are anticipated.

4.2 Architectural Resources

4.2.1 Historic Context

In December 1939, the National Advisory Committee for Aeronautics (NACA) began construction of the Ames Aeronautical Laboratory northwest of Naval Air Station Sunnyvale airfield. The NACA built the new laboratory adjacent to the airfield for defense-related military and industrial aeronautical research. The location was important because of access to the airfield, major aviation industry leaders, good weather, and a new high-powered electrical station in Sunnyvale. The Army leased 62 acres of the installation to the NACA in December 1939, and the NACA purchased 40 acres of adjacent, undeveloped agricultural lands (Hartman 1970). Specific geographical issues including a high water table and high potential for seismic activity were taken into account in the design of the campus facilities.

Initial development of the campus focused on the construction of massive wind tunnel facilities to test models and full-scale airplanes. A flight research hangar, an electrical substation supplying 40,000 horsepower (approximately 30,000 kilowatts), two 7-ft. x 10-ft. wind tunnels, and a 16-ft. wind tunnel were the first major facilities constructed in 1940–1941. In March 1942, construction began on the gigantic 40-by-80-ft. structure

(Building N-221), the world's largest low-speed wind tunnel for testing full-scale aircraft at the time (Muenger 1985). While construction continued during World War II, intensive development of the laboratory centered on aeronautical research facilities to support wartime aviation. Beside the core of wind tunnels and flight research hangar, Ames eventually developed Streamlined Moderne-style concrete administrative and office buildings around Bush Circle to the west of Shenandoah Plaza by 1943. A second aircraft hangar was added, and the ramps and taxiways connecting the airfield to the NACA area were extended.

During World War II, Ames operated around the clock, and researchers contributed important advances in aviation technology, including the development of airplane deicing equipment. Research and development continued steadily into the postwar period, with high-speed aviation at the forefront. At the end of World War II, there were five wind tunnels in operation at Ames, with several new supersonic speed wind tunnels under construction between February and September 1945. The postwar airfield improvements related to the Navy's flight programs, especially the extension of the main runway (32R-14L), allowed for more experimentation with high-speed aircraft. In 1946, R.T. Jones arrived to test his theory of sweptback wing design to avoid high drag of straight wings at transonic, supersonic, and high-subsonic speeds (Vincenti 2001). The NACA's research resulted in some of the most significant advancements in aeronautical engineering up to that time (Anderson n.d.).

In the 1950s, the Ames campus developed further with new facilities to support research on both fundamental theoretical aerodynamics and specific industry concerns, most notably in sweptback wing design. Research at Ames tested vehicles at supersonic speeds, again supporting theoretical progress with applied experimentation, and also laid the groundwork for developing flight simulators and computer-based modeling. One of the most significant research developments at Ames was Julian H. Allen's theory on blunt-nosed atmospheric reentry. The concept that blunt bodies dissipate heat more efficiently on reentry had far-reaching implications for all future space exploration vehicles (Vincenti et al. 2007). New facilities also were constructed to support the growing complexities of aerothermodynamics and hypervelocity ballistics research. Completed in 1956, the Unitary Plan Wind Tunnel complex (Hartman 1970) included an 11-ft. x 11-ft. transonic, a 9 ft. x 7-ft. supersonic, and an 8-ft. x 7-ft. supersonic wind tunnel, and was powered by a dedicated power plant that generated up to 240,000 horsepower (Butowsky 1984; Muenger 1985). The unique complex was used by industry, military, and university partners.

The launch of *Sputnik* in 1957 propelled the United States into the space age. NASA was established and began officially operating on October 1, 1958. NASA subsumed the NACA's former facilities. Ames, now ARC, turned toward the technological challenges of space travel. Its programs in applied research related to testing and improving aircraft in the early years of NASA, as NASA organized to address the unprecedented directive to achieve a lunar landing. Most research programs at ARC remained relatively unchanged until the early 1960s, when NASA Headquarters restructured the organization of its field centers to address space-related demands. ARC, which as an aeronautical laboratory traditionally focused on the physical science and engineering of aviation research, initially resisted the new space research programs. In 1963, Ames started the real shift from aeronautical laboratory to an interdisciplinary research center whose primary mission was basic and applied research on aerodynamics of reentry vehicles, flight control of space vehicles and aircraft, and space environment physics (Muenger 1985).

In the 1960s, ARC continued its applied research programs, and the airfield was the site of extensive research into vertical/short takeoff and landing (V/STOL) technologies and aircraft. Although aeronautics research with V/STOL studies and supersonic transport feasibility investigation continued, astronautics became the more visible research area at ARC. Aerothermodynamics and hypervelocity ballistics research related to astronautics led to expansion of the campus and the construction of new facilities, including the hypervelocity research laboratory and shock tunnel, a Mach 50 helium tunnel, a hypervelocity free-flight facility, a new impact range, and the gas thermodynamics and arc jet complex, which were designed to reproduce the extreme conditions that a space vehicle would be subjected to in space. Advancements in flight simulators also occurred during this time. In 1963, NASA approved ARC engineers' proposal for the construction of a complex of four flight simulation facilities. Other buildings constructed in 1965 and 1966 included a space environments research facility and structural dynamics laboratory that were built to simulate conditions and forces in space; a life sciences research laboratory; and a spaceflight guidance laboratory. These new facilities primarily focused on solving the major spaceflight problems of speed and the heat generated by it, and the control of space vehicles during flight. By

1969, ARC facilities included 18 wind tunnels, two sets of ballistic ranges, 10 flight simulators, 11 arc jet facilities, eight laboratories, and 56 major buildings (Muenger 1985).

ARC contributed to the successful development of viable spacecraft for all of NASA's space programs, including Mercury, Gemini, Apollo, and the Space Shuttle programs. In 1971, ARC opened a Space Shuttle development office and eventually conducted half of all the wind-tunnel tests for the second phase of the Space Shuttle design in the National Full-Scale Aerodynamics Complex (NFAC), the Unitary Plan Wind Tunnel Complex, and the 3.5-ft. hypervelocity tunnels (Bugos 2014; Muenger 1985). Started in 1978, the gigantic 80-ft. x 120-ft. Subsonic Wind Tunnel addition to the 40-ft. x 80-ft. wind tunnel was completed in 1982. Designated as the NFAC in 1987, it was the world's largest open-circuit tunnel able to accommodate a variety of large-scale aircraft including fighter jets, Space Shuttle models, and a Boeing 737. ARC also hosted a fleet of airborne science aircraft at Moffett Field that made major discoveries in infrared astronomy and high-altitude observation instruments. The airfield became the staging area for some of the most significant earth sciences missions of the 1970s and 1980s.

After Moffett Federal Airfield was transferred to NASA in 1994, ARC became a larger and more diverse research campus, hosting new tenants in the former military buildings at Shenandoah Plaza and the airfield. Into the 21st century, renovation and new development continue to further NASA's programs, including aviation and biosciences, as well as other tenants' operational, scientific, educational, and technological programs and industries.

4.2.2 Previous Studies

Previous efforts to identify historic properties at ARC that have covered portions of the APE include thematic studies of Apollo Program-era and Space Shuttle Program-era facilities, a reconnaissance survey, and the NRHP nomination for the NASA Ames Wind Tunnel Historic District. Table 1 lists relevant evaluation efforts in previous surveys at ARC.

Table 1. Previous Built Environment Studies in the APE

Date	Author	Title	Findings
1984	National Park Service	*Man in Space: National Historic Landmark Theme Study*	Unitary Plan Wind Tunnel (N227) recommended for designation as an NHL.
2001	Architectural Resources Group, Inc.	*Building Evaluations, NASA Ames Research Center, Mountain View, California*	Evaluated 10 buildings at Ames campus (including N222) for individual NRHP eligibility associated with flight and aerospace development, including wind tunnel research, flight simulation, space transport and reentry systems, and hypersonic vehicle flight research. Recommended 10 buildings not individually NRHP eligible; did not include evaluation as a potential historic district.
2005	Page & Turnbull	*Reconnaissance Survey of NACA and NASA Buildings*	Surveyed the Ames Campus to identify potentially eligible resources and historic district.
2007	Page & Turnbull	*Evaluation of Historic Resources Associated with the Space Shuttle Program at Ames Research Center*	Recommended Buildings N238 and N243 eligible for listing in the NRHP under Criterion A and Criteria Consideration G; did not identify other resources eligible under the Space Shuttle Program context.
2017	AECOM	*National Register Nomination for the NASA Ames Wind Tunnel Historic District*	Nominated historic district with five contributing facilities to the NRHP, including nine buildings: N215, N220, N221 and N221B, N226, and N227 and N227A-C; listed in 2017.

4.2.2.1 Man in Space: National Historic Landmark Theme Study (Butowsky 1984)

In 1984, the National Park Service (NPS) completed the Man in Space: National Historic Landmark Theme Study. The purpose of the study was to evaluate potential resources at all NASA centers and component facilities that related to the theme of Man in Space, in reference to Apollo program-era facilities, and to recommend resources for designation as National Historic Landmarks (NHLs). The study looked at resources related to the following subthemes: Technical Foundations before 1958; Efforts to Land a Man on the Moon; Exploration of the Planets and Solar System; and the Role of Scientific and Communications Satellites. ARC was one of many NASA Centers evaluated as part of the study. The Man in Space Theme Study recommended 24 resources for designation as NHLs because they "represent the best and most important surviving examples of this technology" (Butowsky 1984). The only property at ARC recommended for designation was N227, the Unitary Plan Wind Tunnel. As a result of the study, N227, including N227A, N227B, and N227C, was designated an NHL in 1985.

4.2.2.2 Building Evaluations, NASA Ames Research Center, Mountain View, California (Architectural Resources Group, Inc. 2001)

In 2001, Architectural Resources Group evaluated 10 buildings, including one in the APE, for potential individual eligibility for listing in the NRHP. The 10 buildings, consisting of N204, N204A, N205, N206, N207A, N208, N209, N218A, N222, and N223, were evaluated as ineligible for listing in the NRHP. The buildings were not evaluated as a potential historic district, and further investigation to determine this potential was recommended.

4.2.2.3 Reconnaissance Survey of NACA and NASA Buildings (Page & Turnbull 2005)

In 2005, Page & Turnbull completed a reconnaissance survey of the Ames Campus to identify potentially eligible properties under NRHP and California Register of Historical Resources (CRHR) criteria. The reconnaissance survey area covered the APE in entirety, including 22 buildings currently in the APE (N212, N213, N214, N215, N216, N216A, N216B, N220, N221, N221A, N221B, N222, N226, N227, N227A, N227B, N227C, N227D, N246, N247, N251, and N263). Buildings that were over 50 years old at the time and potentially significant were evaluated under NRHP and CRHR criteria. Of the 22 buildings in the APE, N212, N216, N220, N221, N221A, N222, and N226 were evaluated as potentially significant; N227, N227A, N227B, and N227C were already listed in the NRHP. The remaining buildings were either identified as "non-contributing" to a potential historic district or as "properties to be evaluated in future." Various Department of Parks and Recreation (DPR) 523 forms were prepared for certain buildings included in the survey (see Archival Records in Appendix C).

4.2.2.4 Evaluation of Historic Resources Associated with the Space Shuttle Program at Ames Research Center (Page & Turnbull 2007)

In 2007, Page & Turnbull completed a Space Shuttle Program thematic study and assessment of 11 resources located at ARC. Each identified resource was evaluated utilizing specialized criteria developed between NASA and the NPS. In addition to evaluating each structure under NRHP Criteria A–D, the structures were evaluated under Criteria Considerations B and G. Of the 11 resources surveyed, N238 (Arc Jet Laboratory) and N243 (Flight and Guidance Simulation Laboratory) were determined to meet NRHP criteria within the context of the Space Shuttle Program under Criterion A and Criteria Consideration G. The remaining nine resources were found not eligible for listing in the NRHP under the themed context.

4.2.2.5 National Register Nomination for the NASA Ames Wind Tunnel Historic District (AECOM 2017)

In 2017, the NASA Ames Wind Tunnel Historic District was listed in the NRHP (see Archival Records in Appendix C). The district consists of five contributors (including nine buildings) and 10 non-contributors. Contributing structures primarily are wind tunnels and buildings that support the functions of the wind tunnels. Although many of the structures have their own building numbers, they are functionally related and connected, and are counted as one resource. Located within the NASA Ames campus, the district is surrounded by various administrative and research-related buildings that represent successive eras of the campus's development. Within the district are mature trees, shrubs, manicured lawns, and hardscape features (i.e., DeFrance Avenue and Durand Road) that contribute to its landscape and setting. The district retains all seven aspects of integrity and has the ability to convey its significance at the national level. The district meets Criterion A in the areas of science, invention, and engineering at the national level of significance because this district contributed greatly to advancements in the aeronautical and space industries in the United States (U.S.). The district also is eligible under Criterion C in the area of engineering, because the wind tunnels represent a significant work of engineering. The period of significance begins with the construction of Building N-220 in 1940 and ends in 2011, the year that the Space Shuttle Program (SSP) ended. The tunnels and their supporting buildings performed critical roles in aeronautical research and design, and were among the most sophisticated scientific tools constructed and used by the U.S. government and commercial businesses. The research conducted within the wind tunnels was crucial to aircraft and spacecraft research and design. As the district's period of significance extends to a time period less than 50 years old, the district meets the requirements of Criteria Consideration G because the facility is exceptionally significant as the leading research and development facility in the areas of aeronautics and space in the U.S.

4.2.3 Current Study

The APE encompasses the NASA Ames Wind Tunnel Historic District and contains 22 resources within the district and two additional buildings outside of the district (Table 2). Based on previous studies, five facilities (composed of nine buildings) are listed in the NRHP as part of the district: Buildings N215, N220, N221, N221B, N226, N227, N227A, N227B, and N227C. The remaining 13 buildings in the district are non-contributing. Of the 13 non-contributing buildings, seven are less than 50 years old, do not appear to have exceptional significance to meet Criteria Consideration G that would warrant evaluation under the NRHP criteria, and are not eligible for individual listing in the NRHP (Buildings N216A, N216B, N246, N247, N251, N263, and N288). The other six of the 13 non-contributing buildings were previously evaluated as not eligible for individual listing in the NRHP. Building N212 was previously evaluated as eligible for listing in the NRHP and Building N213 was previously evaluated as not eligible for listing in the NRHP; these buildings have had few alterations since previously recorded and integrity remains the same. See Appendix C for DPR 523 forms and the NRHP nomination for the NASA Ames Wind Tunnel Historic District.

Table 2. Architectural Resources in the APE

Name	Description	Year Built	NRHP Evaluation Status
N212*	Applied Manufacturing Division Welding Shop	1950	Eligible
N213*	Research Support Building	1950	Not eligible
N214	Paint Shop	1942	Non-contributing/Not eligible
N215	7-ft. x 10-ft. Wind Tunnel No. 1	1940	Listed – Ames Wind Tunnel Historic District
N216	Machine Shop	1941	Non-contributing/Not eligible
N216A	Model Preparation Building	1973	Non-contributing/Less than 50 years old
N216B	Army Model Assembly Building	1973	Non-contributing/Less than 50 years old
N220	Technical Services Machine Shop	1940	Listed – Ames Wind Tunnel Historic District
N221	40-ft. x 80-ft. Wind Tunnel	1944	Listed – Ames Wind Tunnel Historic District Eligible for individual listing
N221A	20-G Centrifuge	1964	Non-contributing/Not eligible
N221B	80-ft. x 120-ft. Wind Subsonic Tunnel	1985	Listed – Ames Wind Tunnel Historic District
N222	2-ft. x 2-ft. Transonic Wind Tunnel	1951	Non-contributing/Not eligible
N225	Electrical Substation	1940	Non-contributing/Not eligible
N226	6-ft. x 6-ft. Supersonic Wind Tunnel	1948	Listed – Ames Wind Tunnel Historic District
N227	Unitary Plan Wind Tunnel	1955	National Historic Landmark Listed – Ames Wind Tunnel Historic District
N227A	11-ft. Transonic Wind Tunnel	1955	National Historic Landmark Listed – Ames Wind Tunnel Historic District
N227B	9-ft. x 7-ft. Transonic Wind Tunnel	1955	National Historic Landmark Listed – Ames Wind Tunnel Historic District
N227C	8-ft. x 7-ft. Transonic Wind Tunnel	1955	National Historic Landmark Listed – Ames Wind Tunnel Historic District
N227D	Substation	1955	Non-contributing/Not eligible
N246	Model Construction Facility	1973	Non-contributing/Less than 50 years old
N247	Astrobiology Institute and Space Biosciences	1975	Non-contributing/Less than 50 years old

Name	Description	Year Built	NRHP Evaluation Status
N251	Motor Pool Building	1977	Non-contributing/Less than 50 years old
N263	Telecommunications Building	1989	Non-contributing/Less than 50 years old
N288	Biosciences Collaborative Facility	2020	Non-contributing/Less than 50 years old

*outside the NASA Ames Wind Tunnel Historic District boundary

5. Affected Historic Properties

5.1 Building N212

Built in 1950, Building N212 is the Applied Manufacturing Division Welding Shop. It is a two-story industrial-style building with a concrete foundation, exposed concrete walls, and a flat roof. The building's massing is simple with minimal ornamentation, including simple, flat, horizontal concrete bands that run across each façade. The building has one-over-three steel awning windows divided by horizontal concrete bands. The windows are grouped in regular sets of either three or four separated by concrete piers with grooves that align with the window mullions. Some of the windows have been replaced with louvers or covered with mechanical ductwork. The north elevation has a pair of sliding, high-bay utility doors. The west façade, facing Mark Avenue, has a pedestrian entry with a concrete canopy over aluminum-framed door and window.

Originally used as the Structural Fabrication Shop, the building supports the Advanced Composites Group, which is a technical support group for all research disciplines at Ames. Its capabilities include composite fabrication, plastic fabrication, and other non-metallic fabrication processes. The Advanced Composites Group contributes to the design and manufacturing of a wide variety of test equipment and models. This facility contains spray booths for finish applications, autoclaves for composite fabrication, and many machine tools. It was one of several research and support buildings built between 1940 and 1958. This facility was crucial in creating accurate models for the various types of testing that occurred at Ames. Aeronautical test models and various support hardware were developed in N212 for ongoing NASA programs. Additionally, the building exhibits the Streamline Modern/International Style architectural influences that are common on the Ames Campus. This building possesses integrity of location, design, setting, materials, workmanship, feeling, and association. It is eligible for the NRHP under Criteria A and C.

5.2 NASA Ames Wind Tunnel Historic District

The NASA Ames Wind Tunnel Historic District, which is listed in the NRHP, contains five contributing facilities—Buildings N215, N220, N221/N221B, N226, and N227A-D–and landscape features. The NASA Ames Wind Tunnel Historic District meets Criterion A in the areas of science, invention, and engineering at the national level of significance because this district contributed greatly to advancements in the aeronautical and space industries in the U.S.. The district also is eligible under Criterion C in the area of engineering, because the wind tunnels represent a significant work of engineering. The period of significance begins with the construction of Building N-220 in 1940 and ends in 2011, the year that the SSP ended. The tunnels and their supporting buildings performed critical roles in aeronautical research and design and were among the most sophisticated scientific tools constructed and used by the U.S. government and commercial businesses. The research conducted within the wind tunnels was crucial to aircraft and spacecraft research and design. As the district's period of significance extends to a time period less than 50 years old, the district meets the requirements of Criteria Consideration G because the facility is exceptionally significant as the leading research and development facility in the areas of aeronautics and space in the U.S. The boundary for the district was delineated to specifically include the wind tunnels and those buildings directly associated with wind tunnel research.

5.2.1 Building N215

Building N215, the 7-ft. x 10-ft. Wind Tunnel No. 1, is composed of a two-story building and wind tunnel. The two-story portion of the building is oriented along Durand Road and has a rectilinear plan (Photo 1). The building has a concrete foundation, steel-reinforced concrete walls, and a flat roof. The exterior walls feature grooved horizontal concrete bands across each façade that articulate the first and second floors. The building has three-over-three mixed steel and wood windows throughout. The main entry along Durand Road has a concrete awning with rounded corners. Exterior steel and concrete stairs have been added to this side of this building.

5.2.2 Building N220

Building N220, Technical Services Machine Shop, is a two-story building with a rectangular plan. The building has a concrete foundation, steel-reinforced concrete walls, and a flat roof. The exterior walls feature grooved horizontal concrete bands across the south, east, and west sides that articulate the first and second floors and contain steel-framed industrial windows. The north side of the building along Durand Road contains steel nesting hangar doors with continuous steel windows in the first and second stories.

5.2.3 Building N221 and N221B

Buildings N221 and N221B comprise the National Full-Scale Aerodynamics Complex. Building N221 is the 40-ft. by 80-ft. Wind Tunnel, which was constructed in 1944. The south elevation of the building is approximately 440 ft. long and 175 ft. tall. The building materials on this elevation consist of a mix of corrugated metal siding and transite cement asbestos corrugated siding surrounded by the exoskeleton of the structure. That exoskeleton features 17 geodesic bents. The east elevation also is a mix of corrugated metal siding and transite cement asbestos-corrugated metal siding. On this elevation, the exoskeleton has 29 geodesic bents. The entrance cone and the test section diffuser are metal and also are surrounded by steel bents. The interior of the building is used for offices, a laboratory, and research space. The test section of Building N221's wind tunnel measures 40 feet high, 80 feet wide, and 80 feet long. Its interior has a thick acoustical lining that was added after the building's original construction to help absorb sound. The wind tunnel features a closed loop with a half-mile-long air circuit. The fan mechanism features six fans set in a three-over-three pattern. Building N221B is the 80-ft. x 120-ft. Subsonic Wind Tunnel, which was constructed in 1982. It is connected to N221 on the wind tunnel's western elevation at an approximately 45-degree angle extending to the northwest. It has a similar exoskeleton as Building N221. The tunnel is open at both ends and takes in air using a horn-shaped inlet that is approximately 400 foot long. The fan blades are made of handcrafted laminated wood.

5.2.4 Building N226

Building N226 is the 6-ft. x 6-ft. Supersonic Wind Tunnel, which was built in 1948. It is a two-story building with a flat roof and includes a center section flanked by two wings. The building features concrete siding and steel-framed three-over-three awning windows separated by a concrete band. The main entrances are on the east elevation, with each wing having a pair of aluminum storefront doors. The center section has a pair of steel-framed sliding doors with multi-light glazing. Above this entrance is a cantilevered concrete canopy with rounded edges. Below the canopy is a sign that reads "NASA 6 x 6 Ft Supersonic Wind Tunnel." A secondary entrance is on the south elevation, which is set with a single-entry aluminum storefront door accessed by an open steel staircase. A similar secondary entrance is on the second story's southwest corner on the west elevation. The wind tunnel structure is west of the building. It is a closed circuit, single-return type wind tunnel. The tunnel is steel-framed with steel sheets on the exterior. It has an asymmetric, sliding-block nozzle and the test section features a perforated floor and ceiling. The test section is 6 feet high, 6 feet wide, and 14.4 feet long.

5.2.5 Building N227A-D

The Unitary Plan Wind Tunnel is a system of wind tunnels constructed in 1956 and designated an NHL in 1985. This unique system has three test sections: the 11-ft. x 11-ft. Transonic Tunnel (N-227A), the 9-ft. x 7-ft. Supersonic Tunnel (N227B), and the 8-ft. x 7-ft. Transonic Tunnel (N227C). N227D is the Unitary Plan Wind Tunnels Electrical Auxiliary Building and Substation. Buildings N227 and N227A through C are interconnected, and although N227D is functionally related, it is a separate building. In addition to the Unitary Plan Wind Tunnels, Building N227 also contains a laboratory and offices. It is a two-story building with a three-story center section. The building has a flat roof and concrete and corrugated metal siding. Fenestration consists of steel-framed awning ribbon windows. The windows on the two-story portions of the building are separated by a concrete band. The main entrance is on the north elevation and is set with a pair of storefront doors with fixed sidelights and a transom light. Leading to the entrance are concrete stairs. Sheltering the entrance is a concrete canopy supported by narrow columns. N227A is connected to Building N227's north elevation. This wind tunnel is a closed-return, variable-density tunnel with an 11-square-foot test section. N227B is connected to Building N227 on its west elevation. It is a Supersonic Wind Tunnel of the closed-return, variable-density type with a 9-foot by 7-foot test section that measures a total of 18 feet in length. N227C also is a supersonic closed-return, variable density wind tunnel equipped with a symmetrical, flexible wall throat. Materials for the wind tunnel structures include steel-framed construction. The 11-ft. x 11-ft. wind tunnel was renovated in 1996. Control systems were automated, and turbulence reduction screens and segmented flaps in the wide-angle diffuser were added. N227D is rectangular in plan and has a flat roof. It is two stories tall and clad in corrugated metal siding. It features a steel-framed awning and fixed windows on its west elevation.

5.2.6 Historic District Landscape Features

The segments of DeFrance Avenue and Durand Road within the district's boundary are two-lane concrete-lined roadways with concrete curbs. Durand Road is approximately 860 feet long and 35 feet wide. DeFrance Avenue is approximately 1,380 feet long and 35 feet wide. The streets are part of the circulation pattern and hardscape features of the district. Additional landscape features include original street lamps, mature trees and shrubs, and manicured lawns that lie in front of and in between the contributing buildings and structures. The roadways, patterns of lawns, and other landscape features define the immediate campus setting of the historic district, and tie the contributing properties together as a discernible grouping of research facilities.

6. Assessment of Effects

The Criteria of Adverse Effect pursuant to 36 CFR §800.5(a)(1) are applied to assess effects of the undertaking on historic properties within the APE:

> (1) Criteria of adverse effect. An adverse effect is found when an undertaking may alter, directly or indirectly, any of the characteristics of a historic property that qualify the property for inclusion in the NRHP in a manner that would diminish the integrity of the property's location, design, setting, materials, workmanship, feeling, or association. Consideration shall be given to all qualifying characteristics of a historic property, including those that may have been identified subsequent to the original evaluation of the property's eligibility for the NRHP. Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance, or be cumulative.

There are no known archaeological sites in the APE. The proposed work is not within any identified sensitive archaeological zones and would occur in previously disturbed areas with low potential for deeply buried prehistoric sites. Therefore, there are no effects on archaeological resources as none are present in the APE. Should the project uncover previously unknown subsurface archaeological resources, contractors will immediately halt construction, secure the site, and notify NASA of the unanticipated discovery. NASA will follow the Standard Operating Procedure for unanticipated discoveries as outlined in the Integrated Cultural Resources Management Plan for ARC. With the exception of the potential to affect unknown subsurface archaeological resources, the project is not anticipated to have any direct effects on historic properties.

The project has the potential for indirect effects through visual and contextual changes that may alter the setting of Building N212 and the NASA Ames Wind Tunnel Historic District, particularly two of its contributors: Buildings N215 and N227 (including N227A-C). However, alterations that are consistent with the Secretary of the Interior's Standards for the Treatment of Historic Properties are not considered an adverse effect. The new construction of Building N278 will be infill on the former site of the 7-ft. x 10-ft. Wind Tunnel No. 2 (formerly Building N216) and within the NASA Ames Wind Tunnel Historic District. Recommendations for new infill construction correlate to those for compatible new additions set forth in the Standards for Rehabilitation (36 CFR § 67.7), specifically Standards 9 and 10.

Standard 9 states:

> New additions, exterior alterations, or related new construction shall not destroy historic materials that characterize the property. The new work shall be differentiated from the old and shall be compatible with the massing, size, scale, and architectural features to protect the historic integrity of the property and its environment.

The project will not destroy any historic materials. Buildings N216 and N251 will be demolished. Building N216 was a support structure of the former 7-ft. x 10-ft. Wind Tunnel No. 2, which was previously demolished. The building is non-contributing to the NASA Ames Wind Tunnel Historic District due to its lack of integrity; it is not eligible for individual listing in the NRHP and is not considered a historic property. Building N251 and its associated structures comprise the Motor Pool facility, which was constructed in 1977 and does not exhibit historical or architectural significance under NRHP criteria or exceptional significance that would meet Criteria Consideration G; it is not eligible for listing the NRHP and is not considered a historic property. No significant historic materials are present on the project site (Photograph 1).

Photograph 1. Project site, view facing southwest, Building N251 at center and Building N216 at near left.

The main consideration for the new construction is how it will impact the character of the historic district in which it will be located, particularly the adjacent contributing district elements. Of the five contributing facilities to the district, only Buildings N215 and N227 are within relevant sight and proximity to the Building N278 project site. These are highly specialized wind tunnel structures. The project site is located between the facilities, facing the rear elevation of each facility (the Building N215 main façade is along Durand Road to the south and the Building N227 main façade is along Walcott Road to the north). In addition, potential impacts on Building N212, which will be directly across Mark Avenue, must be considered. The setting of all three facilities includes human-scale streetscapes and landscapes populated with large, industrial-type facilities (Photograph 2). To be compatible within this setting, the project need only complement its surrounding buildings. Architecturally, the building portions of Buildings N212, N215, and N227, like many buildings on the Ames Campus, share similar industrial features with some Streamline Moderne/International Style detailing in concrete and glass exterior forms, flat roofs, grouped industrial-style windows, and concrete canopies over main entrances. It follows that infill construction on the project site be compatible with the massing, size, scale, and architectural features of Buildings N212, N215, and N227.

The design intent for Building N278 is to achieve a balance between differentiation and compatibility within the proposed district (see Select Architectural Drawings in Appendix B). The new construction will be differentiated from the adjacent historic buildings through its contemporary design and materials. The proposed height for Building N278 is two stories, which is generally consistent with the existing height of the building façades in the district and immediately adjacent to the project site, including the main façades of Building N212 (facing Mark Avenue), Building N215 (facing Durand Road), and Building N227 (facing Walcott Road). The proposed massing of the building is rectangular with recessed and setback sections that emphasize horizontality, which reflects the surrounding existing buildings. The proposed setbacks from Warner Road and Mark Avenue maintain the character of the existing relationship of adjacent historic buildings to the street. The proposed materials are primarily smooth stucco, tilted concrete or insulated metal exterior walls and aluminum and insulated glass curtain walls with translucent panels and insulated glass units for all doors, which are similar to traditional materials (concrete, glass, and steel) used throughout the district. Overall, the new construction will be compatible through an appropriate height, scale, massing, setbacks, orientation, differentiated design, and materials. The historic properties will retain their historic character, thus protecting the integrity of the historic properties in the APE and being consistent with Standard 9.

Photograph 2. Building N227 (rear) across from project site, view facing northwest from Warner Road.

Standard 10 states:

> New additions and adjacent or related new construction shall be undertaken in such a manner that if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

The project proposes to construct a permanent facility that will not be feasibly reversible. However, as a free-standing infill building where a wind tunnel and building once existed, the proposed Building N278 will not impair the essential form or integrity of the adjacent historic buildings or the historic district consistent with Standard 10.

As a whole, the project would minimally alter the district. The new construction will have a compatible profile through its modern design. Proposed landscaping, including a greenbelt on the west side of the building and lawns, shrubs, and trees around the periphery, is in keeping with the current setting of the adjacent historic properties. The proposed function of Building N278 as a scientific research facility will be in keeping with the historical associations of research and development at ARC, and the new facility will reflect the changing nature of the research center following guidance in the Advisory Council for Historic Preservation's (ACHP) 1991 *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities* (ACHP 1991). Construction of Building N278 will have no impact on integrity aspects of location, design, materials, workmanship, or association of Building N212 or the NASA Ames Wind Tunnel Historic District. The overall impact of the new infill construction will not significantly alter the adjacent historic properties' integrity aspects of setting or feeling because of its design, which is consistent with the Secretary of the Interior's Standards. Therefore, the undertaking will not result in adverse effects on historic properties.

7. Summary of Findings

The criteria of adverse effect were applied to historic properties in the APE including Building N212 and the NASA Ames Wind Tunnel Historic District and its contributors. The proposed undertaking would not alter, directly or indirectly, any of the characteristics of a historic property that qualify it for inclusion in the NRHP. Therefore, the proposed undertaking would have no adverse effects on historic properties per 36 CFR § 800.5(b).

Building N212 and the NASA Ames Wind Tunnel Historic District and its contributors were included within the undertaking's APE; Buildings N212, N215 and N227 will be visually and contextually impacted by the undertaking. The significance of the adjacent historic properties is primarily associated with research and development, important researchers, and exceptional engineering dating to the 1940s and continuing through the 20th century. This assessment of effects found that the proposed design of the new Building N278 is sufficiently differentiated from and compatible with the adjacent historic properties, and that it is consistent with the Secretary of the Interior's Standards. As a new research facility on the site of a former research facility, the proposed Building N278 will have an appropriate function, scale, and aesthetic to complement historic properties within the proposed historic district. Due to its compliance with the Secretary of the Interior's Standards, the new building will have minimal impact on the ability of the adjacent historic properties to convey their historical and architectural associations that make them eligible for the NRHP. Furthermore, no archaeological resources, which may qualify as historic properties, are known to exist in the APE and there is a low potential for unanticipated archaeological resources within the heavily disturbed vertical APE. As such, a finding of No Adverse Effect is recommended.

8. References

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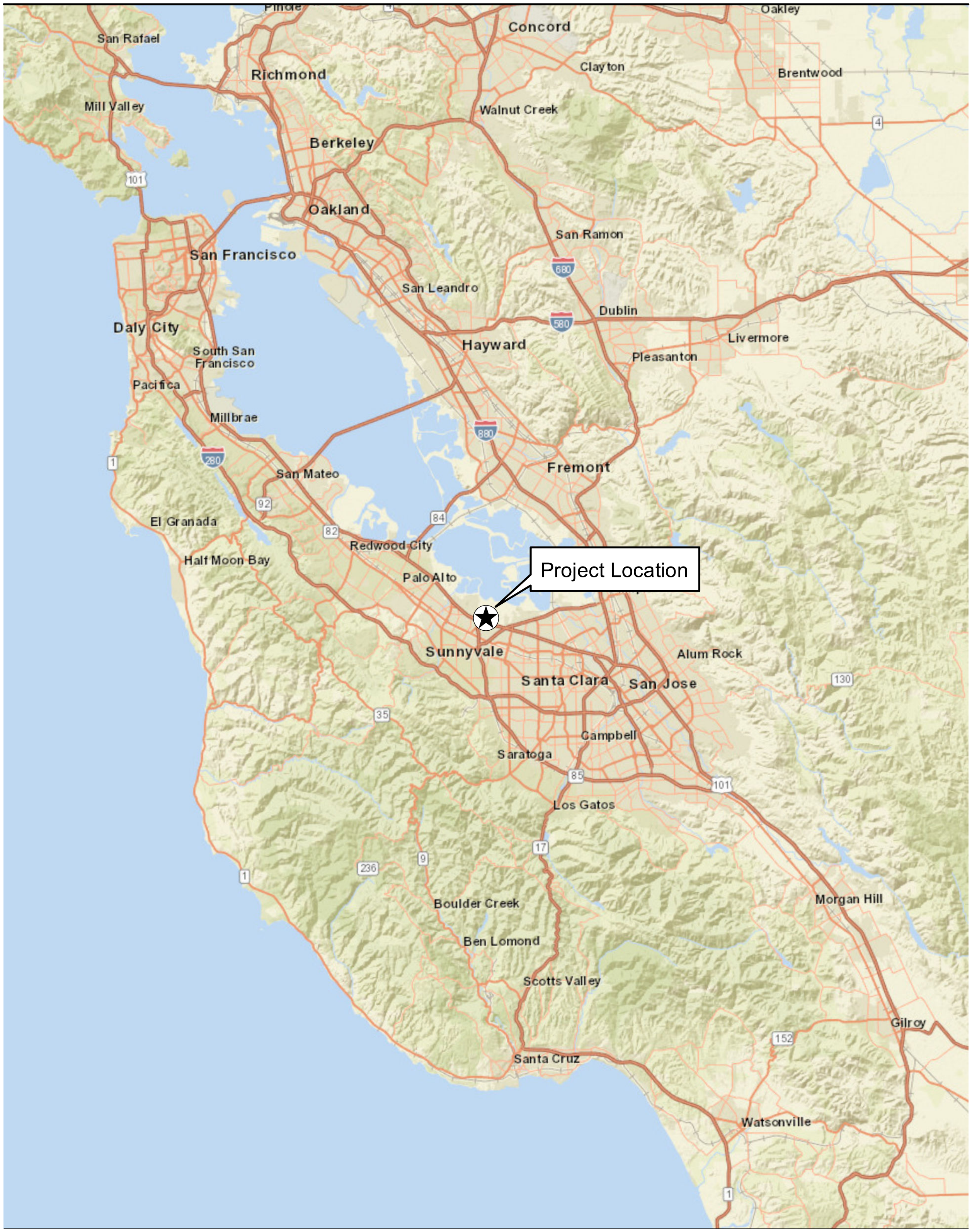
Appendices

A. Figures

B. Select Project Drawings

C. Archival Records

Appendix A – Figures

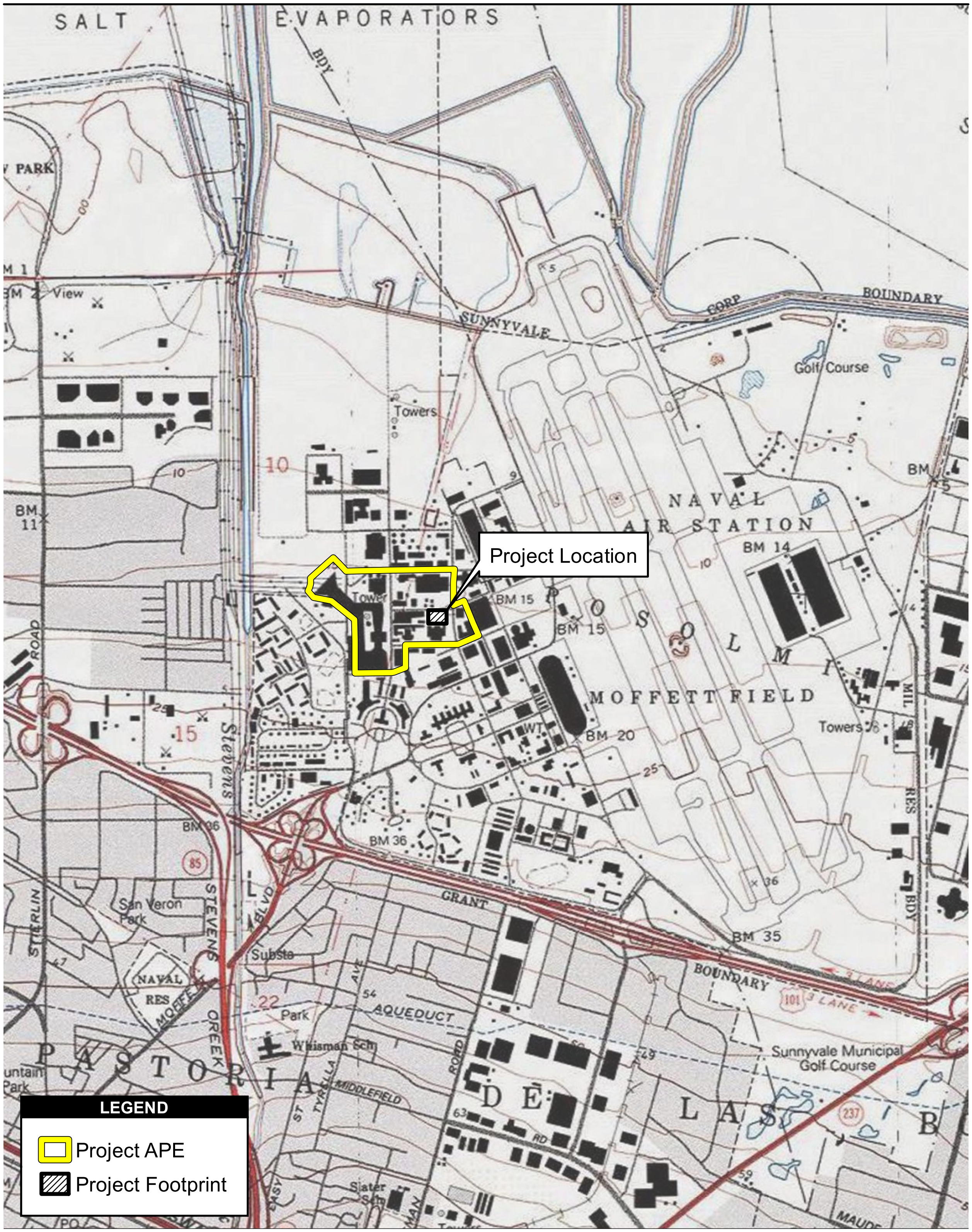


Source: ESRI, AECOM, NASA

Figure 1
Project Location

EMO Facility N278 Project

Path: \\na.aecomnet.com\lfs\AMER\SanDiego-USSDG1\DCS\Projects\NASA\900-CAD-GIS\mxd\Bldg_N278\BldgN278_Figure01_ProjectLocation.mxd, 8/20/2020, downsl1

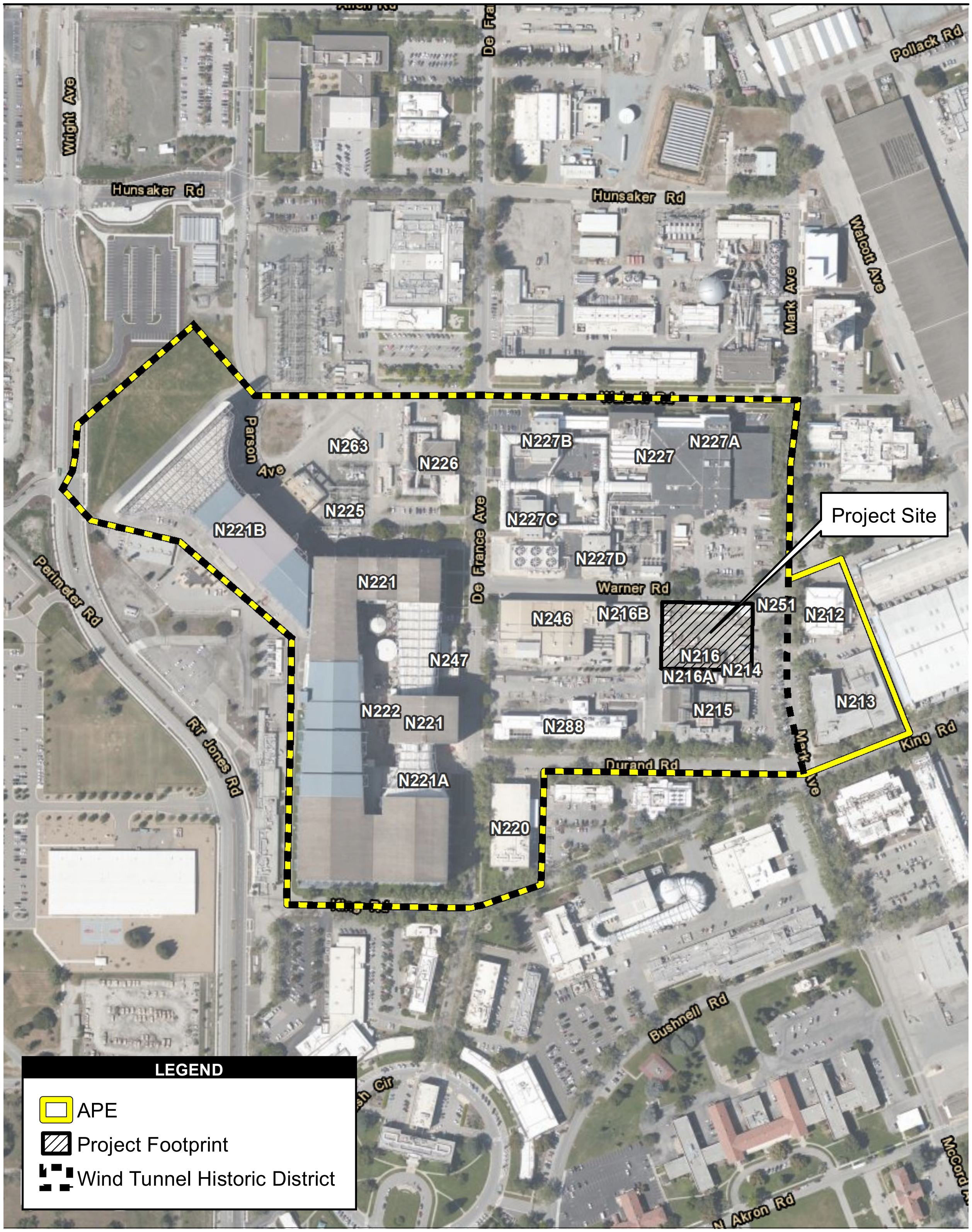


Source: ESRI, AECOM, NASA, National Geographic Society; USGS 7.5' Topographic Quadrangle: Mountain View

0 1,000 2,000 4,000 Feet

Scale: 1 = 24,000; 1 inch = 2,000 feet

Figure 2
Project Vicinity Map



Source: ESRI, AECOM, NASA

0 200 400 800 Feet

Scale: 1 = 4,800; 1 inch = 400 feet

Figure 3
APE Map

Path: L:\DCS\Projects\NASA\900-CAD-GIS\mxd\Bldg_N278\BldgN278_Figure03_APE.mxd, 8/21/2020, downsl1

The following content was redacted from this public posting:

Archaeological Sensitivity Map

Appendix B – Select Architectural Drawings (Jacobs 2019)

The following content was redacted from this public posting:

Appendix B
Select Architectural Drawings (Jacobs 2019)

Appendix C – Archival Records

United States Department of the Interior
National Park Service

National Register of Historic Places Registration Form

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in National Register Bulletin, *How to Complete the National Register of Historic Places Registration Form.* If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions.

1. Name of Property

Historic name: _NASA Ames Wind Tunnel Historic District___________________________
Other names/site number: ____
Name of related multiple property listing**:**
____
(Enter "N/A" if property is not part of a multiple property listing

2. Location

Street & number: _NASA Ames Research Center_____________________________________
City or town: _Moffett Field________ State: _California__ County: _Santa Clara (85)______
Not For Publication: ☐ Vicinity: ☐

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act, as amended,

I hereby certify that this _X_ nomination ___ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60.

In my opinion, the property _X_ meets ___ does not meet the National Register Criteria. I recommend that this property be considered significant at the following level(s) of significance:

_X_national ___statewide ___local

Applicable National Register Criteria:

_X_A ___B _X_C ___D

____

Rebecca Klein, Federal Preservation Officer **Date**

National Aeronautics and Space Administration_____________________________________

State or Federal agency/bureau or Tribal Government

In my opinion, the property _X_ meets ___ does not meet the National Register criteria.

____

Signature of commenting official: **Date**

Deputy State Historic Preservation Officer, California State Office of Historic Preservation

Title : **State or Federal agency/bureau or Tribal Government**

4. National Park Service Certification

I hereby certify that this property is:

___ entered in the National Register

___ determined eligible for the National Register

___ determined not eligible for the National Register

___ removed from the National Register

___ other (explain:) ______________________

Signature of the Keeper Date of Action

5. Classification

Ownership of Property

(Check as many boxes as apply.)

Private:	
Public – Local	
Public – State	
Public – Federal	X

Category of Property

(Check only **one** box.)

Building(s)	
District	X
Site	
Structure	
Object	

Number of Resources within Property
(Do not include previously listed resources in the count)

Contributing	Noncontributing	
1	8	buildings
0	0	sites
4	2	structures
0	0	objects
5	10	Total

Number of contributing resources previously listed in the National Register 1

---

6. Function or Use

Historic Functions
(Enter categories from instructions.)
Other – Wind Tunnels

Current Functions
(Enter categories from instructions.)
Other – Wind Tunnels
Other – Centrifuge
Other – Electrical Substation
Other – Administrative Offices

7. Description

Architectural Classification
(Enter categories from instructions.)
OTHER – Engineering structure – wind tunnels
MODERN MOVEMENT/Moderne, Streamline Moderne

Materials: (enter categories from instructions.)
Principal exterior materials of the property: Concrete, steel, transite steel, corrugated metal

Narrative Description
(Describe the historic and current physical appearance and condition of the property. Describe contributing and noncontributing resources if applicable. Begin with **a summary paragraph** that briefly describes the general characteristics of the property, such as its location, type, style, method of construction, setting, size, and significant features. Indicate whether the property has historic integrity.)

Summary Paragraph

The National Aeronautics and Space Administration (NASA) Ames Wind Tunnel Historic District is in the northern section of the NASA Ames Research Center (ARC). The district consists of five contributors and 10 noncontributors. Contributing structures primarily are wind tunnels and buildings that support the functions of the wind tunnels. Although many of the structures have their own building numbers, they are functionally related and connected, and are counted as one resource. Located within the NASA Ames campus, the district is surrounded by various administrative and research-related buildings that represent successive eras of the campus's development. Within the district are mature trees, shrubs, manicured lawns, and hardscape features (i.e., DeFrance Avenue and Durand Road) that contribute to its landscape and setting. The district retains all seven aspects of integrity and has the ability to convey its significance at the national level.

Narrative Description

Contributors

Building N-215 (7- by 10-Foot Wind Tunnel and Army Aeromechanics Lab)
Building N-215 or the 7- by 10-foot Wind Tunnel Number 1 and Army Aeromechanics Lab is on Durand Road and was constructed in 1941. It is a two-story building with a concrete foundation, exposed concrete walls, and a flat roof. The building's massing is simple and the ornamental detail is minimal. This building features flat, horizontal concrete bands that run across each façade. The bands articulate the first and second floors. The building has 3/3 awning windows that are sandwiched between the concrete bands. The windows along the south façade are steel-framed. The east and west façades have wood-framed windows, and the north façade has a combination of steel and wood windows. The windows are grouped in sets of either three or four and are separated by concrete piers with grooves that align with the window mullions.

The building's main entry has a simple concrete awning with rounded corners. The entry doors are an aluminum storefront type and not original to the building. The east side of the building has been retrofitted with a steel and concrete staircase. Some windows have been removed to accommodate new doors. The west side of the building serves as the main entry to the Ames Health Unit. A ramp has been added to accommodate this entry. A second steel staircase also has been added to this side of this building. An addition on the north side of the building connects to the wind tunnel.

The wind tunnel apparatus is composed of steel framing, some of which is exposed to distinguish this functional component from the more stylized control/office building component. The overall footprint of the wind tunnel is slightly larger than that of the control/office component, and it is set in a closed-loop shape approximately three stories in height. There is an exterior entry into the wind tunnel on the east side of the building, and a Butler building-type structure with corrugated metal and sheet metal siding covers portions of the wind tunnel on the west side. The interior of the building contains the controls for the wind tunnel and test chamber area. The wind tunnel configuration generally is square with exception of the turbine mechanism area that is rounded to house the fan, which is approximately 30 feet in diameter. The blades of the fan inside the wind tunnel are made of wood. The test section is 7 feet high and 10 feet wide.

Building N-220 (Technical Services Building)

Building N-220, or the Technical Services Building, was built in 1940. The Technical Services Building was constructed to serve as the production area for equipment used to support testing and research, including the aircraft and spacecraft models used in wind tunnel testing. It is a two-story building with a rectangular plan and concrete foundation. The building features a flat roof, concrete siding, and steel-framed awning ribbon windows separated by a concrete band. The building's massing is simple and the ornamental detail is minimal. The main entrance is on the west elevation and is set with a pair of aluminum storefront doors. Sheltering the entrance is a concrete canopy with rounded edges. Etched into the concrete above the doors are the NACA logo and the words "Technical Service." Secondary entrances are located on the north and south elevations. The north entrance has a single-entry steel door with glazing.

Buildings N-221 and N-221B (National Full-Scale Aerodynamics Complex)

NASA designated Building N-221 and Building N-221B as the National Full-Scale Aerodynamics Complex (NFAC) in 1987. Building N-221 is the 40- by 80-foot Wind Tunnel, which was constructed in 1944. The south elevation of the building is approximately 440 feet long and 175 feet tall. The building materials on this elevation consist of a mix of corrugated metal siding and transite cement asbestos-corrugated siding surrounded by the exoskeleton of the structure. That exoskeleton features 17 geodesic bents. The east elevation also is a mix of corrugated metal siding and transite cement asbestos-corrugated metal siding. On this elevation, the exoskeleton has 29 geodesic bents. The entrance cone and the test section diffuser are metal and also are surrounded by steel bents. The interior of the building is used for offices, a laboratory, and research space. The test section of Building N-221's wind tunnel measures 40 feet high, 80 feet wide, and 80 feet long. Its interior has a thick acoustical lining that was added after the building's original construction to help absorb sound. The wind tunnel features a closed loop with a half-mile-long air circuit. The fan mechanism features six fans set in a 3-over-3 pattern.

Building N-221B is the 80- by 120-foot Subsonic Wind Tunnel, which was constructed in 1982. It is connected to N-221 on the wind tunnel's western elevation at an approximately 45-degree angle extending to the northwest. It has a similar exoskeleton as Building N-221. The tunnel is open at both ends and takes in air using a horn-shaped inlet that is approximately 400 feet long. The fan blades are made of handcrafted laminated wood.

Building N-226 (6- by 6-Foot Supersonic Wind Tunnel)

Building N-226 is the 6- by 6-foot Supersonic Wind Tunnel, which was built in 1948. It is a two-story building with a flat roof and includes a center section flanked by two wings. The building features concrete siding and steel-framed 3/3 awning windows separated by a concrete band. The main entrances are on the east elevation, with each wing having a pair of aluminum storefront doors. The center section has a pair of steel-framed sliding doors with multi-light glazing. Above this entrance is a cantilevered concrete canopy with rounded edges. Below the canopy is a sign that reads "NASA 6 x 6 Ft Supersonic Wind Tunnel." A secondary entrance is on the south elevation, which is set with a single-entry aluminum storefront door accessed by an open steel staircase. A similar secondary entrance is on the second story's southwest corner on the west elevation. The wind tunnel structure is west of the building. It is a closed-circuit, single-return type wind tunnel. The tunnel is steel-framed with steel sheets on the exterior. It has an asymmetric, sliding-block nozzle and the test section features a perforated floor and ceiling. The test section is 6 feet high, 6 feet wide, and 14.4 feet long.

On the interior, the ground floor of the building currently is used for storage. The southern portion of the second floor is used for offices and meeting spaces, which is consistent with its historic use. The second floor is accessed by the original staircase that features curved wood handrails. Extant elements of the interior wind tunnel's test section include a Schlieren photography box, control panels, tunnel sections, and a model craft test chamber. The wind tunnel has been decommissioned and the remaining portion of the second story (incorporating the testing portion of the wind tunnel) has been converted for educational purposes. Today, it is known as the Administration/Education Facility.

The building has undergone few exterior alterations. After 1982, the dry air storage tank, originally northeast of the north wing, was removed. The cooling tower situated west of the tunnel also was removed.

Buildings N-227 and N-227A through D (Unitary Plan Wind Tunnels)
The Unitary Plan Wind Tunnels is a system of wind tunnels constructed in 1956 and designated a National Historic Landmark in 1985. This unique system has three test sections: the 11- by 11-foot Transonic Tunnel (N-227A), the 9- by 7-foot Supersonic Tunnel (N-227B), and the 8- by 7-foot Transonic Tunnel (N-227C). N227D is the Unitary Plan Wind Tunnels Electrical Auxiliary Building and Substation.

Buildings N-227 and N-227A through C are interconnected, and although N-227D is functionally related, it is a separate building. In addition to the Unitary Plan Wind Tunnels, Building N-227 also contains a laboratory and offices. It is a two-story building with a three-story center section. The building has a flat roof and concrete and corrugated metal siding. Fenestration consists of steel-framed awning ribbon windows. The windows on the two-story portions of the building are separated by a concrete band. The main entrance is on the north elevation and is set with a pair of storefront doors with fixed sidelights and a transom light. Leading to the entrance are concrete stairs. Sheltering the entrance is a concrete canopy supported by narrow columns.

N-227A is connected to Building N-227's north elevation. This wind tunnel is a closed-return, variable-density tunnel with an 11-square-foot test section. N-227B is connected to Building N-227 on its west elevation. It is a Supersonic Wind Tunnel of the closed-return, variable-density type with a 9-foot by 7-foot test section that measures a total of 18 feet in length. N-227C also is a supersonic closed-return, variable density wind tunnel equipped with a symmetrical, flexible wall throat. Materials for the wind tunnel structures include steel-framed construction. The 11- by 11-foot wind tunnel was renovated in 1996. Control systems were automated, and turbulence reduction screens and segmented flaps in the wide-angle diffuser were added.

N-227D is rectangular in plan and has a flat roof. It is two stories tall and clad in corrugated metal siding. It features a steel-framed awning and fixed windows on its west elevation.

Landscape Features
The segments of DeFrance Avenue and Durand Road within the district's boundary are two-lane concrete-lined roadways with concrete curbs. Durand Road is approximately 860 feet long and 35 feet wide. DeFrance Avenue is approximately 1,380 feet long and 35 feet wide. The streets are part of the circulation pattern and hardscape features of the district. Additional landscape features include original street lamps, mature trees and shrubs, and manicured lawns that lie in front of and in between the contributing buildings and structures. The roadways, patterns of lawns, and other landscape features define the immediate campus setting of the historic district, and tie the contributing properties together as a discernible grouping of research facilities.

Noncontributors

- Building N-216, Machine Shop (1941)
- Building N-216A, Model Preparation Building (1973)
- Building N-216B, Army Model Assembly Building (1973)
- Building N-218A, Electrical equipment (1970)
- Building N-221A, the 20-G Centrifuge Building (1964)
- Building N-225, known as Substation West (1940)
- Building N-246, Model Construction Building (1973)
- Building N-247, the 40- by 80-foot Wind Tunnel Office Building (1975)
- Building N-251, Motor Pool (1977)
- Building N-263, Telecommunications Building (1989)

Integrity

Location. The contributing buildings and structures are in their original locations.

Design. Over the years, necessary modifications have been made to the buildings, thereby somewhat altering each individual building's integrity of design, mostly on the interior. These modifications, however, were necessary for the testing and experimenting for which the buildings were designed. These alterations were made to the interiors and exteriors of individual buildings; however, as a whole, the district retains sufficient integrity of design to convey its significance in advancements in the aeronautical and space programs. The basic design of the wind tunnels is essentially maintained and still consists of control rooms and test sections, and retains the same measurements as when first constructed. The contributing buildings retain their original design of plan and massing, entrances, and fenestration patterns, and the spatial relationships between the buildings remain as they did historically.

Setting. The overall setting for the district remains intact. Some of the earlier wind tunnels were demolished and other buildings and structures have been built on the border of the district's boundaries, but these alterations reflect the ongoing development of NASA Ames as an active scientific campus. The overall character of the district is evident and a relationship between the buildings, including N-220 and the wind tunnels and the interconnection between the Unitary Plan wind tunnels, continues. The same is true for the layout of the streets within the district and the simple landscape features. Integrity of setting is retained for the district.

Materials. Integrity of materials is retained within the district. The contributing buildings have most of their original materials, including siding, window framing, and doors. New material has been minimally introduced in the district and much of the historic fabric is intact. In most instances when there is new material, it is in-kind material.

Workmanship. The district retains integrity of workmanship. The contributing buildings continue to function as wind tunnels or support facilities for those wind tunnels. Although the wind tunnels have been upgraded to keep pace with changes that occurred within NASA, those changes were required to continue the use of those properties as state-of-the-art testing facilities.

Feeling. The district retains integrity of feeling. The wind tunnel district relates the feeling of a significant scientific and engineering district within the period of 1940 to 1982. The physical features necessary to understand the district's integrity of feeling are present in the spatial patterns within the district and the height, massing, and design of the wind tunnels. These intact elements support the district contributors' continued use as research facilities within a specialized scientific campus, which is directly tied to the district's overall significance. The historic character of the district is retained.

Association. The buildings and structures within the district have functioned for the purposes of the advancements of aeronautical and space industries since being constructed. Despite the fact that the surrounding campus has continued to expand and adapt to meet evolving research needs, the contributing properties within the historic district primarily retain research functions that are closely related to their historic uses and that continue to make use of their character-defining features. Therefore, the district conveys that direct link between significant scientific and engineering achievements.

Overall, the district as a whole retains all seven aspects of integrity to convey the significance of the NASA Ames Wind Tunnel Historic District.

8. Statement of Significance

Applicable National Register Criteria
(Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing.)

- [X] A. Property is associated with events that have made a significant contribution to the broad patterns of our history.
- [ ] B. Property is associated with the lives of persons significant in our past.
- [X] C. Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents a significant and distinguishable entity whose components lack individual distinction.
- [ ] D. Property has yielded, or is likely to yield, information important in prehistory or history.

Criteria Considerations
(Mark “x” in all the boxes that apply.)

- [ ] A. Owned by a religious institution or used for religious purposes
- [ ] B. Removed from its original location
- [ ] C. A birthplace or grave
- [ ] D. A cemetery
- [ ] E. A reconstructed building, object, or structure
- [ ] F. A commemorative property
- [X] G. Less than 50 years old or achieving significance within the past 50 years

Areas of Significance
(Enter categories from instructions.)
Science
Invention
Engineering

Period of Significance
1940–2011

Significant Dates
1940 – Construction of N-220
1941 – Construction of N-215
1944 – Construction of N-221
1948 – Construction of N-226
1956 – Construction of the Unitary Plan Wind Tunnels
1972 – Beginning of the Space Shuttle Wind Tunnel Test Program
1982 – Construction of N-221B
2011 – End of the Space Shuttle Program

Significant Person
(Complete only if Criterion B is marked above.)
____
____
____

Cultural Affiliation
N/A

Architect/Builder
National Advisory Committee for Aeronautics (NACA) Engineers
National Aeronautics and Space Administration (NASA) Engineers

Statement of Significance Summary Paragraph (Provide a summary paragraph that includes level of significance, applicable criteria, justification for the period of significance, and any applicable criteria considerations.)

The NASA Ames Wind Tunnel Historic District meets Criterion A in the areas of science, invention, and engineering at the national level of significance because this district contributed greatly to advancements in the aeronautical and space industries in the United States (U.S.). The district also is eligible under Criterion C in the area of engineering, because the wind tunnels represent a significant work of engineering. The period of significance begins with the construction of Building N-220 in 1940 and ends in 2011, the year that the Space Shuttle Program (SSP) ended. The tunnels and their supporting buildings performed critical roles in aeronautical research and design, and were among the most sophisticated scientific tools constructed and used by the U.S. government and commercial businesses. The research conducted within the wind tunnels was crucial to aircraft and spacecraft research and design. As the district's period of significance extends to a time period less than 50 years old, the district meets the requirements of Criteria Consideration G because the facility is exceptionally significant as the leading research and development facility in the areas of aeronautics and space in the U.S.

The California State Historic Preservation Officer previously concurred that Buildings N-221 and N-226 were eligible for individual listing in the National Register on June 17, 2008. The Unitary Plan Wind Tunnels (Buildings N-227A through C) were designated a National Historic Landmark (NHL) in 1985.

Narrative Statement of Significance (Provide at least **one** paragraph for each area of significance.)

The NASA Ames Wind Tunnel Historic District is significant under Criterion A in the areas of science, invention, and engineering for its associations with aeronautical and aerospace research, the development of aircraft and spacecraft, and the evolution of wind tunnel technology in the U.S. The district contains the world's greatest collection of wind tunnels, and is the leading research facility for the aerospace industry (Bugos 2014:ix; Garber 2005). All but one of the district's contributors continue to be utilized as wind tunnels and/or wind tunnel support facilities. Building N-226 is decommissioned and is currently used for educational purposes.

As highly technical scientific testing facilities, the wind tunnels within the district are significant for their contributions to science, specifically aeronautical and aerospace research. More than 500 aircraft, including those of the U. S. military and leading commercial companies, have been tested in Building N-221 alone, while N-221B is capable of testing aircraft the size of a Boeing 737. The wind tunnels provided a safer, economical, and a practical way for testing, compared to regular flight analysis, which often involved risks to pilots and usually was more expensive. This was particularly true during World War II, when this research was desperately needed. When Building N-215 first opened in the early 1940s, the research conducted in the building allowed aeronautical engineers and designers to correct design flaws in aircraft used by the U.S. military, including the B-32 and the XSB2D-1. The use of wind tunnel models, like those constructed in Building N-220, played a prominent role in aeronautical research. The models built during the early years of wind tunnel operation were the pioneers for the industry, because they could simulate propeller flows.

When Building N-221 became operational, its use focused on aircraft development. It allowed for testing of future larger military and commercial aircraft. It also is an important component of the vertical takeoff and landing research for aircraft, helicopters, and aeroacoustics conducted at ARC. Aircraft tested in Building N-221 included the Northrop N9M-2 flying wing prototype, the Grumman XF7F-1 Tigercat, and the Douglas A-26B low-level bomber. Building N-221B has also been instrumental in research where low-speed handling was especially critical during landing and take-off, and was used to test U.S. Department of Defense (DOD) and civilian aircraft. Flight research supplemented the research done in the wind tunnels, and data from both were checked against each other (Bugos 2000:19–20). The wind tunnels were used to accurately predict vehicle flight loads and performance. This has helped define stabilization and control performance in various types of experimental aircraft. The contributors to the district performed the same functions for spacecraft testing.

The district is significant in the area of invention, for its contributions to the successful development of viable spacecraft for all of NASA's space programs, including Mercury, Gemini, Apollo and the Space Shuttle programs. Starting in May 1962, research in the lower speed wind tunnels in the district tested the launch aerodynamics of the Apollo command capsule coupled with the Saturn V rocket, and scale models of the F-2 capsule were tested in the Unitary Plan Wind Tunnel (Bugos 2010). After 1971, Building N-221, the Unitary Plan Wind Tunnel, and other hypervelocity tunnels at ARC performed half of all wind tunnel tests during the crucial secondary phase of the Space Shuttle design (Bugos 2010). The lifting body studies performed in the wind tunnels refined the Space Shuttle configuration (Bugos 2010). Building N-221B was used to develop the Space Shuttle drag chute design (Bugos 2014). The Unitary Plan Wind Tunnel Complex was instrumental in the development of spacecraft, and was designated as an NHL in 1985 for its contributions to successful spaceflight (Butowsky 1984b).

Also under Criterion A, the district is representative of the history of wind tunnel engineering. Construction of the 7- by 10-foot Wind Tunnel 1 (Building N-215) began Ames's long history in wind tunnel engineering in 1941. Expanding on early wind tunnel design, the urgent need to advance aviation technologies during World War II led to the development of new types of wind tunnels that could provide testing capabilities and simulate specific conditions to solve immediate aviation concerns. Ames's engineers created all types of wind tunnels as research needs evolved with the advancement of aeronautics and astrophysics, sometimes through trial and error. The district contributors represent the history and progressive evolution of wind tunnel engineering from conventional wind tunnels to high-powered supersonic, transonic, and hypersonic wind tunnels.

The NASA Ames Wind Tunnel Historic District is also significant under Criterion C in the area of engineering for its important embodiment of wind tunnel technology. A wind tunnel test replicates a flow field by moving air across a test subject, often a model outfitted for data collection. As such, the wind tunnels and the models used for testing are important laboratory tools, and are some of the most complex scientific structures ever built in the U.S. The 7- by 10-foot Wind Tunnel 1 (Building N-215) was the first wind tunnel constructed at Ames, and represents early wind tunnel technology. The district contains many examples of uniquely engineered wind tunnels that advanced the capabilities of this basic wind tunnel design.

The NFAC houses the largest wind tunnels in the world. The 40-by-80-foot Wind Tunnel (Building N-221) is the second largest wind tunnel in the world, and the largest low-speed, closed-loop wind tunnel. It represents an early full-scale wind tunnel in which larger models and even full-size airplanes were tested. The 80- by 120-foot Subsonic Wind Tunnel (Building N-221B) is currently the world's largest open-circuit wind tunnel. Its unique design allows for testing with reduced tunnel-wall interference, thereby making the tunnel important for aircraft noise research. The tunnel has the sheer capacity to test a variety of large-scale aircraft, including fighter jets, lifting-body configurations, Space Shuttle models, supersonic transports, parachutes, trucks, and highway signs (Bugos 2010:260–270).

The 6- by 6-foot Supersonic Wind Tunnel (Building N-226) was the first supersonic wind tunnel designed with a test chamber large enough to accommodate a human being working inside to set up a test. It was the first wind tunnel to use H. Julian Allen's fixed and moving wall design. As originally planned, Building N-226 enabled the tunnel to continuously operate while the nozzle contour was modified to accommodate various Mach number[1] tests. More conventional supersonic wind tunnel designs required that the tunnel be shut down each time a test was run at a different Mach number. This marked a difference from other wind tunnels at ARC because it responded to the problems identified with conventional supersonic wind tunnel design. The design of Building N-226 pioneered supersonic wind tunnel technology.

The Unitary Plan Wind Tunnel Complex (Building N-227 and N-227A through D) is a designated NHL, a landmark in the development of conventional wind tunnels. The complex at Ames was specifically designed as one in a series of wind tunnels built around the U.S. to diversify testing capabilities. The complex includes three optional closed-loop wind tunnels with separate test sections that share the same power drivers to force air through the sections. The tunnels and test sections include the 11- by 11-foot Transonic Test Section, the 9- by 7-foot Supersonic Test Section, and the 8- by 7-foot Supersonic Test Section.

The table below summarizes the important scientific and engineering characteristics for each contributing wind tunnel.

Wind Tunnel Name	**Mach Number**	**Speed**	**Stagnation Pressure**	**Reynolds Number[2]**	**Dimensions: Test Section**
N-215	–	0 to 220 knots	1.0 atmosphere	2.3 x 10^6 per foot	Height: 7 feet Width: 10 feet Length: 16 feet
N-221	–	0 to 200 knots	1.0 atmosphere	0 to 2.1 x 10^6 per foot	Height: 40 feet Width: 80 feet Length: 80 feet
N-221B	–	0 to 100 knots	1.0	0 to 2 x 10^6 per foot	Height: 80 feet Width: 120 feet Length: 190 feet
N-226[*]	.25 to 2.2	–	0.3 to 1.0 atmospheres	1.0 x 10^6 to 5.0 x 10^6	Height: 6 feet Width: 6 feet Length: 14.4 feet
N-227A	0.4 to 1.4	–	0.5 to 2.25	1.7 to 9.4 x 10^6 per foot	Height: 11 feet Width: 11 feet Length: 22 feet
N-227B	1.55 to 2.5	–	0.3 to 2.0	1.5 to 6.5 x 10^6 per foot	Height: 7 feet Width: 9 feet Length: 18 feet
N-227C	2.45 to 3.5	–	0.3 to 2.0	1.0 to 5.0 x 10^6 per foot	Height: 8 feet Width: 7 feet Length: 16 feet

The NASA Ames Wind Tunnel Historic District is significant at a national level because of its association with wind tunnel engineering and advancements in the aeronautical and aerospace research facilities of the U.S., and because the wind tunnels are important engineering structures and some of the most complex scientific structures ever built in the U.S. The district contributors also include the first and second largest wind tunnels in the world. NASA also constructed wind tunnels at its other research facilities. The NACA constructed its first wind tunnel at Langley Research Center (Langley) in 1920 and constructed others in the 1920s and 1930s. One of these, the Full-Scale Wind Tunnel (FST), was the first open-throat, semi-elliptical wind tunnel to be powered by two side-by-side propellers. The NACA also

[1] Mach number is defined as the ratio of the speed of an airplane with respect to the surrounding air to the local speed of sound in the air. The speed of sound varies with air density. Therefore, the Mach number varies with altitude and temperature.
[2] Reynolds number expresses the ratio of inertial forces to viscous forces. It is a dimensionless number.
[*] No longer operational.

constructed an Atmospheric Wind Tunnel (AWT) in its John H. Glenn Research Center at Lewis Field (Glenn) in Ohio in 1941. Like the wind tunnel facilities at ARC, both of those wind tunnels played key roles in aeronautical research during and post-World War II and in the space program. However, the AWT at Glenn was demolished in 2009 and, despite being designated an NHL in 1985, the FST at Langley was demolished in 2010. Although other wind tunnel facilities remain at Langley, ARC retains NASA's largest collection of extant wind tunnels dating to the period of significance.

The NASA Ames Wind Tunnel Historic District's period of significance extends from 1940 and the construction of Building N-220, to 2011, the end of the SSP, although additional significance associated with the ongoing research conducted in the wind tunnels may be realized in the future. The establishment of the SSP introduced a new era for the U.S. Space Program, which involved the use of reusable space flight vehicles. The wind tunnels played a prominent role in the development and improvement of the Space Shuttle, which allowed the United States to achieve successful Space Shuttle missions and advance the country's space program. In addition, one contributor, Building N-221B, is less than 50 years old. Although the established end of the district's period of significance is less than 50 years old, and the district contains a major contributor that is less than 50 years old, the district has achieved additional significance within the past 50 years due to its exceptional importance related to its contributions to the SSP and the exceptional contributions of Building N-221B.

According to NASA's guidelines published in *Evaluating Historic Resources Associated with the Space Shuttle Program: Criteria of Eligibility for listing in the National Register of Historic Places (NRHP)* (NASA 2006), to qualify for listing in the National Register within the context of the SSP, a property must be:

(1) real or personal property owned or controlled by NASA;
(2) constructed, modified, or used for the SSP between the years 1969 and 2011;
(3) classified as a structure, building, site, object, or district;
(4) eligible under one or more of the four National Register criteria;
(5) meet appropriate Criteria Considerations, and
(6) retain enough integrity to convey its historical significance.

The NASA Ames Wind Tunnel Historic District is owned and controlled by NASA (1); was used for the SSP between the years 1969 and 2011 (2); is classified as a district (3); and is eligible under National Register Criteria A and C (4).

The NASA Ames Wind Tunnel Historic District relates to the SSP context as an Engineering and Administrative Facility (Property Type 7). The district meets the significance criteria of the property type, because:

- It is a test facility directly associated with activities of significance which were associated with component testing and the implementation of the SSP;
- It is a place where persons who made lasting achievements to the SSP worked or convened; and
- It clearly embodies the distinctive characteristics of a type or method of construction.

Under Criterion A, a SSP property:

- Must be of significance in reflecting the important events associated with the SSP during the period of significance (1969–2011); or
- Must be distinguished as a place where significant program-level events occurred regarding the origins, operation and/or termination of the SSP.

The district is eligible for listing in the National Register under Criterion A within the SSP context for its direct association with the development of the Space Shuttle. Development of the Space Shuttle required an extensive wind tunnel test program that involved all of the major wind tunnels in the U.S., including the wind tunnels at ARC. The program to test potential Space Shuttle launch and entry vehicle configurations was the largest wind tunnel research effort undertaken by the U.S. (Romere and Brown 1995). Building N-221, the Unitary Plan Wind Tunnel, and other hypervelocity tunnels at ARC performed half of all wind tunnel tests during the crucial secondary phase of the Space Shuttle design (Bugos 2010). The lifting body studies performed in the wind tunnels refined the Space Shuttle configuration (Bugos 2010). Prototypes and models of the orbiters were tested in the 40- by 80-foot Wind Tunnel (Building N-221) prior to the first flight, and the Space Shuttle drag chute was tested and refined in the 80- by 120-foot Subsonic Wind Tunnel (Building N-221B) (Bugos 2014) . After the 2003 *Columbia* disaster, the wind tunnels were used to test the mechanical properties of thermal protection systems that would allow the SSP to return to flight (Bugos 2010). Throughout operation of the SSP, modifications to the Space Shuttle configuration and orbiters were tested in ARC's wind tunnels. Because the district was the site of important events associated with the SSP and nationally significant program-level events regarding the origins and operation of the SSP, the NASA Ames Wind Tunnel Historic District is eligible under Criterion A within the context of the SSP.

Under Criterion C, a SSP property:

- Was uniquely designed and constructed or modified to support the pre-launch testing, processing, launch and retrieval of the Space Shuttle and its associated payloads; or
- Reflects the historical mission of the Space Shuttle in terms of its unique design features without which the program would not have operated; or
- Reflects the distinctive progression of engineering and adaptive reuse from the Apollo era to the Space Shuttle era.

The district is also eligible for listing in the National Register under Criterion C within the SSP context. The wind tunnels were instrumental in the pre-launch testing of the Space Shuttle, and were modified to provide the appropriate conditions for spaceflight testing in direct association with SSP.

The NASA Ames Wind Tunnel Historic District meets Criteria Consideration G for properties that have achieved significance within the past 50 years due to its exceptional significance within the context of the SSP (5). It is exceptionally significant for its contribution to the design, development, and operation of the Space Shuttle orbiter by providing essential aerodynamic research. As outlined in Section 7, the district retains its integrity of location, design, setting, materials, workmanship, feeling, and association to its period of significance (6). The district meets all the criteria of significance within the SSP context.

Building N-221B is connected to N-221 on the wind tunnel's west elevation and was completed in 1982 as part of NASA's and ARC's efforts to upgrade its wind tunnel facilities in the late 1960s and 1970s. NASA rededicated Buildings N-221 and N-221B as the NFAC in 1987. Building N-221B is exceptionally significant as the world's largest wind tunnel, and although it was constructed less than 50 years ago, Building N-221B is an important part of ARC's wind tunnel complex and played a significant role in the advancement of both aeronautical and aerospace research, particularly with large-scale aircraft and spacecraft, including the Space Shuttle drag parachute (Bugos 2014; NASA 2012).

In addition to meeting Criteria A and C and Criteria Consideration G, the district retains integrity. The district and its contributors have the essential physical features necessary to understand why the district is important. The Advisory Council on Historic Preservation's (ACHP) publication, *Balancing Historic Preservation Needs with the Operation of Highly Technical or Scientific Facilities*, offers guidance for assessing integrity of scientific facilities stating that "…historic scientific equipment and facilities in use today meet at least the design, materials, and association components of integrity" (ACHP 1991:32). This guidance articulates that the significance of highly technical research and scientific facilities is most directly conveyed through the physical fabric of the structures, equipment, and other apparatuses that facilitated significant research activities. The district's contributing buildings meet this guidance and retain even more elements of integrity than the ACHP advises.

Although the noncontributing buildings and structures were built within the district's period of significance, they did not directly contribute to the district's significance.

- Building N-216, constructed in 1940, is associated with the second 7- by 10-foot wind tunnel that is no longer extant. Because that wind tunnel was removed, the building has lost sufficient integrity to be considered a contributing element to the district.

- The model assembly and construction buildings (Buildings N-216A, N-216B, and N-246) were built in 1973 to consolidate model construction, which was historically based in Building N-220 and spread out in various buildings associated with the separate research divisions.

- The electrical equipment (N-218A and N-225) within the district's boundary were part of the infrastructure, but that equipment served a more basic utilitarian purpose and did not play a significant role in the research and testing conducted in the wind tunnels.

- Building N-247 is the office building for the 40- by 80-foot wind tunnel. Built in 1975, the building does not contribute to the district, because it only served administrative purposes and does not convey the engineering achievement of the wind tunnels.

- Building N-251 contains facilities for ARC's transportation needs, such as fuel stations, offices, and equipment repair bays. Built in 1977, this building does not contribute to the district because it has no direct association with the district's significance.

- Testing and research conducted in Building N-221A (20-G Centrifuge, built in 1964) focused on the effects of hyper-gravity on humans, animals, and plants. This is a different type of research than done by the district's contributing buildings and structures.

- Building N-263 is used as a telecommunications building and is a simple, Butler-style building constructed in 1989. It has no direct link to the research conducted in the district.

In summary, the NASA Ames Wind Tunnel Historic District meets Criterion A in the areas of science, invention, and engineering at the national level of significance because this district contributed greatly to advancements in the aeronautical and space industries in the U.S. The district also is eligible under Criterion C because the wind tunnels represent a significant work of engineering. The district also is eligible under Criterion Consideration G, because it has achieved significance within the past 50 years for its exceptional importance related to the SSP and the contributions of the wind tunnels, including Building N-221B, to aeronautical and aerospace research. The district retains integrity of design, materials, and association, which are considered most critical in conveying the contributors' significant associations with national aeronautical and aerospace research.

HISTORIC CONTEXT

To relate the district to important themes in the history of national aeronautical and aerospace research in the U.S., the following context describes the history of the NACA and NASA, the development of the NACA's and NASA's wind tunnel programs, the development of ARC, and the development of the SSP.

This information illustrates the significance of the district as a unique property and the historical themes it represents.

Development of the NACA and NASA

NASA originated from the NACA, which was created in 1915 as a civilian agency of the federal government (Rosholt 1966:3). Even after the first flight of Orville and Wilbur Wright in 1903, the U.S. failed to develop a long-term, committed interest in aviation. Europeans, however, recognized the utility of aeronautics and promoted its advancement and use of this new technology, particularly for military purposes. For example, at the start of World War I, thousands of aircraft existed in Europe but only 23 were in the U.S. (Chambers 2014:1). The Secretary of the Smithsonian Institution, Charles D. Wolcott, encouraged Congress to create an agency devoted to research and design in aeronautics. In 1915, Congress attached a rider to the Naval Appropriations Act to create the Advisory Committee for Aeronautics, modeled after a similar committee in England. At the first meeting, the committee renamed itself the NACA (Chambers 2014:1; Rosholt 1966:20). The President appointed 12 members to the NACA, including representatives from the U.S. Army and U.S. Navy, the Smithsonian Institute, the National Bureau of Standards (NBS) and the Weather Bureau. The Committee reported directly to the President (Chambers 2014:1).

The NACA was allocated only $5,000 for its first year, which allowed it to hold occasional meetings and encourage research projects at some universities (Rosholt 1966:20). In 1916, the Committee proposed the need for a joint Army-Navy-NACA experimental field and aeronautical research laboratory and considered 15 potential sites for the new laboratory. In 1917, the War Department, acting on the NACA's recommendations, purchased more than 1,600 acres in Virginia and began construction of Langley, the first civilian research laboratory (Chambers 2014:2).

As war approached in Europe, the importance of the NACA grew. The number of personnel increased from 130 in 1925 to 300 in 1935. In 1939, Congress authorized a second research laboratory at Naval Air Station Sunnyvale (Moffett Field) in California. The Lewis Flight Propulsion Laboratory in Cleveland, Ohio, was established in 1942 (Rosholt 1966:21). The work performed at these facilities contributed greatly to the air success of the Allies during World War II, which built on the aeronautical research done in the 1930s. During the war years, much of the NACA's work focused on perfecting and improving existing aircraft, based on information available at the time. After the war, the NACA was able to redirect its focus on advancing aeronautical research, including speed, high altitudes, and jet and rocket engines (Rosholt 1966:21). To aid in this research, the NACA built the Pilotless Aircraft Research Station at Wallops Island, Virginia, in 1945. This new facility was used for launching rockets. In 1947, the High-Speed Flight Station was established at Edwards Air Force Base (AFB) in southern California (Rosholt 1966:21). Post-World War II research by the NACA contributed to the success of transonic and supersonic flight, particularly the flights of the X-I and the X-15 rocket research aircraft (Rosholt 1966:21). By 1957, nearly 50 percent of the NACA's work was devoted to space-related research.

In October 1957, Russia launched *Sputnik I*, the first artificial satellite to orbit Earth. In November of that year, Russia launched *Sputnik II*. In response, Congress held several hearings, centered on developing a space program. In July 1958, President Eisenhower signed the National Aeronautics and Space Act (Van Nimmen et al. 1976:3). This act created NASA and arranged for the transfer of personnel, functions, and facilities from the NACA to NASA.

NASA officially began functioning on October 1, 1958. In its infancy, NASA focused on organizing itself and on building a national program out of several existing programs to create a fully integrated research and development agency. This reorganization included the (1) transfer of DOD's Advanced Research Projects Agency (ARPA); (2) creation of the International Geophysical Year Satellite program, Vanguard; and (3) establishment of the Army-owned Jet Propulsion Laboratory, operated by the California Institute of Technology in Pasadena (Van Nimmen et al. 1976:4).

Project Mercury, NASA's manned space flight program, was the agency's top priority and, by 1959, it made significant progress in its effort to send the first American into space orbit. That same year, NASA worked on scientific investigations in space and launched eight scientific Earth satellites and two lunar probes. It also developed engines, including the F-1; constructed tracking networks; and continued aeronautical research programs started by the NACA (Rosholt 1966:77). In November 1959, DOD transferred its Saturn rocket booster program from ARPA to NASA (Rosholt 1966:1144).

Under the Eisenhower administration, NASA's programs competed with many of the President's other long-range national programs. The administration viewed NASA's progress as adequate and determined that no "space race" was being waged against the Soviet Union. This changed with the election of President John F. Kennedy, who very much believed in the "space race" and that the U.S. was losing. He wanted the situation reversed (Rosholt 1966:183–184). After the Soviet Union successfully sent a cosmonaut into space on April 12, 1961, President Kennedy gave the directive that NASA was to put a man on the moon within the decade. This accelerated NASA's Apollo program and substantially increased NASA's budget to accomplish Kennedy's goal (Van Nimmen et al. 1976:4). It also increased NASA's personnel by 50 percent, from early 1962 to mid-1963. NASA hired nearly 18,000 new employees, mostly scientists, engineers, and aerospace professionals (Rosholt 1966:243–244).

In 1963, the successful Project Mercury was completed. All facilities and staff associated with the Mercury program turned their focus on the Gemini and Apollo programs (Rosholt 1966:247). During the early 1960s, NASA continued to make achievements in space science, research, and development.

Development of the Wind Tunnel Program

Wind tunnels played a pivotal role in the development of modern aircraft. Frank H. Wenham of the Aeronautical Society of Great Britain generally is credited with designing the first wind tunnel in 1871. Wenham's initial experiments involved various models that were mounted in the tunnel to measure the lift and drag forces made from the air rushing by the models. These experiments proved valuable to aerodynamicists in expanding their knowledge and understanding for controlling lift and drag. In the U.S., Samuel P. Langley, Secretary of the Smithsonian Institution, began aeronautics experiments in 1886. However, the Wright brothers became America's first aviators, and their successful first flight in 1903 was the result of their experiments using a wind tunnel. The U.S., however, did not embrace this new technology to the extent happening in Europe. Between 1903 and 1914, most major European countries had government-funded aeronautical laboratories and wind tunnels. In the U.S. during the same period, only four wind tunnels were built (Baals and Corliss 1981).

The first of the four U.S. tunnels was located at Catholic University in Washington, D.C. It was a 6- by 6-foot tunnel, designed by university professor Albert Zahm in 1901. Zahm's wind tunnel was sponsored by a wealthy industrialist who died early during Zahm's work. Lacking the necessary funds to continue, Zahm's wind tunnel closed in 1908. Zahm began working for the Navy's Aerodynamical Laboratory at the Navy yard in Washington, D.C. In 1913, Zahn built an 8- by 8-foot wind tunnel to generate information for the development of future naval airplanes. In 1918, two more tunnels were constructed. A 5.5-foot tunnel was built by William Durand at Stanford University in Palo Alto, California, and a 4.5-foot octagonal tunnel was built in Washington by NBS. The tunnel at Stanford was used for propeller research and NBS's tunnel was used for researching air turbulence and boundary layer phenomena (Baals and Corliss 1981).

Wind Tunnels at Langley Research Center

The first wind tunnel built by the NACA was constructed at Langley. Known as Wind Tunnel No. 1, it was a replica of Britain's 5-foot-diameter wind tunnel and was intended to provide a foundation of aerodynamic testing methods and analysis techniques to the NACA's inexperienced staff (Chambers 2014:4). The tunnel was operational in June 1920 (Baals and Corliss 1981). In 1921, Langley built the Variable Density Tunnel (VDT). The VDT, designed by Max Munk, was built in a large tank that could be pressurized to 20 atmospheres. The VDT allowed researchers to more accurately simulate full-scale flight conditions. The VDT put Langley at the forefront of aeronautical research (Chambers 2014:4–5; Baals and Corliss 1981). The VDT began operations in 1922 and, for the next 10 years, research with the VDT focused primarily on providing aerodynamic data on the performance of airfoils for wings (Chambers 2014:5).

In 1927, Langley constructed the Propeller Research Tunnel (PRT). This tunnel allowed researchers to test full-scale propeller-powered engines and supporting fuselage shapes. It was the first large wind tunnel built at Langley. During this same period, Langley decided to replace Wind Tunnel No. 1with two new wind tunnels in the same building. The first new tunnel allowed researchers to safely study spin-recovery procedures. The second tunnel replacing Wind Tunnel No. 1 was a 7- by 10-foot AWT. This tunnel went into operation in 1930 and was designed to research high-lift wings, stability, and control. The AWT was so successful that the NACA built four more in the following years (Baals and Corliss 1981).

Talk of building a full-scale wind tunnel at Langley began in the late 1920s as NACA engineers were designing the PRT. In March 1929, Smith DeFrance was named head of the new FST and was responsible for the construction and operations of the complex. The FST was the first open-throat, semi-elliptical wind tunnel to be powered by two side-by-side propellers. The advantage of the open-throat was the minimal wind tunnel wall effects, and this wind tunnel allowed for large aircraft to be mounted in the test section (Chambers 2014:14). However, the possibility existed for flow quality problems. DeFrance and his team recognized that the design for the FST was complicated and challenging, and requested that George Lewis construct a 1/15-scale model of the new tunnel to analyze the design and make the necessary modifications for the final design. The project was completed in May 1931 (Chambers 2014:3, 111).

The missions and technical pursuits at Langley and at the other NACA aeronautical laboratories were altered by World War II. The focus turned to jet- and rocket-propulsion. During the post-World War II period, testing centered on conceptual studies that included advanced high-lift devices and boundary-layer control for lift augmentation. By the 1960s, it was necessary to update the FST, including the hardware used during testing, because of free-flight model testing that had begun. These tests were used to assess longitudinal and lateral directional characteristics, to create criteria for satisfactory behavior. As the U.S. moved towards putting a man on the moon, Langley's FST played a pivotal role in the program (Chambers 2014:185, 240).

The FST at Langley was in continuous use from its inception. In 1975, it was necessary for the tunnel to undergo an extensive rehabilitation. The rehabilitation was completed at the end of 1976, and the first test in the rehabilitated tunnel, a large supersonic transport model, occurred in January 1977 (Chambers 2014:306, 308). During this period, the FST continued to provide valuable test data for the military. In the 1980s, NASA Headquarters approved the High-Angle-of-Attack Technology Program. All three NASA locations—Langley, Glenn, and ARC—were involved in this program, focusing on the assessment and development of computational and experimental methods to improve engineering methods for earlier prediction and modifications for high-angle-of-attack conditions. The FST at Langley became the primary test tunnel for this research. In 1985, the FST was recognized as an NHL (Chambers 2014:319, 325, 356).

By the 1990s, most FST tests were conducted under the highest level of security and remain classified today, but Langley also did civil aircraft testing. However, in 1992, NASA underwent a change in leadership that resulted in a massive organizational change. With the new leadership came new directions and focus. The decision was made to deactivate the FST in 1995. Because of the enormity of the building and the presence of asbestos in the siding and roofing panels, the initial decision was to mothball the building rather than to demolish it (Chambers 2014:355–357, 403).

Old Dominion University made a proposal to NASA in 1997. The university would control the interior and roof maintenance of the FST building if NASA remained responsible for the maintenance and corrosion control of the building's exterior. The agreement made the FST the largest university wind tunnel operating in the world. The university modified the tunnel to attract customers from the motorsports industry, particularly NASCAR. Out of 50 NASCAR teams, 35 used the FST for tests, which brought in more than $1 million in revenue. The university continued to attract clients to the FST into the early 2000s (Chambers 2014:413–415, 422, 423).

In 2008, NASA completed an agency facilities study, an assessment of its 300 technical facilities for program utilization requirements through 2028. The study determined that the FST was not a necessary part of the core capabilities for NASA's future research. Alternative uses, including a space museum, could not be agreed on, and a decision was made to demolish the FST. Demolition began in fall 2010 (Chambers 2014:445–446).

Wind Tunnels at John H. Glenn Research Center at Lewis Field

Early research at Langley focused mostly on aerodynamics and made tremendous contributions to the aerodynamics of propellers and engine nacelles, but not much research was conducted on operation of engines. The Powerplants Division, led by Carlton Kemper, maintained a small staff of 12 in 1938. The Powerplants Division focused on the fundamentals of engine power, efficiency, and fuel consumption, but not on the problems associated with them. Engine testing was left to the manufacturers and the military. This led to inconsistences because private companies could not afford to build large test facilities.

As part of the decision to expand its research facilities, the NACA recognized that it lacked sufficient engine research facilities. In October 1939, the Special Committee on New Engine Research Facilities was created. The committee called for a $10 million laboratory that would include test stands for engines, a fuels and lubricants facility, and a wind tunnel for engines. In 1940, the NACA announced that its new facility, Aircraft Engine Research Laboratory (AERL), would be constructed on a 200-acre site north of Cleveland, Ohio (Arrighi 2010:8–11, 16, 21).

The ground-breaking ceremony was held on January 23, 1941; however, design work for the new wind tunnel had already begun at Langley. Great pressure existed to get the facility built and operating because it was likely that the U.S would enter World War II and a backlog of Navy and Army engine problems needed to be fixed. In addition to the engineers and draftsman working on the designs for the facility's AWT at Langley, another group at ARC was tasked with designing the AWT's shell and electrical drive system. The engineers at ARC also were designing the drive system for a new 40- by 80-foot wind tunnel. The Cleveland facility was to have six main buildings: an Engine Research Building, a hangar, a Fuels and Lubricants Building, an Administration Building, a Propeller Test Stand, and an AWT that was officially referred to as the Engine Research Tunnel. Construction of the Cleveland facility was slowed because of World War II; however, it was critical to the war effort for the facility to be functional as soon as possible. The military provided special supplies, contracts were amended with contractors, and Congress approved the necessary funds. The Powerplants Division from Langley was transferred to AERL. AERL opened in 1943 and AWT construction was accelerated (Arrighi 2010:21–23, 30–31).

During World War II, all efforts at Langley, ARC, and AERL focused on tests that assisted the military. The AWT at AERL was the first wind tunnel in the U.S. capable of operating full-scale aircraft engines in conditions that duplicated those encountered by aircraft during actual flights (Arrighi 2009:11). During the first 10 years, research centered on tests related to technologies associated with turbojet, ramjet, and turboprop engines (Arrighi 2009:29). The AWT was the only tunnel that allowed combustion and performance characteristics of a turbojet to be studied under altitude conditions. Because it was the only such facility in the country, this resulted in an average backlog of eight to 12 months for research requests. The solution was to build two altitude test cells in the Engine Research Building. It contained static chambers into which full-size engines could be installed and run at altitudes up to 50,000 feet and temperatures ranging from 200 to -70 degrees Fahrenheit. Activated in 1947, it took some of the burden off the AWT, and its compressors increased the capabilities of the AWT's exhaust system. A second pair of engine test cells, the Propulsion Systems Laboratory completed in 1952, further reduced the AWT's workload (Arrighi 2010:77, 103).

As war loomed in Korea, modifications were made to the AWT that were intended to modernize the facility. An addition to the Exhauster Building was constructed to house three Ingersoll-Rand compressors. A pump house and exhaust cooler pit were built underneath the tunnel, and two more cells were added to the cooling tower. These modifications allowed the AWT to continue analyzing jet engines, which were becoming increasingly larger (Arrighi 2010:143–144). However, with the launch of Sputnik I, research at AERL switched to the space program, and the AWT was used for Project Mercury qualification testing. The AWT played a critical role in Project Mercury, speeding up the preflight testing and saving money (Arrighi 2009:12, 2010:194). The facility was renamed the NASA Lewis Research Center (LRC) in 1958 (Arrighi 2009:11).

When NASA was tasked to put a man on the moon, engineers sealed off portions of the AWT, creating two large test chambers renamed the Space Power Chambers. The AWT also was instrumental to the Apollo Program and the Centaur missions (Arrighi 2009:12). One chamber simulated the vacuum of outer space and the other simulated conditions of the upper atmosphere (Arrighi 2010:198).

In the early 1970s, NASA began cancelling its large space programs. In the mid-1970s, use of the AWT stopped. The LRC was to have a minimal role in the SSP and its workforce was dramatically reduced. In the early 1980s, efforts were made to modify the AWT for testing, but the costs were too high (Arrighi 2009:2, 2010:297–298, 307). NASA officially changed the name of the facility in 1999 to the NASA John H. Glenn Research Center at Lewis Field (Glenn) (NASA 2015).

In 2003, NASA conducted a study on its wind tunnels and propulsion test facilities. It was determined that 29 of the 31 active tunnels were unique and should be maintained, but the AWT was not in service and was not considered in the study (Arrighi 2010:316–317). Based on recommendations of the U.S. House Subcommittee on Space for NASA to dispose its underused facilities, the decision was made in 2004 to demolish the AWT. Demolition was completed in 2009 (Arrighi 2009:2).

Development of ARC

In 1936, the Special Committee on the Relations of the NACA to National Defense in Time of War was established by the U.S. in anticipation of potential international hostilities. The committee recommended a second NACA aeronautical laboratory to supplement Langley. A second laboratory was needed because of Langley's vulnerability to attack and its need for expansion (Hartman 1970:5–9; Muenger 1985:3). Langley was quickly outgrowing its facilities, with a labor force that had grown from three employees in 1918 to almost 500 in 1938 (Muenger 1985:3). By late 1938, the NACA's Special Research Committee of Future Research Facilities was seeking a new site for the NACA's second aeronautical laboratory and recommended Moffett Field between Mountain View and Sunnyvale, California, as the preferred location to the NACA's governing Executive Committee. Shortly after, the NACA requested appropriations of $11 million for the new facility from Congress. Congress initially demurred from the appropriation request, but after persuasive arguments were delivered by NACA representatives George Lewis, Charles Abbott, and Charles Lindbergh, the bill for the second laboratory was passed on August 9, 1939. The NACA representatives' arguments were driven by their knowledge of German progress in aviation technology that was superior to U.S. research and development at the time (Hartman 1970:18).

The Moffett Field location was selected for several reasons, including the proximity of the site to the burgeoning aviation industry on the West Coast (Hartman 1970:20–21; Muenger 1985:4). Moffett Field was an operating airfield and military base under Army Air Corps command that had the advantages of good weather and limited air traffic. In addition, electrical power was an important consideration for the operation of wind tunnels and other facilities critical for experiments conducted in the aeronautical laboratory, and Sunnyvale's new electric station was an important consideration in the siting process. The west coast also had an expanding industrial sphere with connections to academic institutions, including the California Institute of Technology's Guggenheim Aeronautical Laboratory in Pasadena, with which the NACA had developed a rivalry (Muenger 1985:5).

In 1939, the NACA officially selected Moffett Field for its new site, and planning for new buildings and wind tunnels commenced with fervor at Langley. The Army leased 62 acres of the installation to the NACA in December 1939 (Hartman 1970:25). In addition, the NACA purchased 40 acres of adjacent, undeveloped agricultural lands from local farmers. The location had specific geographical issues, including a high water table and high potential for seismic activity, that were taken into account in the design of the facilities. DeFrance, the assistant chief of aerodynamics, led the design team from Langley, while Russell Robinson worked on-site to coordinate industry relations and oversee initial construction. The new laboratory was named the Ames Aeronautical Laboratory in April 1940, in honor of former NACA chairman and physicist Joseph S. Ames.

The NACA created its Western Coordination Office at ARC, led by Robinson, as liaison between the new laboratory and the military, the aviation industry, and academic institutions. Defense-related aeronautical research was in high demand, and the purpose of the new laboratory, particularly its proposed wind tunnels, was to lead or supplement military and industrial research. An important connection with nearby Stanford University had been developed previously with Stanford faculty and graduates (including Robinson, William Durand, Elliott Reid, H. Julian Allen, and John Parsons working with the NACA and at Langley). The new Ames laboratory also focused on recruiting graduates from several other west coast universities.

DeFrance led the design from Langley while a contingent of Langley staff, including Parsons and Edward R. Sharp, made the move to California in late 1939 and early 1940 to lead the construction effort. Ground-breaking occurred on December 20, 1939. The first NACA building constructed in 1940 was a utilitarian building that served as the construction office. A research hangar, an electrical substation supplying 40,000 horsepower (approximately 30,000 kilowatts), two 7- by 10-foot wind tunnels, and a 16-foot wind tunnel were the first major facilities designed for the site. By August 1940, the Flight Research Building (Building N-210), containing the flight research engineering staff, an airplane hangar, and maintenance shop was completed, and three wind tunnels were under construction. The construction effort lasted over a year at an urgent and anxious pace because of the onset of war in Europe with the technical staff from the flight research engineering and theoretical aerodynamics departments involved in several aspects of the effort (Hartman 1970:32; Muenger 1985:16). The NACA named DeFrance to be engineer-in-chief of the facility in June 1940.

In April 1941, the first 7- by 10-foot wind tunnel (Building N-215) started operating, followed by the second wind tunnel (Building N-216) (no longer extant) four months later. The scale of these tunnels was in high demand for both industry and military testing, which made it practical to build two identical tunnels. The tunnels functioned using models to test “for drag, lift lateral force, and pitch, yaw, and rolling moment,” with airspeeds between 400 and 480 kilometers per hour (Muenger 1985:16). In October 1941, the high-speed 16-foot tunnel (Building N-218) (no longer extant) started operating. The scale of this tunnel allowed for testing full-scale aircraft components at airspeeds up to 1,100 kilometers per hour. The experimental design of this tunnel, along with a similar 16-foot wind tunnel at Langley, was new and therefore required some adjustments to achieve its desired level of functionality (Hartman 1970:36).

As progress continued on the first three wind tunnels, DeFrance led the design of the world’s largest low-speed wind tunnel for testing full-scale aircraft at Ames. DeFrance previously designed a 30- by 60-foot low-speed wind tunnel at Langley. The Pittsburgh–Des Moines Steel Company bid approximately $6 million to build the tunnel and, in March 1942, construction began on the 40- by 80-foot structure at Ames (Building N-221) (Muenger 1985:17). The 40- by 80-foot wind tunnel was not completed until June 1944, at which time the high-speed 1- by 3.5-foot wind tunnel (no longer extant) also was completed.

Initially, one research division, the Research Division, was at Ames (Hartman 1970:40). Subdivisions took shape organically as facilities became available, centering around the wind tunnels and various research design issues. One research group focused on 7- by 10-foot wind tunnel research and one around 16-foot wind tunnel research, one concentrated on theoretical aerodynamics, and another dealt with small flight research. Staff and jobs often combined and separated on an improvisational basis as research groups were “shuffled for maximum efficiency,” and “very loosely organized.” This pattern of institutional fluidity would persist throughout Ames’s history under DeFrance’s management (Muenger 1985:18–19).

After construction of the 40- by 80-foot wind tunnel, the topical division of aeronautical research at Ames branched into two major subsets: theoretical high-speed aerodynamics and applied research. The high-speed aerodynamics section or the Theoretical and Applied Research Division, concentrated its research on the 7- by 10-foot and the 16-foot wind tunnels and modeling, and the applied research section or the Full-Scale and Flight Research Division, used the 40- by 80-foot wind tunnel and full-scale aircraft. Cooperation between theoretical and applied research sections became very important as research shifted to designing and testing for military needs during World War II.

When the U.S. entered World War II in December 1941, research at Ames immediately shifted to solving specific problems with military aircraft that were assigned by the NACA to its laboratories. This research included testing military aircraft prototypes, evaluating aerodynamics and handling, and refining designs for immediate application. One critical need was accelerating research into thermal methods for de-icing aircraft. De-icing research had been conducted at Langley since the 1920s, and lead researcher Lewis A. Rodert continued his study on the subject at Ames. Between Rodert’s work at Ames and in Minnesota, an applicable solution for de-icing was developed, and airplanes immediately were fitted with the de-icing technology, in effect solving the aircraft icing problem. Although unrelated to the wind tunnels, this was a major success for Ames and established its reputation for coordination and effectiveness within the aviation industry, the military, and the public (Hartman 1970:69–77; Muenger 1985:20–22).

The World War II period was significant in Ames’s development and in the level of intensity of its research at the time. During the war, the wind tunnels were in high demand and in constant operation. Although Ames personnel had increased from 51 in September 1940 to 844 in August 1945, the facility still had a shortage of manpower, even with the Navy assigning 200 men from its V-12 college program to assist the laboratory (Muenger 1985:24).

Ames supported five wind tunnels at the end of World War II and, in light of the need for higher speed research, started design work on a 12-foot pressure tunnel and two new supersonic wind tunnels. Allen led the advanced planning and design of the 1- by 3-foot supersonic wind tunnels that were constructed between February and September 1945. The Navy also funded a larger 6- by 6-foot supersonic wind tunnel (Building N-226) that started construction in May 1945. The shift towards high-speed research resulted in the creation of a third main research division at Ames – the High-Speed Research Division. DeFrance appointed Allen to head the division, which centered on research conducted in the 1- by 3.5-foot wind tunnel, the two 1- by 3-foot tunnels, and the 6- by 6-foot supersonic tunnel.

In the post-war period, the government dedicated itself to maintaining the level of scientific and technological progress seen during World War II. As a result, Ames reverted to its progressive aeronautical research on a steady and encouraging platform of coordinated industrial and scientific interests and research efforts. In 1946, Robert Thomas (R.T.) Jones arrived at Ames from Langley. While at Langley, Jones produced the theory of sweepback to avoid high drag of straight wings at transonic speeds, but his findings were not publicized until they were confirmed by experimentation. At Ames, Jones continued to refine the narrow and swept-wing performance at supersonic and high-subsonic speeds (Vincenti, n.d.:145–149).

Under DeFrance's continued leadership, Ames's research organization remained somewhat nebulous, but new attempts were made to standardize operational practices and formalize the organizational structure, particularly as the aeronautical field grew and became more complex (Muenger 1985:58). The NACA became more geared towards collaboration with other agencies and industrial and academic institutions for more unified research. In the late 1940s, the NACA spearheaded the Unitary Plan, to unify and coordinate research and development among the national stakeholders in aeronautical research (Hartman 1970:150–151).

The Unitary Plan Act was passed by Congress on October 27, 1949. The appropriations for the Unitary Plan allocated $136 million to each of the three NACA laboratories to build a supersonic wind tunnel (Launius et al. 2002:5). At ARC, the Unitary Plan Wind Tunnel complex was designed and under construction by 1950. Completed in 1956 at a cost of $27 million, the complex was powered by a new power plant that generated up to 240,000 horsepower to operate three wind tunnels (Butowsky 1984a; Muenger 1985:54). For versatility, three tunnels were constructed—an 11- by 11-foot transonic, a 9- by 7-foot supersonic, and an 8- by 7-foot supersonic wind tunnel—with 20-foot valves connecting them (Butowsky 1984a). The complex was in high demand from the industry, military, and university partners for the capabilities of the complex, including tests for Boeing and Douglas commercial airplanes and military airplanes (Butowsky 1984a). Eventually in the 1960s and 1970s, the Unitary Plan Wind Tunnel complex was used to test almost all crewed space vehicles (Butowsky 1984a).

In the 1950s, Ames continued to build off its wartime expansion, with double the staff and facilities at the end of World War II (Muenger 1985:47). However, compromises had to be made because of financial restrictions on the Ames operating and development budget. The early 1950s were a low point in the enthusiasm of the research facility because of an excess of research obligations and limited funding for Ames-originated research, and because of a lack of funding for new facilities (Hartman 1970:175). The facility also was understaffed and the wind tunnels were underused, operating with a single shift instead of a double shift. The lack of availability created a backup of work and delayed development tests requested by the aviation industry.

Despite the seeming slowdown of operations, the fields of transonic and supersonic flight were burgeoning, and the field of automatic control became a new challenge (Muenger 1985:65). Ames had been conceived more as a theoretical research laboratory than as a full-scale testing laboratory, but World War II had shifted the balance to applied research on actual aircraft. In the 1950s, the research direction at

Ames included theoretical aerodynamics research, centered on the six transonic or supersonic wind tunnels under the High-Speed Research Division: the two 1- by 3-foot tunnels, the 1- by 3.5-foot tunnel, the 6- by 6-foot tunnel, the 10- by 14-inch hypersonic tunnel, and the free-flight tunnel (Muenger 1985:73). Research under both the high-speed and full-scale divisions focused on fundamental research and specific industry concerns, most notably in sweptback wing design, remote control, and vertical and short take-off and landing. Also at this time, computer-based systems were being implemented. One of the most significant research developments from this period was Allen's work on atmospheric reentry in the High-Speed Research Division. Allen developed a theory on blunt body heating that led to the discovery that blunt-nosed bodies, rather than conical-nosed bodies, dissipated heat more efficiently on reentry. This blunt-body concept had far-reaching implications for all vehicles reentering Earth's atmosphere and on space exploration (Vincenti et al. 2007:5–10).

In the 1950s, the Full-Scale and Flight Research Division also transformed under Harry Goett to include six research branches: flight operations, flight research, the 40- by 80-foot wind tunnel (N-221), the new 8-inch low-density tunnel, the new 10- by 10-inch heat-transfer tunnel, and dynamics analysis research (Muenger 1985:72). Research in the division took on vehicles at supersonic speeds, again supporting theoretical progress with applied experimentation. This division also laid the groundwork for developing flight simulators and computer-based modeling.

With construction of new tunnels in in the mid-1950s, obsolete tunnels were closed. The 1- by 3.5-foot supersonic tunnel was replaced with a new 2- by 2-foot transonic tunnel, and operation of the original two 7- by 10-foot tunnels was reduced (Buildings N-215 and N-216). New facilities also were constructed to support the growing complexities of aerothermodynamics and hypervelocity ballistics research.

After Sputnik in 1957, the U.S. was propelled into the space age, and Ames along with the other NACA laboratories turned towards the technological challenges of space travel on the foundation of their long-standing aeronautical and aerodynamics research. The NACA sought to be the leader of the planned space agency, based on its dramatic discoveries and long-standing dedication to fundamental research, and as a service institution to serve industrial, military, and academic research, transitioning naturally to lead newly formed NASA in 1958 (Muenger 1985:81–83).

The transition from the NACA to NASA led to reorganization at Ames beginning in 1959. The distinction between aeronautical and space-related research became more defined. The High-Speed Research Division became the AeroThermodynamics Division, which included the supersonic free-flight tunnel branch, the heat transfer branch, the fluid mechanics branch with the 1- by 3-foot supersonic tunnels and the 2- by 2-foot transonic tunnel, and the trisonic aerodynamics branch with the 6- by 6-foot supersonic tunnel. The Vehicle Environment Division included a physics branch, an entry simulation branch, a structural dynamics branch, the 3.5-foot hypersonic wind tunnel branch, and the hypervelocity ballistic range branch. The Full-Scale and Flight Research Division was renamed the Full-Scale and Systems Research Division and included the 40- by 80-foot wind tunnel, flight and systems simulation and operations, dynamics analysis, and guidance and control. Flight research, with the exception of vertical and/or short take-off and landing (V/STOL) research, which was reliant on the 40- by 80-foot wind tunnel, was transferred to Edwards AFB. The Unitary Plan Wind Tunnel Division remained unchanged and the 14-foot transonic tunnel and the 10- by 14-inch supersonic tunnel were deactivated. The new Instrumentation Division was created, as well as a life-sciences research group and Manned Satellite Team, which, along with the 1960s Manned Lunar Mission Team, later influenced the planning of the Apollo program. In 1962, a separate Space Sciences Division was established (Muenger 1985).

Although aeronautics research with V/STOL studies and supersonic transport feasibility investigation continued at Ames in the 1960s, astronautics became the more visible research area at the facility with aeronautics in second place. With the loss of most of its flight research divisions, ARC worked to establish new research areas to maintain its position as a cutting edge research facility, and the division between conventional aeronautics and space-related studies became more apparent. In 1962, NASA Headquarters authorized Ames to proceed with the Pioneer project, which involved a series of interplanetary solar probes. The success of the Pioneer project established Ames as a crucial component of NASA and facilitated the acquisition of the Biosatellite project in1963, which involved biological experiments in space. NASA Headquarters defined the primary mission of ARC as basic and applied research on aerodynamics of reentry vehicles, flight control of space vehicles and aircraft, and space environment physics (Muenger 1985).

ARC expanded rapidly during the 1960s as NASA constructed new facilities at the center. The hypervelocity research laboratory and shock tunnel were built in the early 1960s and, in 1965, the 3.5-foot tunnel was modified to simulate the atmospheres of Mars and Venus. A Mach 50 helium tunnel; a hypervelocity free-flight facility; a new impact range; and arcjet tunnels, which were designed to reproduce the extreme heat that a space vehicle would be subjected to in space, also were constructed. Advancements in flight simulators also occurred during this time. The first flight simulators built at ARC were constructed in the 1950s using spare parts. By 1965, ARC's simulator equipment filled a former NACA hangar, which was known as the Space Flight Simulation Laboratory. One early vertical testing machine was installed on the outside of the 40- by 80-foot wind tunnel to make use of the structure's height and frame. In 1963, ARC engineers submitted a proposal to NASA Headquarters for the construction of a complex of four flight simulation facilities. NASA approved the plan and constructed Buildings N-243 and N-243A at ARC to house the equipment (Muenger 1985; Page & Turnbull 2007).

Other buildings constructed in 1965 and 1966 included a space environments research facility and structural dynamics laboratory that were built to simulate conditions and forces in space; a life sciences research laboratory; and a spaceflight guidance laboratory. These new facilities primarily focused on solving the major spaceflight problems of speed and the heat generated by it, and the control of space vehicles during flight. Models of Mercury and Gemini capsules were tested in the hypervelocity free-flight facility and flight simulators and Apollo capsule models were used to test spacesuit designs. In the late 1960s, ARC began to slowly regain its flight research aircraft that had been transferred to Edwards AFB when NASA took over. The climate at ARC was more conducive to testing V/STOL than at Edwards AFB, and the 40- by 80-foot wind tunnel and the comprehensive flight simulation facility at ARC made it the best location to research and test V/STOL. The Army Aeronautical Research Laboratory, which had been established at ARC in cooperation with NASA in 1965, modernized the 7- by 10-foot wind tunnel, allowing ARC staff to use the tunnel at a low cost. By 1969, the ARC facilities included 18 wind tunnels, two sets of ballistic ranges, 10 flight simulators, 11 arc jet facilities, eight laboratories, and 56 major buildings (Muenger 1985).

In 1967, a nationwide review of American wind tunnels identified the 40- by 80-foot wind tunnel, as well as ARC's 12-foot pressure tunnel and the Unitary Plan wind tunnels, as key national resources, and ARC initiated a long-term effort modernize its wind tunnels. In 1978, ground was broken on the 80- by 120-foot Subsonic Wind Tunnel section that was added to the closed-loop 40- by 80-foot wind tunnel. The 80- by 120-foot wind tunnel was completed in 1982 and the combined facility was rededicated as the NFAC in 1987. The 40- by 80-foot wind tunnel had been upgraded to achieve airspeeds of 345 miles per hour and the 80- by 120-foot wind tunnel operated at 115 miles per hour and was the world's largest open-circuit tunnel able to accommodate a variety of large-scale aircraft including fighter jets, Space Shuttle models, and a Boeing 737. A common, six-fan drive system included fans 40 feet in diameter with 15 laminated wood blades, which at full power, turn 180 revolutions per minute. The 80- by 120-foot wind tunnel was used to test DOD and civilian aircraft as well as the Space Shuttle drag chute, which led to changes to the chute that flew on every Space Shuttle mission after that test. In 1971, ARC opened a Space Shuttle development office and conducted half of all the wind-tunnel tests for the second phase of the Space Shuttle design using the NFAC, the Unitary Plan Wind Tunnel Complex, and the 3.5-foot hypervelocity tunnels (Bugos 2014; Muenger 1985).

Development of the Space Shuttle Program

The idea of a reusable launch vehicle in space goes back as far as the early 1950s, when DOD explored such a concept for U.S. military operations. Over the next 10 years, efforts were made to determine the best technology to develop a vehicle that resembled a rocket, a spacecraft, and an airplane. Little further movement occurred until 1969, when President Richard Nixon created the Space Task Group, whose goal was to explore the future of NASA and its space program, ushering in a new era for space exploration. Three years later, after the task group recommended a new course for the Space Program, NASA's shuttle program (known as the Space Transportation System) officially was launched (Archaeological Consultants, Inc. 2008:2–1, 2; Science Applications International Corporation 2007).

The SSP operated from 1981 to 2011 as the U.S. government's manned launch vehicle program. When originally created, the SSP was meant to work with an International Space Station (ISS). However, delays in establishment of an ISS temporarily halted those plans. Despite this initial setback, NASA moved forward with its goal of creating a Space Shuttle orbiter. The proposed shuttle was unique in resembling a reusable manned space vehicle that would launch vertically into space like a rocket and land back on Earth similar to an airplane. After launch, the Space Shuttle was to serve several purposes, including carrying and recovering large payloads into orbit, performing service missions, and providing crew rotations for the ISS after it was created. Each orbiter was to support a crew of four to seven astronauts and carry up to 65,000 pounds. The shuttle was to land at either Kennedy Space Center in Florida or Edwards AFB in California. When built, the shuttle had a projected lifespan of 100 launches or 10 years of operation (Dutton & Associates 2010:33; Archaeological Consultants, Inc. 2008:2-4).

In 1972, NASA awarded Rocketdyne Division of North American Rockwell a contract to develop and produce the Space Shuttle main engine. The manufacturing location was in Canoga Park, California, and test facilities were in California and Mississippi. For the next several years, tests were conducted on vehicle engine performance, vehicle components, and complete propulsion systems, as well as design and manufacturing techniques of the Space Shuttle orbiter (Archaeological Consultants, Inc. 2008:2-3).

One challenge in the design of the Space Shuttle was the technical management of the aerodynamic, aerothermodynamic, and structural characteristics of the launch and entry vehicle configuration, which required an extensive wind tunnel test program. NASA's formal wind tunnel test program for the Space Shuttle began in September 1972 and ended in September 1983 (Whitnah and Hillje 1984). All of the major wind tunnels in the U.S., including NASA's wind tunnels at Marshall Space Flight Center, Langley, Johnson Space Center, and ARC, conducted testing as part of the program. The program for the Space Shuttle was the largest wind tunnel research effort undertaken by the U.S. Approximately 100,000 total hours of aerodynamics, heat transfer, and structural dynamics testing was conducted for elements of the Space Shuttle (Romere and Brown 1995). Several of ARC's wind tunnels, each with different subsonic, transonic, supersonic, and hypersonic capabilities, were used as part of the program, including: the 40- by 80-foot Wind Tunnel (Building N-221), the 11- by 11-foot wind tunnel (Building N-227A), the 9- by 7-foot wind tunnel (Building N-227B), the 8- by 7-foot supersonic wind tunnel (Building N-227C), and the 6- by 6-foot supersonic wind tunnel (Building N-226) (Whitnah and Hillje 1984). Testing was coordinated by NASA management at the Johnson Space Center. The program integrated the efforts of the NASA, DOD, and private industry aerodynamic communities, interfaced with other Space Shuttle system programs, and used virtually every major wind tunnel facility in the United States (Romere and Brown 1995).

Efforts were also well underway to create a laboratory in space to be used together with the Space Shuttle. In September 1973, the European Space Agency and NASA agreed to design and develop a Spacelab. The lab was to be a manned, reusable, microgravity lab, flown in space at the rear of the Space Shuttle cargo bay. Construction was started in 1974, and the first space lab mission was in 1983, lasting nearly a year. Five Spacelab missions were flown between 1983 and 1985. NASA stopped missions briefly after the *Challenger* disaster but resumed the missions in 1990 (Archaeological Consultants, Inc. 2008:2-22).

During this period, NASA also was looking for an aircraft that could transport the orbiter vehicle across the country. In 1974, it awarded Boeing the contract after studies found the 747 could be effectively modified as an orbiter carrier. The altered 747 was put into service in 1977. Its first task was to move the test shuttle Enterprise to Edwards AFB (Archaeological Consultants, Inc. 2008:2-10).

Additional tests for the SSP took place in the ensuing years, as efforts continued to move the shuttle into service. Initial testing focused on the approach and landing phases of the shuttle as well as structural integrity. Testing was essentially complete by 1979, and led to significant but successful redesign of the orbiter. As development of the Space Shuttle orbiter was well underway, NASA's focus turned to manning the vehicle. In 1976, NASA sent out a call for astronauts who would serve as pilots or mission specialists for the shuttle. Two years later, it selected a group of eight from candidates consisting of 21 military offices and 14 civilians. Within that group, 15 of the applicants were assigned to the position of pilots and 20 as mission specialists. The inaugural class included Sally Ride, the first woman in space; Guion Bluford, the first African-American in space; and Kathryn Sullivan, the first woman to complete a spacewalk (Archaeological Consultants, Inc. 2008:2-15).

Several orbiters were built under the SSP, including the *Enterprise*, *Columbia*, *Challenger*, *Discovery*, *Atlantis*, and *Endeavor*. Enterprise was built as a prototype of the shuttle orbiter and had its first flight in February 1977. The original name of *Enterprise* had been Constitution in honor of the Bicentennial, but later it was changed to *Enterprise* after Star Trek's Starship Enterprise. *Columbia* was the first successful launch of the manned spaceship and proved that the new technology was effective. Columbia carried a crew of two, Commander John W. Young and pilot Robert L. Crippen. After launching on April 12, 1981, *Columbia* landed without incident two days later at Edwards AFB. The launch showed that the shuttle could fly into orbit, conduct successful operations, and return safely. *Columbia* flew additional test flights through 1982. Space Shuttle *Challenger* joined the fleet in 1982, *Discovery* in 1983, and *Atlantis* in 1985. *Endeavor* was the last shuttle launched (1992) under the program. Between 1982 and 1985, *Columbia*, *Challenger*, *Discovery*, and *Atlantis* flew an average of four to five launches per year. During their years of operations, the shuttle orbiters flew various missions, including science missions with the Spacelab module, and the retrieval and repair of communication satellites. All missions, with the exception of six, landed at Edwards AFB in California (Archaeological Consultants, Inc. 2008:2-9, 14, 15; Page & Turnbull, Inc. 2007:III-5, 8, 114).

In 1983, NASA suffered a major setback with the *Challenger* disaster. On January 28, Challenger broke apart 73 seconds after lift-off, with a crew of seven on-board. After the accident, the SSP was suspended for about two and a half years. A government committee, known as the Rogers Commission, investigated the incident and concluded that it was related to a failure of a seal in the solid rocket booster. The commission also reviewed the overall SSP and determined the program was under significant strain and pressure to be successful, which further stressed its resources. Additional failures were found in management. As a result of the findings, focus shifted to redesign of the shuttles and astronaut gear. Also, some reorganization and decentralization of the program occurred. The flight schedule was reduced to fewer launches and some payloads were scrapped (Archaeological Consultants, Inc. 2008:2-16).

Discovery launched in September 1988, which marked a return to flight after a hiatus of 32 months in manned spaceflights following the *Challenger* disaster. *Discovery* was followed by the launch of *Endeavor*, which was completed in 1990, and made its inaugural flight in 1992.

Improvements were made to the new shuttle and, overall, NASA reduced the number of flights per year. During the first decade of the SSP, nearly 80 percent of missions terminated at Edwards AFB. The next decade, however, this was reversed with most landings occurring at Kennedy Space Center (Archaeological Consultants, Inc. 2008:2-15, 17, 18).

A total of 123 Space Shuttle missions took place from Kennedy Space Center between April 1981 and May 2008. Before the *Challenger* accident, roughly two to nine missions were flown each year. After 1988, the average increased to six missions yearly until the *Columbia* accident in 2003. The most productive years for the SSP were between 1992 and 1997, when approximately seven to eight missions occurred annually (Archaeological Consultants, Inc.2008:2-18).

In more recent years, the shuttle was involved in several planetary and astronomy missions, including the Galileo probe to Jupiter; the development of the Hubble Space Telescope, which was launched in April 1990; the joint U.S./Russian Shuttle Mir Program (started in 1996); and the creation of the ISS in 1998. *Discovery* was the first mission to dock with the ISS in 1999. After the ISS was launched, the Spacelab was retired mainly because all Spacelab experiments could now be carried out in the new ISS (Dutton & Associates 2010:33).

By the year 2000, shuttle launches were mostly routine. However, on January 16, 2003, another tragedy struck the SSP. That morning, *Columbia* launched with a crew of seven. It was to return to Earth following a 16-day mission. Minutes prior to its touchdown at Kennedy Space Center, the spacecraft was lost during re-entry over Texas, and all aboard died. Following the accident, an investigation was conducted, and it was determined the craft went down because of technical and management errors. A breach occurred in the thermal protection system on the leading edge of the left wing during lift off that resulted in the destruction of the Shuttle orbiter on landing. NASA spent the next two years improving the safety of its Space Shuttle orbiters. Following a two-year hiatus, the launch of Orbiter *Discovery* in July 2005 marked the first return to flight. A year later, *Atlantis* was launched (Archaeological Consultants, Inc. 2008:2-24). Meanwhile in 2004, President George W. Bush announced that the SSP would be concluding. The shuttle was officially retired in August 2011, after *Atlantis* completed its last mission one month before (Archaeological Consultants, Inc. 2008:2-1).

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Previous documentation on file (NPS):

____ preliminary determination of individual listing (36 CFR 67) has been requested
_X_ previously listed in the National Register
____ previously determined eligible by the National Register
_X_ designated a National Historic Landmark
____ recorded by Historic American Buildings Survey #____________
____ recorded by Historic American Engineering Record # __________
____ recorded by Historic American Landscape Survey # ___________

Primary location of additional data:

____ State Historic Preservation Office
____ Other State agency

_X_ Federal agency
____ Local government
____ University
_X__ Other
Name of repository: National Archives, San Bruno, CA

Historic Resources Survey Number (if assigned): ________________

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10. Geographical Data

Acreage of Property 46.3

Use either the UTM system or latitude/longitude coordinates

Latitude/Longitude Coordinates (decimal degrees)
Datum if other than WGS84:__________
(enter coordinates to 6 decimal places)

1. Latitude: 37.418054 Longitude: -122.064540
2. Latitude: 37.417572 Longitude: -122.058924
3. Latitude: 37.414800 Longitude: -122.058805
4. Latitude: 37.413774 Longitude: -122.063589

Verbal Boundary Description (Describe the boundaries of the property.)

Beginning at the intersection of Walcott Road to the north and Mark Avenue to the east, the boundary follows Mark Avenue south to Durand Road. The boundary heads west on Durand Road and cuts south between buildings N219 and N220, until it meets King Road. It then turns west on King Road until it reaches Gamma Lane and heads north on Gamma Lane. The boundary follows the wind tunnel clear zone around N221B, moving east towards Parson Avenue. It drops slightly south on Parsons Avenue and then heads east across DeFrance Avenue to Boyd Road.

Boundary Justification (Explain why the boundaries were selected.)

The boundary includes the area of ARC that historically contained the wind tunnels and those buildings associated with the research conducted in the tunnels.

11. Form Prepared By

name/title: Patricia Ambacher, M.K. Meiser, Madeline Bowen, and Mark Bowen
organization: AECOM
street & number: 401 W. A Street, Suite 1200
city or town: San Diego state: CA zip code: 92101
e-mail: trina.meiser@aecom.com
telephone: 619-610-7600
date: September 2016

Additional Documentation

Submit the following items with the completed form:

- **Maps:** A **USGS map** or equivalent (7.5 or 15 minute series) indicating the property's location.

- **Sketch map** for historic districts and properties having large acreage or numerous resources. Key all photographs to this map.

- **Additional items:** (Check with the SHPO, TPO, or FPO for any additional items.)

Photographs

Submit clear and descriptive photographs. The size of each image must be 1600x1200 pixels (minimum), 3000x2000 preferred, at 300 ppi (pixels per inch) or larger. Key all photographs to the sketch map. Each photograph must be numbered and that number must correspond to the photograph number on the photo log. For simplicity, the name of the photographer, photo date, etc. may be listed once on the photograph log and doesn't need to be labeled on every photograph.

Photo Log

Name of Property: NASA Ames Wind Tunnel Historic District
City or Vicinity: Moffett Field
County: Santa Clara
State: CA
Photographer: Mark Bowen and Patricia Ambacher
Date Photographed: December 8 and 9, 2014
Location of Original Digital Files: AECOM, 401 W. A Street, Suite 1200, San Diego, CA 92101

Description of Photograph(s) and number, include description of view indicating direction of camera:

Photo #1 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0001)
Building N-215, main façade (south elevation), camera facing north.

Photo #2 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0002)
Building N-215, south and east elevations, camera facing northwest.

Photo #3 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0003)
Building N-215, west and south elevations, camera facing northeast.

Photo #4 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0004)
Building N-215, west elevation, camera facing east.

Photo #5 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0005)
Building N-215, interior lobby and original staircase, camera facing west.

Photo #6 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0006)
Building N-215, interior wind tunnel fan, camera facing west.

Photo #7 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0007)
Building N-215, interior wind tunnel fan, camera facing east.

Photo #8 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0008)
Building N-220, main façade (west elevation), camera facing southeast.

Photo #9 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0009)
Building N-220, west and south elevations, camera facing northeast.

Photo #10 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0010)
Building N-221, main entrance on east elevation, camera facing west.

Photo #11 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0011)
Building N-221's 40-foot by 80-foot wind tunnel and Building N-221A (noncontributor), camera facing southwest.

Photo #12 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0012)
Building N-221's 40- by 80-foot wind tunnel and Building N-221A (noncontributor), camera facing west.

Photo #13 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0013)
Building N-221, east elevation, test chamber housing and intersection of Durand Road and DeFrance Avenue (contributing landscape features), camera facing northwest.

Photo #14 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0014)
Building N-221, north elevation of test chamber housing and east elevation; Building N-247 (foreground) (noncontributor); DeFrance Avenue (contributing landscape feature), camera facing southwest.

Photo #15 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0015)
Building N-221, main entrance on east elevation; Building N-247 (left and foreground) (noncontributor), camera facing west.

Photo #16 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0016)
Building N-221's east and north elevations (left) and Building N-221B (left), camera facing southwest.

Photo #17 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0017)
Building N-221B, east elevation and 80- by 120-foot test chamber in the center; Building N-263 (foreground) (noncontributor), camera facing southwest.

Photo #18 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0018)
Building N-221 interior showing tunnel shops area, camera facing south.

Photo #19 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0019)
Building N-221B 80- by 120-foot wind tunnel test section showing loading gantry, camera facing northwest.

Photo #20 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0020)
Building N-221B 80- by 120-foot wind tunnel interior with observation ports on walls and personnel access doors.

Photo #21 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0021)
Building N-221, wind tunnel test chamber, camera facing northwest.

Photo #22 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0022)
Building N-226, main entrance on west elevation, camera facing northwest.

Photo #23 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0023)
Building N-226, south and east elevations; 6- by 6-foot wind tunnel (left); camera facing northwest.

Photo #24 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0024)
Building N-226's 6- by 6-foot wind tunnel, camera facing northeast.

Photo #25 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0025)
Building N-226, original interior staircase, camera facing east.

Photo #26 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0026)
Building N-226, interior 6- by 6-foot Supersonic Wind Tunnel Chamber, camera facing east.

Photo #27 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0027)
Building N-227, center section and main façade (north elevation), camera facing southwest.
Photo #28 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0028)
Building N-227 (right) and Building N-227A (left corner), north elevation, camera facing southeast.

Photograph #29 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0029)
Interior of 227-A showing 11- by 11-foot Transonic Wind Tunnel Chamber, camera facing north.

Photo #30 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0030)
Building N-227B, camera facing southeast.

Photograph #31 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0031)
Interior of Building N227-B showing 9- by 7-foot Supersonic Wind Tunnel Chamber, camera facing north.

Photograph #32 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0032)
Building N227-C; east elevation; camera facing west.

Photograph #33 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0033)
Interior of Building N227-C showing 8- by 7-foot Supersonic Wind Tunnel Chamber; camera facing south.

Photograph #34 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0034)
Building N227-D; south elevation; camera facing north.

Photograph #35 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0035)
Interior of Building N227-D, showing auxiliary equipment; camera facing southeast.

Photograph #36 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0036)
Unitary Plan Wind Tunnels 11-Stage Axial Flow Fan (left) and Aftercooler (right); exterior view; camera facing southeast.

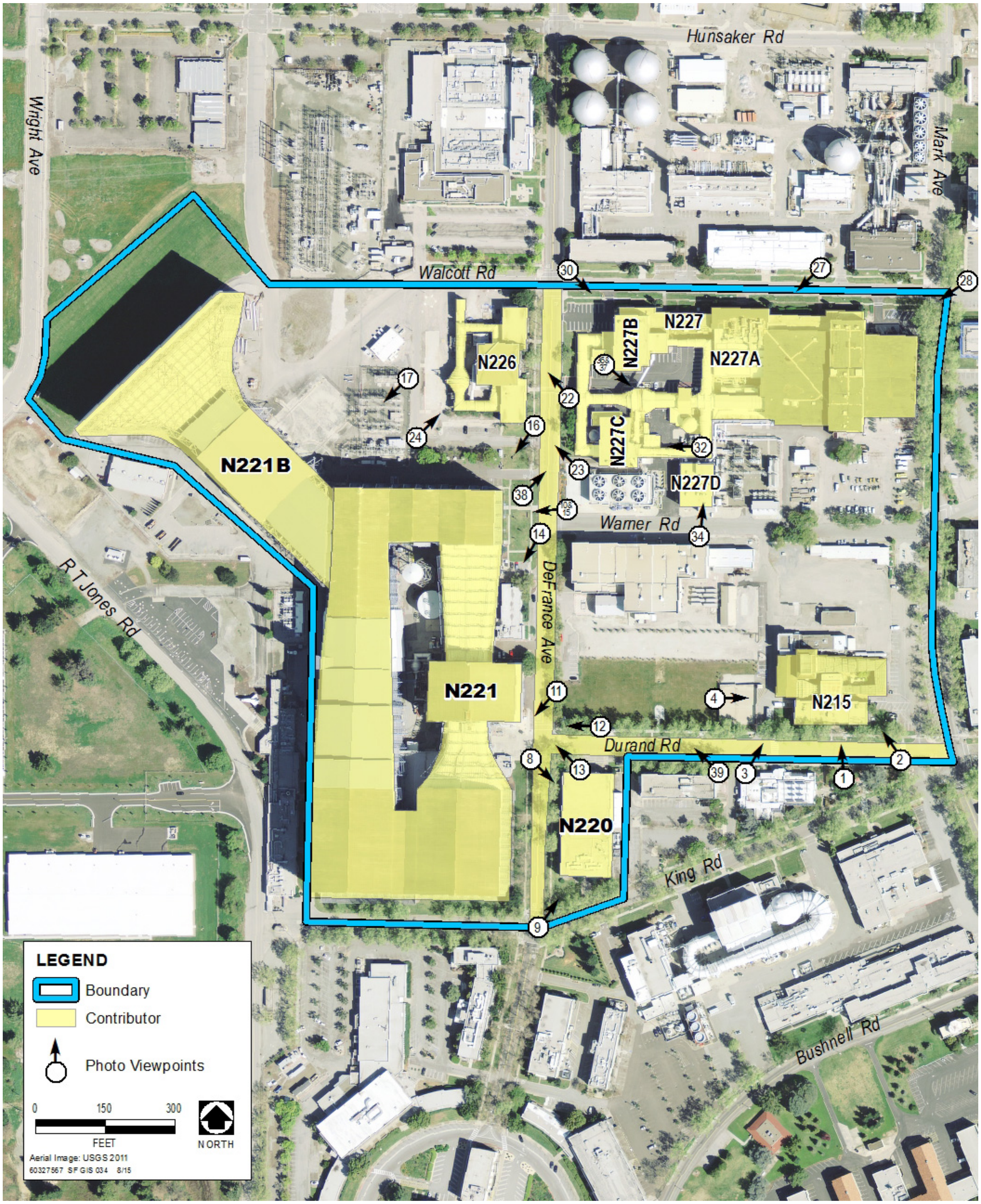
Photograph #37 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0037)
Unitary Plan Wind Tunnels Aftercooler; exterior view; camera facing southeast.

Photograph #38 (CA_Santa Clara County-NASA Ames Wind Tunnel Historic District_038)
Unitary Plan Wind Tunnels Flow Diversion Valve with NASA logo, camera facing northeast.

Photograph #39 (CA_Santa Clara County_NASA Ames Wind Tunnel Historic District_0039)
Overview shot showing landscape and hardscape (Durand Road), camera facing northwest.

Photograph Key

Note: Photographs 5–7, 18–21, 25–26, 29, 31, 33, and 35 are interior shots and are not keyed on the map.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Mark Ave
Walcott Rd
N227
N227B
N227A
N226
N221B
N227C
N227D
Warner Rd
DeFrance Ave
R T Jones Rd
N221
N215
Durand Rd
N220
King Rd
Bushnell Rd
LEGEND
Boundary
Contributor
Photo Viewpoints
0
150
300
FEET
NORTH
Aerial Image: USGS 2011
60327567 SF GIS 034 8/15

Index of Figures

Note: Original historic photographs are located at NASA Headquarters, Washington, D.C. and ARC.

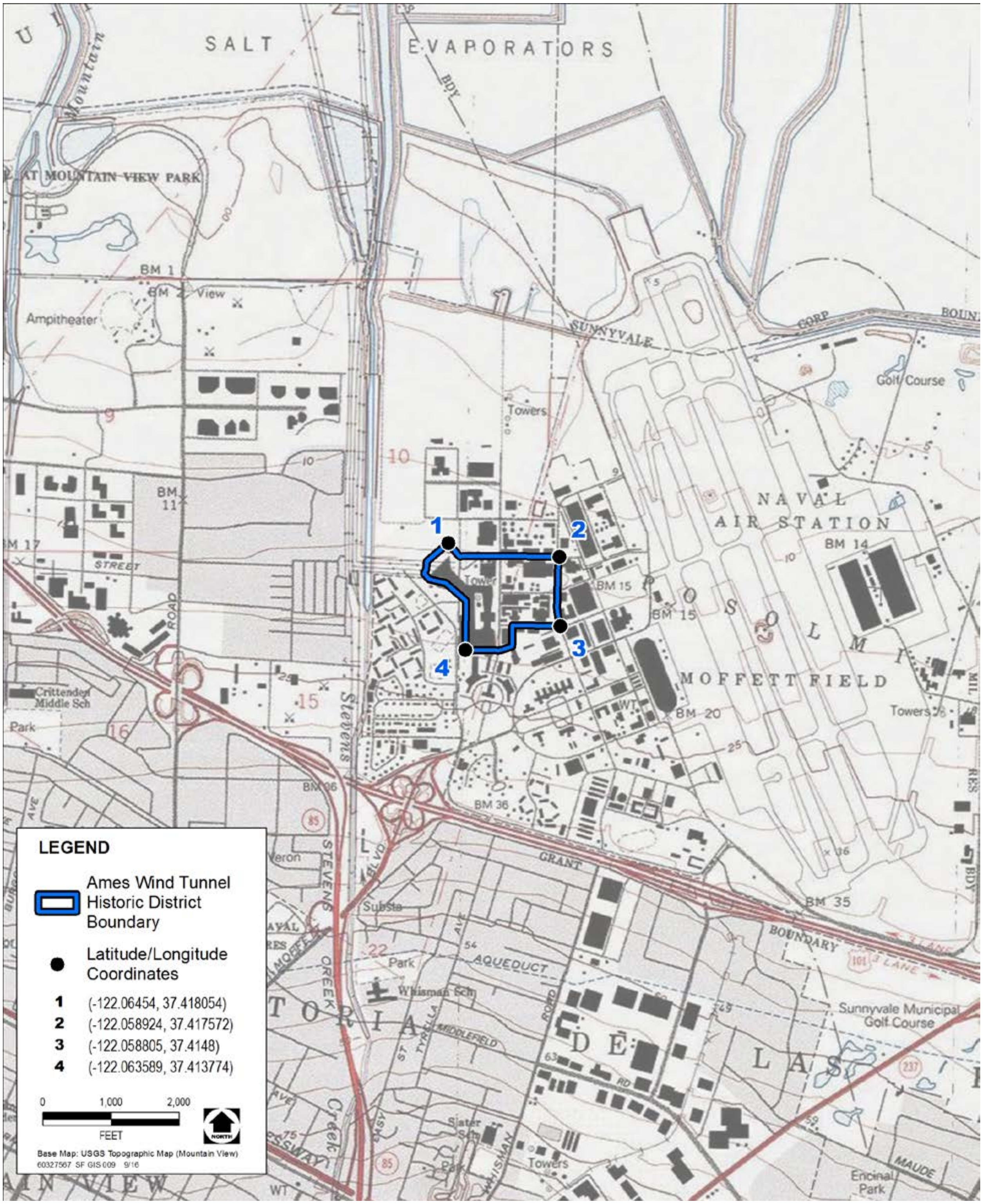
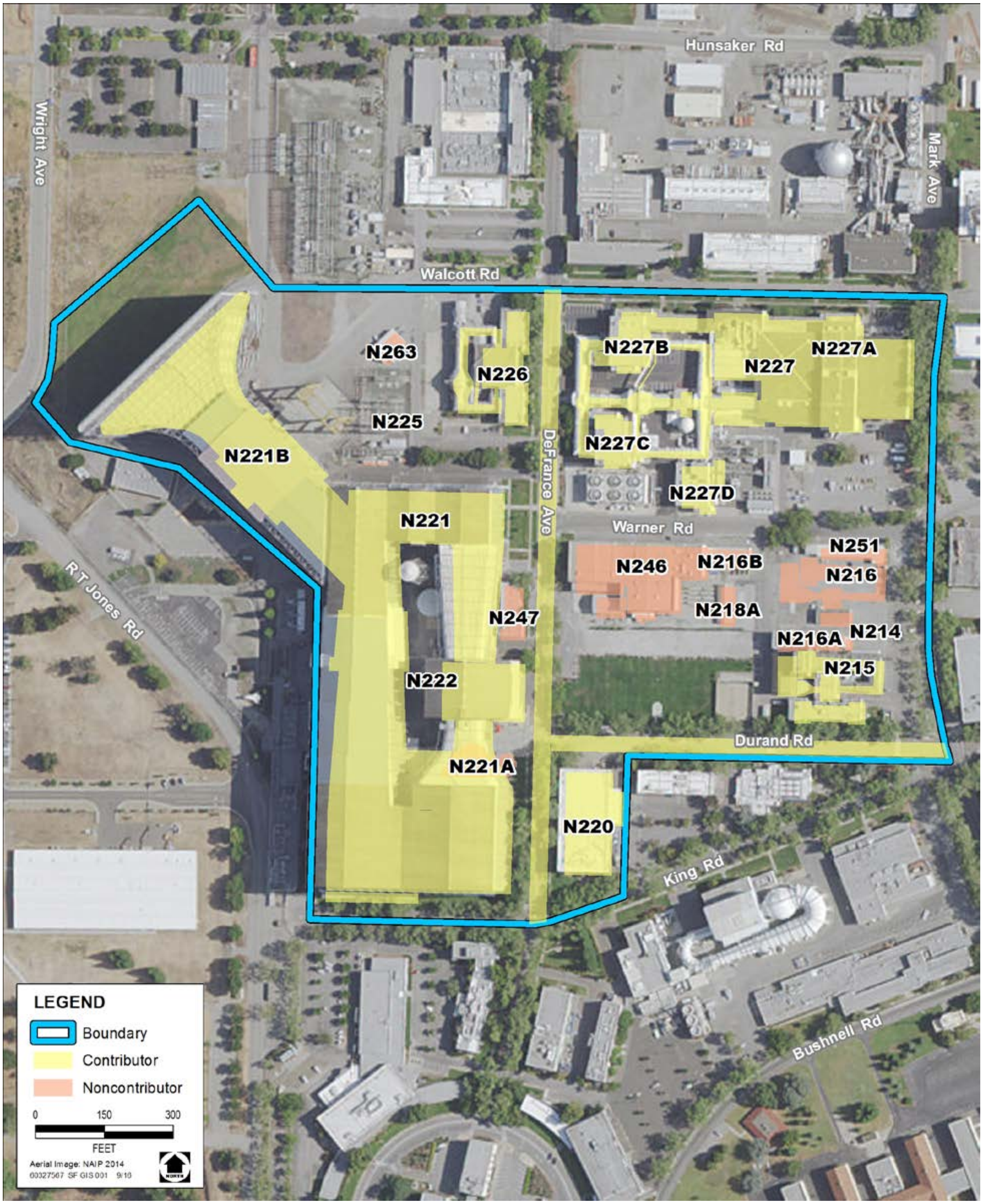

LEGEND
Ames Wind Tunnel Historic District Boundary
Latitude/Longitude Coordinates
1 (-122.06454, 37.418054)
2 (-122.058924, 37.417572)
3 (-122.058805, 37.4148)
4 (-122.063589, 37.413774)
0 1,000 2,000
FEET
NORTH
Base Map: USGS Topographic Map (Mountain View)
60327567 SF GIS 009 9/16
SALT EVAPORATORS
NAVAL AIR STATION
MOFFETT FIELD
Golf Course
Towers
Sunnyvale Municipal Golf Course
Ampitheater
Crittenden Middle Sch
Whisman Sch
Slater Sch

Figure 1



Hunsaker Rd
Wright Ave
Mark Ave
Walcott Rd
N263
N226
N225
N221B
N227B
N227A
N227
N227C
N227D
DeFrance Ave
Warner Rd
N221
N246
N216B
N251
N216
N218A
N247
N216A
N214
N215
N222
R T Jones Rd
Durand Rd
N221A
N220
King Rd
Bushnell Rd
LEGEND
Boundary
Contributor
Noncontributor
0
150
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FEET
Aerial Image: NAIP 2014

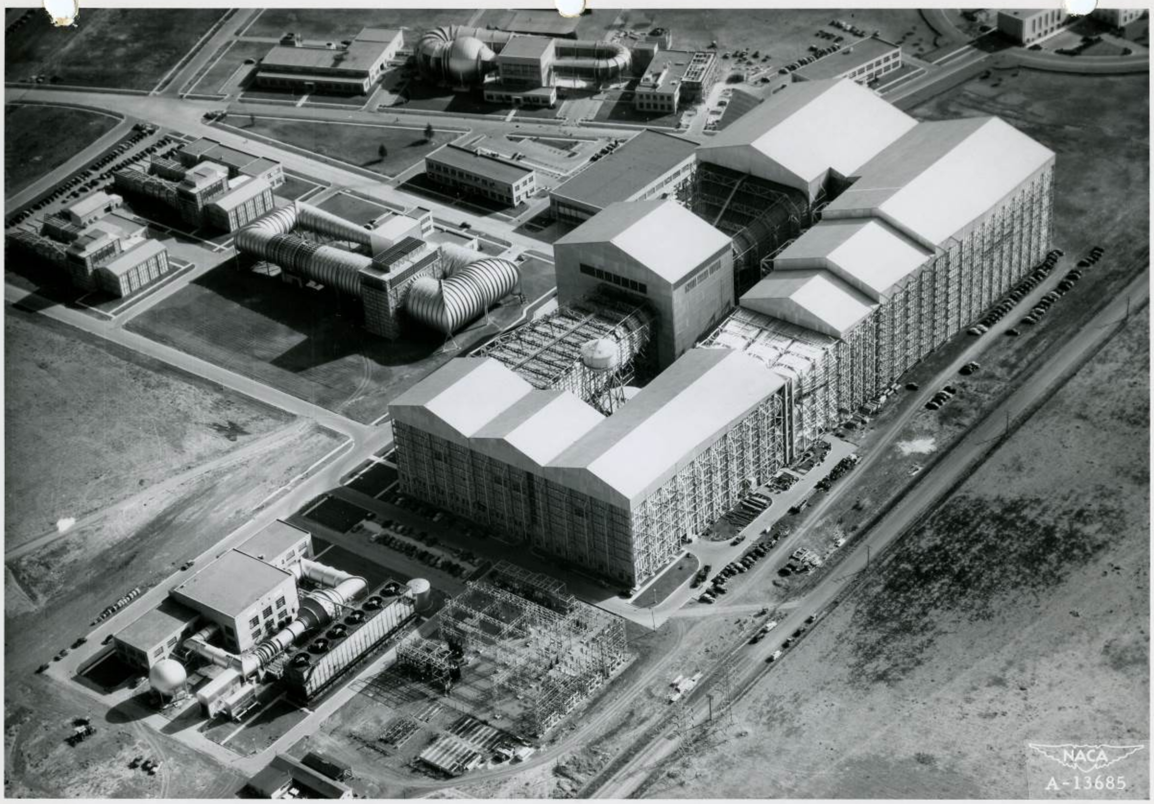
Figure 2

Figure 3

Outside view of the 40 x 80 Foot tunnel at Ames. This is the world's largest wind tunnel, is powered by six 6,000 hp. motors--provides speeds up to 250 mph.

Figure 4

NATIONAL ADVISORY COMMITTEE FO ONAUTICS
AMES AERONAUTICAL LABORATORY, M FIELD, CALIF.



The new 6- by 6-foot Supersonic Wind Tunnel in the left foreground has recently been placed in operation at the NACA's Ames Aeronautical Laboratory, Moffett Field, California. With a speed range from 1.1 to 1.8 times the speed of sound, it helps to fill an urgent need for larger-scale, supersonic research facilities and will play an important role in the development of tomorrow's supersonic aircraft.

Figure 5

A front view of the 6- by 6-foot supersonic wind tunnel, Ames Aeronautical Laboratory, Moffett Field, Calif.

NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

Figure 6

Figure 7


USAF
NACA
A-15956
NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
AMES AERONAUTICAL LABORATORY, MOFFETT FIELD, CALIF.

Figure 8

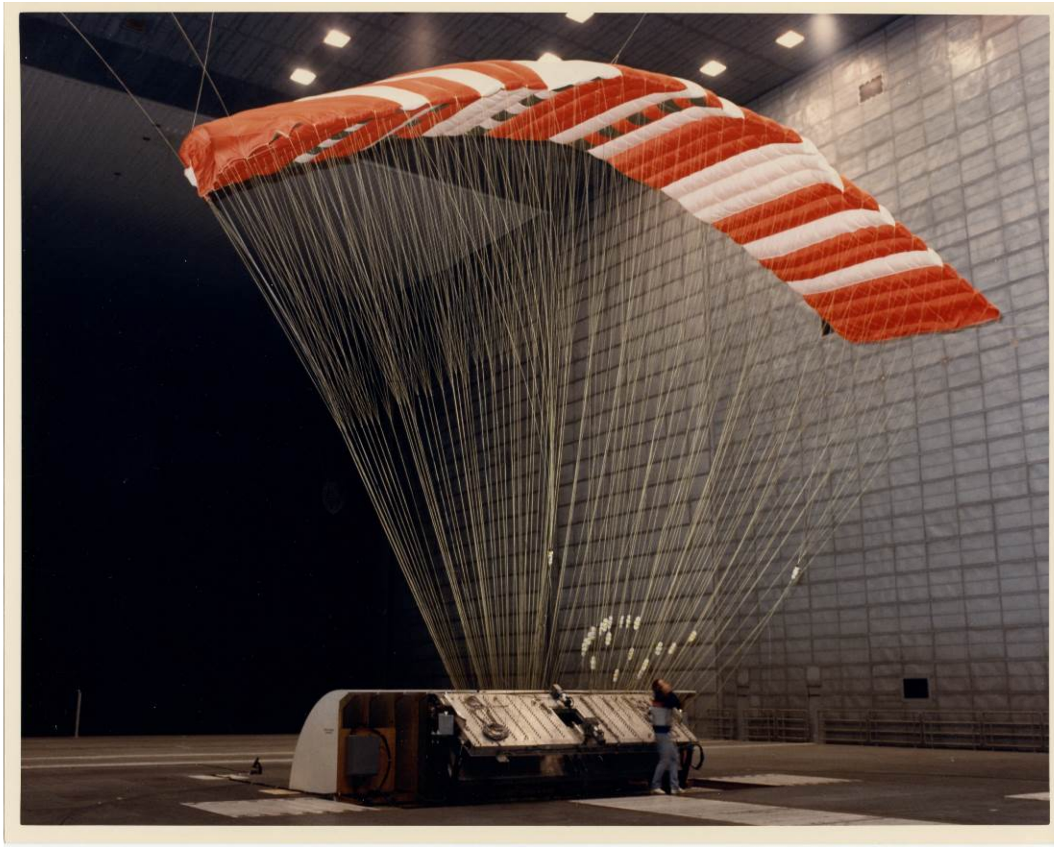


Figure 9

Paperwork Reduction Act Statement: This information is being collected for applications to the National Register of Historic Places to nominate properties for listing or determine eligibility for listing, to list properties, and to amend existing listings. Response to this request is required to obtain a benefit in accordance with the National Historic Preservation Act, as amended (16 U.S.C.460 et seq.).

Estimated Burden Statement: Public reporting burden for this form is estimated to average 100 hours per response including time for reviewing instructions, gathering and maintaining data, and completing and reviewing the form. Direct comments regarding this burden estimate or any aspect of this form to the Office of Planning and Performance Management. U.S. Dept. of the Interior, 1849 C. Street, NW, Washington, D.C.

The following content was redacted from this public posting:

DPR 523 Series Forms